Dick Simon Trucking Failure :

SKF 000001

Automotive Division

August 25, 2000

Plymouth, MI
USA

David Desrocher
Manager Worldwide Procurement
ArvinMeritor Heavy Vehicle Systems
2135 West Maple Road,
Troy, MI, 48084-7186

Dear David:

Please find enclosed a check for $68,403.00 to cover the Dick Simon fee. After reviewing the results of your metallurgical study, we revisited our own analysis and agree that your conclusions are correct. The raceway was not hardened properly resulting in pre-mature eroding of the raceway. We have corrected this issue at our Aiken plant and have forwarded Kevin Belling a copy of the corrective action.

We believe that the operators must be made aware of the consequences of driving a vehicle that has brake drag with these hubs. Instead of a wheel off condition, the hub will remain with the vehicle and generate heat. Though this is a safer mode, you can't continue to operate the vehicle when this condition occurs. At a meeting with Brad Arnold last week, we agreed that a technical bulletin will be issued to advise drivers to shut the vehicle down instead of trying to "limp" home. We also agreed to develop a system to jointly process claims of this kind with the intention of responding quickly to the customer and ensuring that we are making the correct decision.

Irrespective of the failure mode of any wheel end, they have to be prevented. We have the capability to develop wheel sensors that can provide feedback on temperature or an entire matrix of wheel end conditions. Since you are the industry leader with axles and wheel ends, we feel that we should jointly embrace this challenge to make our highways safer, and improve our profitability.

If you have any further questions, please don't hesitate to contact me.

Best Regards,

Robert J. Brady
Senior National Account Manager

cc. B. Arnold, K. Belling, S. Brown, M. Lewis

[redacted]
An SKF Company

NO. 253378

VENDOR NO.	VENDOR DIVISION NO.	YOUR INV. NO.	INV. PAY	DATE YEAR	P.O. NUMBER	GROSS AMOUNT	DISCOUNT	AMOUNT OF PAYMENT
80052	AUGCO	08	08	2000		68,403.00		68,403.00
		ATTN:		ARVIN	MERITOR			
						68,403.00		68,403.00

DETACH BEFORE DEPOSITING

NO. 253378

SKF USA Inc.

PAY TO THE ORDER OF

MERITOR HEAVY VEHICLE SYSTEMS
ARVIN MERITOR
2135 WEST MAPLE RD
TROY MI 48084-7186

DATE 08 24 2000

EXACTLY 68,403 DOLLARS 00 CENTS

V2

First Union Bank of Delaware
Wilmington, DE 19803

AUTHORIZED SIGNATURE

P253378P 0031100225C 2079950039406P

SKF 000002

BOB
BONDY

INTERNAL LETTER

MERITOR

Date June 2, 2000 No. 00bak072

To: D. Deesecker From: B. E. Ketcham
Product Analysis
Troy / SS-005
S-1643

Subject: Dick Simon Trucking

Meritor paid Dick Simon Trucking sixty eight thousand four hundred three dollars ($68,403.00) as compensation for the damage to their Freightliner tractor, VIN 1FUYDSEB7YPB40386, and the loss of the driver's personal property. This amount was determined based on the following:

Vehicle Purchase Price	$74,903
Driver's Personal Property	1,500
Sub-Total	$76,403
Estimated Salvage Value	(8,000)
Total	$68,403

A copy of the vehicle purchase order and the executed Property Damage Release are enclosed.

Assuming that no unresolved issues remain following Meritor's meeting with SKF on June 12, please convey this information with your request for reimbursement.

Sincerely

Enclosure

cc: F. Donnelly (Encl.) – S-128

ARVIN MERITOR
ENGINEERING EXPENSE

$ 6,860
68,403
$ 75,263 TOTAL REQUESTED

CC Lewis V
Weeks
Brown

RV-[illegible]

** TOTAL PAGE.01 **

SKF 00000

MERITOR

REQUEST NUMBER: 20105-1
PROJECT NUMBER: AV-MS-0217
DATE: June 8, 2000

MATERIALS ENGINEERING

METALLURGICAL ANALYSIS OF SKF HUB INVOLVED IN A FREIGHTLINER FF-981 FRONT AXLE FIELD RETURN

FIRST MANUFACTURER:

Serial #: 0101547 | Mfg Date Code: 05488 | BTF-6082-A

MODELS: FF-981 | Vehicle S#: 1FUYD6EB7YP040388

PLANT/SUPPLIERS:

SKF

CUSTOMERS:

Freightliner | Dick Simon Trucking

REFERENCE REPORTS:

SKF Report No.: AT99A184 | SKF Report No.: AT99C313

ABSTRACT:

One passenger side (right) SKF THU hub for an FF-981 front axle assembly was submitted to Meritor Materials Engineering for metallurgical analysis. The front axle assembly was installed in a 1999 Freightliner vehicle that caught fire in service after 17,630 miles. The vehicle was operated by Dick Simon Trucking of Salt Lake City, Utah. The analysis concluded that the root cause of the vehicle fire was the non-induction hardened Inboard Row Outer Ring Bearing Raceway. It is suspected that as the tapered rollers eroded material from the non-induction hardened inboard row outer ring raceway, dimensional changes occurred which caused excessive movement in the assembly, resulting in brake component misalignment. With this misalignment, it is possible that the brake components could have then generated some excessive heat that contributed to the subsequent damage and fire. There have been other instances of bearing seizure/bare-up on FF-981 THU hubs due to missed induction hardening of the outer ring raceways.

KEY WORDS:

Field Return | Legal | Steel - Carbon

Hardenin-Induction | Process | Wear

REQUESTED BY: Bruce Ketcham

TOTAL COST: $ 6,[illegible]

PREPARED BY: Nathan Clark

APPROVED BY: Steven M. Foster

DISTRIBUTION:

D. Donegan
S. Foster
N. Clark
B. Ketcham
D. Bell
J. Mahlman
O. Deeschar
J. McKenzie - AV
J.P. Pan - AV
M. Berlis - AV

SKF 000005

INTRODUCTION

One passenger side (right) SKF Truck Axle Hub Unit (THU) for an FF-981 front axle assembly was submitted to Materials Engineering for metallurgical analysis. The front axle assembly was installed in a 1999 Freightliner vehicle, which caught fire in service after 17,030 miles. The driver reportedly pulled over to the side of the road after experiencing what appeared to be brake drag on the right front axle. After allowing the wheel end to cool, the driver reportedly adjusted the brakes to release the drag and continued driving the vehicle until the right front tire burst into flames. The vehicle was operated by Dick Simon Trucking of Salt Lake City, Utah. Identification markings of the THU are shown in Figure 1.

A metallurgical analysis of the THU was performed by SKF (SKF Report No.: AT99A184) prior to being delivered to Meritor, and therefore a section of the hub was missing upon arrival. The SKF report contained details on many metallurgical aspects of the hub, however data was missing from some key areas, particularly from the inboard and outboard outer raceways, which were reported to be induction hardened. A section of the hub adjacent to the SKF section was removed to evaluate these areas (Figure 2).

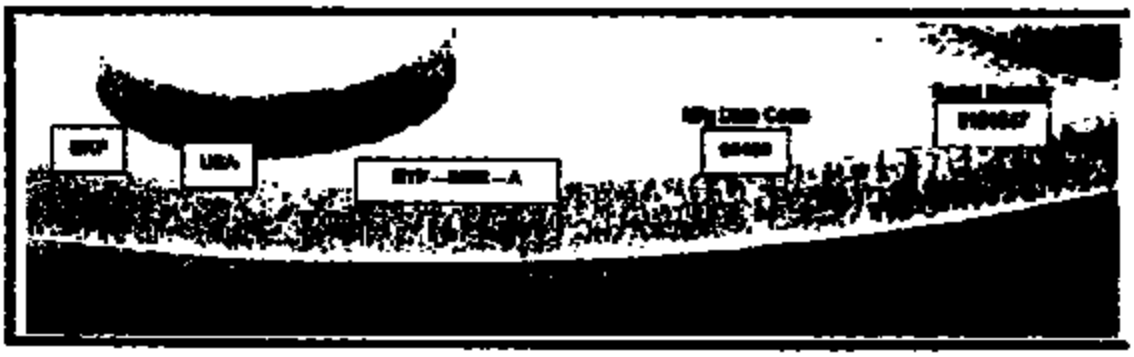

Figure 1. Identification markings on the flange outside diameter of the passenger side (right) SKF Truck Axle Hub Unit. Test traces are shown above each section for clarification.

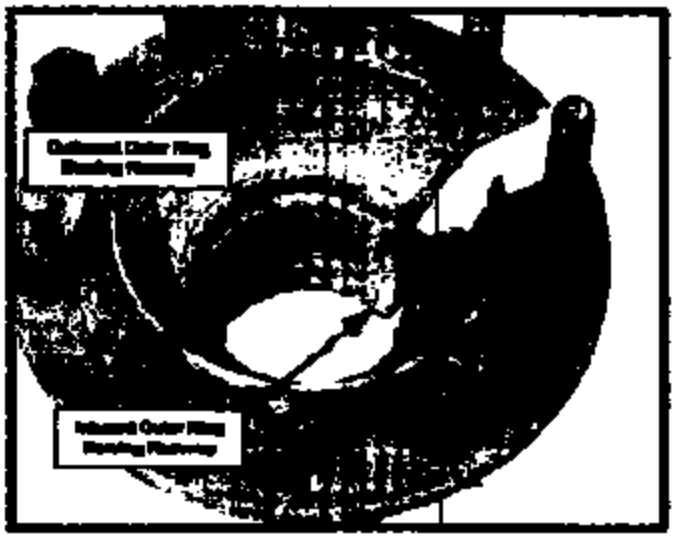

Figure 2. Photograph showing the area of the hub removed for analysis. The arrows point to the inboard and Outboard Outer Ring Bearing Raceways. These raceways are required to be induction hardened.

CONCLUSIONS

- A cross-section of the SKF THU hub was etched to reveal the induction hardened pattern at the outboard outer ring raceway. The inboard outer ring raceway did not exhibit an induction hardened pattern (Figures 3 & 4).

- Microhardness gradients were taken at the induction hardened outboard outer ring raceway and ranged from HRC 40-43 (Figure 8). This hardness range indicates that the raceway was exposed to an estimated temperature of 700-800°F which tempered back the hardness approximately 20 HRC points from its induction hardened state (Figure 8). The microstructure of the outboard outer ring raceway consisted of tempered martensite (Figure 8).

  The hardness values at the inboard outer ring raceway were significantly lower than the outboard outer ring raceway, and ranged from HRC 22-29. Microstructural analysis of the inboard outer ring raceway revealed a mixture of ferrite and pearlite, indicating that this raceway was not induction hardened (Figures 9 & 10).

- It is theorized in the SKF metallurgical report that, *"an initial condition of excessive heat caused the right THU bearing to lose its lubricant and fail. The source of heat, which appears to have affected the hardness levels of the right THU bearing components, may have been a result of the brake pads dragging against the brake drum during operation. This is believed to have caused the seals on the ring to burn and the bearing lubricant to be lost. Thus, the unlubricated condition of the bearing caused its imminent failure."*

  It is Mentor Materials Engineering's opinion that the root cause of the vehicle fire was the non-induction hardened inboard Row Outer Ring Bearing Raceway. It is suspected that as the tapered rollers eroded material from the non-induction hardened inboard row outer ring raceway, dimensional changes occurred which caused excessive movement in the assembly, resulting in brake component misalignment. With this misalignment, it is possible that the brake components could have then generated some excessive heat that contributed to the subsequent damage and fire.

- There have been other instances of bearing seizure/burn-up on FF-991 THU hubs due to missed induction hardening of the outer ring raceways.

EXPERIMENTAL RESULTS

Figure 3 shows the cross-section etched to reveal the induction hardened patterns of the outer ring raceways. No induction hardened pattern was revealed at the inboard outer raceway.

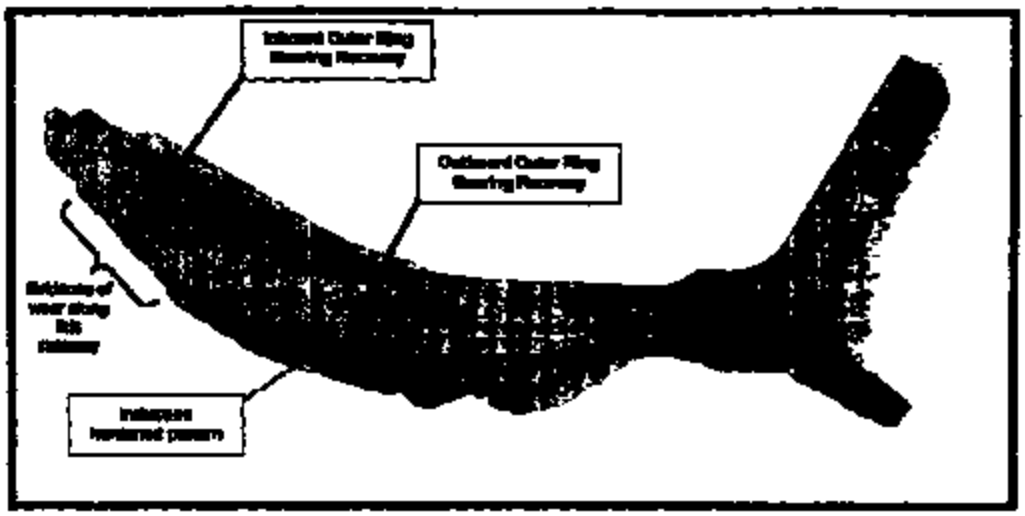

Figure 3. Etched cross-section through the bearing raceways. The red arrow points to the induction hardened pattern of the outboard outer ring raceway. No induction hardened pattern was revealed at the inboard outer ring raceway. Evidence of wear was observed at the inboard outer ring raceway.

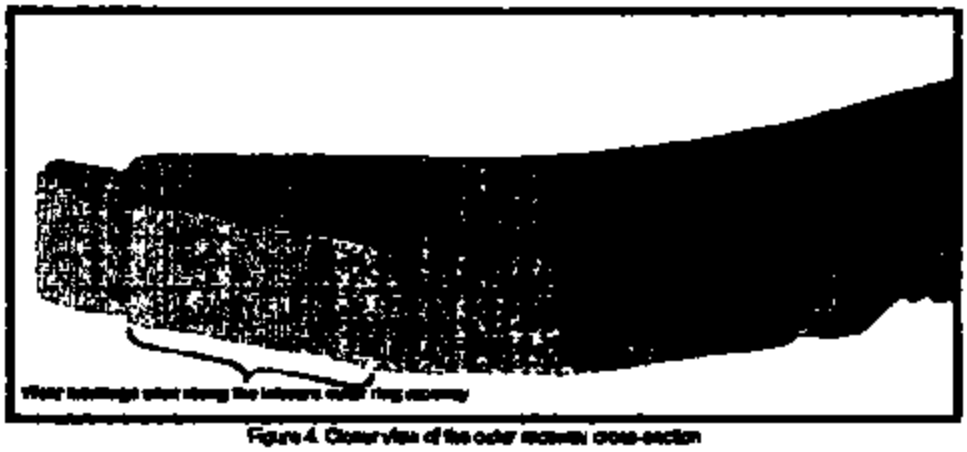

Figure 4. Close view of the outer raceway cross-section

Microhardness

Knoop 500g microhardness gradients were generated at the inboard and outboard outer bearing raceways and are illustrated in Figure 5. Figure 6 shows the estimated temperature exposure of the induction hardened outboard row outer ring raceway, which can be estimated from the tempered hardness values and the carbon content of the steel (taken from SKF report AT99C313).

Figure 5. Microhardness of Outer Raceways

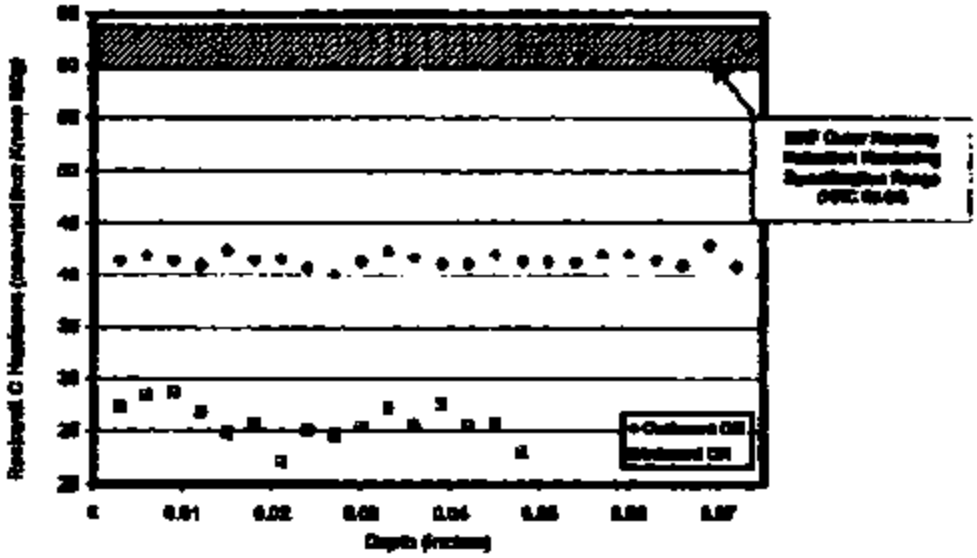

Figure 6. Estimated Temperature Exposure of the Induction Hardened Outboard Outer Ring Raceway

Outboard Outer Ring	46-43	700 - 800

Microstructure
Figure 7 shows the locations of the microstructures pictured in Figures 8-11.

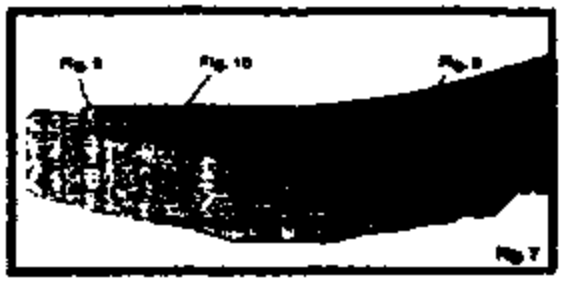

Figure 8. Microstructure of the outboard outer ring bearing raceway consists of tempered martensite. Microhardness indentations are shown at 0.003" intervals.

Figure 9. Microstructure at the end of the inboard outer ring bearing raceway consisted of pearlite and ferrite. The "step" in the surface is a result of the tapered roller bearing wear, and was found to be approximately 0.003" deep. A "swirling" grain flow is seen from the elevated temperature smearing of the non-induction hardened raceway surface.

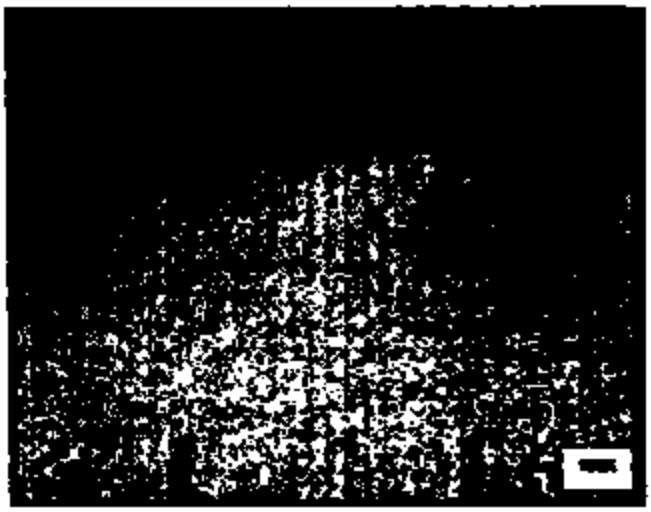

Figure 10. Microstructure near the middle of the inboard outer ring bearing raceway consisted of pearlite and ferrite. As in Fig. 9, the "swirling" grain flow is seen from the elevated temperature smearing of the non-induction hardened raceway surface. The depth of the smearing grain flow was found to be approximately 0.010".

Technical Error Report (TER)

[redacted]

Mandatory fields are marked with *
X1 Section

[redacted]

Reference Number: LA-20000328-43125 Local Reference No.:

Creation Date: 03/28/2000 Received Date: * 03/28/2000

Reason why the report creation was delayed: * Field failure, returned for Warranty

[redacted]

Complaint Reporting Person (21): *	Bruce Weeks/AMER/SKF	Reporting Operational Unit: *	A115 ASU USA
Business Area:	A115 ASU USA	Segment:	A102 AO North America
Division:	Automotive		

[redacted]

Customer Name: * Menlor
Customer No.: * Not Available Customer Invoice No.: * Not Available
If Customer Number is not available press here: [redacted]
If Customer invoice Number is not available press here: [redacted]

[redacted]

Seriousness Code: * [redacted]
Serious Complaint i.e. Corrective Action, Repeating Complaints.

Preliminary Technical Error Type: * [redacted]

Product Designation: * THU
Preliminary Type Of Error: * 1.2X Missing operation Error Detected: * Field in warranty

Additional Complaint Information: In board Outer Ring raceway has not been hardened, due to a missing operation at the factory.

Is there going to be a sample sent ? * [redacted]

Sample Sent Date: * 03/27/2000

Number of Samples to be sent: 2

Packaging Date:	2/24/00 & 3/16/00	Bearing Serial Number:	99385, 100532
Manufacturing Date:	2/24/00 & 3/16/00		
Product Line: *	THU 2.1		
Factory: *	Aiken- Truck - THU	Factory Unit Rep. (XX):	Wilson H Hacker/AIKN/SKF
Business Area co-ordinator (XX):	Juergen Schultheiss/SCHW/SKF	Sample Sending Address (XX):	SKF Automotive Division Aiken Factory 1084 International Place Graniteville, Sc 29829 USA
Business Area:	AD TRUCK	Division:	AUTOMOTIVE

Additional Packaging Information Attachments:

Actions Requested by Customer:	*	TBD
Agreement with Customer:	*	TBD
Application: *		Steer Axel FF-981
Consequences:		TBD
Persons automatically informed by X1:		Wilson H Hacker/AIKN/SKF
Additional Persons involved in the Problem:		Volker Mueller/AIKN/SKF

Corrective Action Report

Person responsible for the CAR if not X2:

Other persons involved in CAR, internally: Mario S Winkler/AIKN/SKF, George F Wilemon/AMER/SKF, Kevin Cannon/AIKN/SKF, Bruce Weeks/AMER/SKF

Sample Received Date or Investigation starts: 04/03/2000

Complete Continment: *

Does this complaint involve Interim Actions: [redacted]

Interim Actions: * Present situation at the induction heatreatment machine EFD is that overflow and rejects are coming out on the same conveyor. Operators are informed about the occurance off the problem and advised to clearly physically separate rejects from good parts.

EFD will be contacted to implement program changes to avoid that non conforming parts are transferred to the machine aid but removed at the faulting station.

All conforming parts are automatically marked with a sequencial number. Non conforming parts have no number. This system has been implemented in middle March.

Interim Actions Answer Date: 04/10/2000

Factory QA:	William H Hacker/AKN/SKF	Channel Rep. to Factory:	Mario G Winkler/AKN/SKF

Channel Designation: * 2.1 Business Area:

If Channel Designation is not available press here: [redacted]

Further Investigation and Conclusions: The reason why soft parts made it thru the channel is caused by a weakness in the heat treatment sequence program and clearly by human error.

Determined Technical Error Type: * [redacted]

Determined Error Type: 04.0 Material Defects on OR *

Actual Problem Description: Missed operation 1.29 in heat treatment *

Root Cause: * Present situation at the induction heatreatment machine EFD is that overflow and rejects are coming out on the same conveyor. Operators are informed about the occurance off the problem.

How many Corrective Actions are needed ? * [redacted]

You need to enter all information for the number of corrective actions chosen. If persons to be assigned for Corrective Actions does not have notes use the comments field below.

#	Corrective Action	Assigned Person	Target Date	Close Date	
1	Inform all personnel about the problem.	Mario G Winkler/AKN/SKF	04/07/2000		[redacted]
2	Contact EDF to change the program.	George F Wireman/AMER/SKF	04/10/2000		[redacted]

3	All conforming parts are marked with a sequencial number.	George F Wireman/AM&R/SKF	03/15/2000		[redacted]
4	Investigate feasibility to install eddy current measuring device after final washing station.	Mario G Winkler/AM&R/SKF	04/19/2000		[redacted]

When the last Corrective Action is performed and the last Close button are pressed, the complaint is considered closed.

Corrective Action Plan Comments: The induction heat treatment machine has been reprogrammed to stop at the hardening station 2 and tempering station 4 when a defects occure. At these two stations the operator has to physically remove the defective part from the HT machine and place it in a designated area fin it is rework, Scrap is immediately discarded in a scrap container. All accepted parts are marked with a serial number. Final inspection personnel has also been instructed to check for the number and mark with green paint. If for any reason a bearing is found without a number (e.g malfunctioning of the marker) the bearing is disassembled and checked. The exit shute will be changed to have a better control over overflow parts coming of the line.

Corrective Action Plan sent to X1 Date: 03/16/2000

Corrective Action Approved by X1: * [redacted]

Corrective Action Plan Approved Date:

Customer Notification Date: * 05/10/2000

Attachments: NONE

Closed at Customer Date:

CAR Close Date:

Number of Days to approve CA Plan: (CA Approved - CA Sent)

Total Complaint Lead-Time (TCL): (Customer Notified - Receive Date) 58

Factory Complaint Lead-Time (FCL): (Sample Received - CA Sent) 31

Sales Complaint Lead-Time 1 [illegible]
(SCL1):
(Received Date - Creation
Date)
Sales Complaint Lead-Time 2
(SCL2):
(Customer Notified - Closed at
Customer)

History: Rev.	Editor	Edit Date
11	[illegible]	[illegible]
10	William H Hudson	[illegible]
9	Lonie A Mathis	[illegible]
8	William H Hudson	[illegible]
7	William H Hudson	[illegible]
6	William H Hudson	[illegible]
5	William H Hudson	[illegible]
4	William H Hudson	[illegible]
3	William H Hudson	[illegible]
2	William H Hudson	[illegible]
1	Lonie A Mathis	[illegible]

Created By: Lonie A Mathis/DET/SKF
Date Created: 03/28/2000

SKF

January 11, 2000

Meritor Heavy Vehicle Systems, LLC
Attn: Mr. Bruce Ketchum
2135 West Maple Road
Troy, MI 48084-7186

Re: Final Report - Steer Truck Hub Unit Analysis
Dick Simon Trucking VIN 1FUYDSEB7YP940398
Truck Hub Units: Right Serial #0101547 Mfg date code 06499
Left Serial #0101564 Mfg date code 06499

Dear Bruce,

Attached please find two copies of the final report detailing our observations and test results on subject hubs. After a painstaking review of all the data and test results and based on the evidence found in the left hand hub unit, it is believed that the most probable cause of the vehicle fire was a brake system malfunction resulting in extreme heat to the hub unit.

The driver's testimony (attached) states that he experienced a brake drag in the right front. He stopped to allow the drum to cool and then readjusted the brake to release the drag. A few miles later the tire caught fire. Most likely the brake drag heated the truck hub unit from the outside, burning the seals and deteriorating the grease which caused the subsequent hub unit failure. This in turn caused even more brake heating from the misaligned brake shoes and drum which resulted in the fire.

This conclusion is supported by the wear on the brake linings. The right side linings are worn significantly more then the left side linings around their entire circumference which would be consistent with a brake drag situation. The left side is then worn even more on the bottom which is consistent with the brake drum supporting the vehicle after the bearing failure. If the bearing failure had occurred first, there would be excessive wear on the bottom of the linings only. The circumferential wear pattern indicates that the brake drag is the most probable cause of the bearing failure and subsequent fire.

Microstructural analysis of the remaining bearing components show that a great amount of heat was applied from a source external to the hub unit (the brake), while little heat came from the bearing failure itself. Also the failed right side hub unit did not display the typical spalling of the raceways that would indicate that the bearing failure came first. The hub unit failed very quickly, probably within a few minutes. Only dents and smears were found on the upper portion of the inner rings from the rollers being out of alignment after the polymer cage had melted. Had the bearing failed first, spalls would have been located on the raceways. The noted fracture of the inner raceways also occurred in the last few minutes of operation due to metal to metal contact between the inner and outer rings after the rollers were gone.

While it cannot be said with 100% certainty that brake drag initiated the fire, there is no evidence to support other possible failure modes. The left and right side hub units are very close in serial number (647 on the right, 604 on the left, both manufactured on the same day). The Allen manufacturing processes are very stable and consistent from bearing to bearing and no defects of any kind were found in the unfailed left side truck hub unit. The right side unit in question appears to have been made to SKF specifications for materials and heat treatment. The advanced nature of the damage from the failure and subsequent fire prevents dimensional analysis.

A lubrication failure is also unlikely as a main cause of the failure because there is no spalling of the raceways, as mentioned above. Grease samples from the left hub unit were found to be normal (report attached). Grease specifications allow 0.2% water in new grease and water content of the left side THU grease is only 0.1%. The "dirt" content noted in the report is simply the run-in particles from the bearing itself. These soft hydrated iron oxides do not effect bearing life. Due to the failure and subsequent fire, there was no grease available in the right side truck hub unit for analysis.

The design of the truck hub unit, and its application on the Easy Steer axle does not result in the same failure mode as earlier, adjustable single row taper roller bearing units. The large washer under the clamp nut effectively prevents the loss of the wheel/tire/drum/hub assembly from the vehicle as would have happened with single row taper designs. The subsequent misalignment of the brake drum with the shoes coupled with continued operation of the vehicle then results in tremendous heating, and can lead to a fire as we believe happened in this case. Drivers need to take more care in analyzing brake failures and determining if continued safe operation of the vehicle is possible.

SKF will retain this material on site at its North American Technical Center in Plymouth for 60 days where it will be available for review. Or it may be shipped according to Meritor's directions. If we receive no further directions as to the disposition of them, after the 60 days we will dispose of these materials.

Sincerely,

J. Bruce Weeks
Project Manager
SKF Automotive Division

cc: SKF
Mr. Steve Brown
Mr. Mike Lewis
Mr. Robert Bondy

Meritor
Mr. Dave Dessecker

Attachments:

Materials Laboratory Final Report number AT99A184 dated 12/14/99
Chemistry Laboratory Final Report number AT99C313 dated 11-18-99

[illegible]

[illegible] 8:27 PM
George B Walrath

To: [illegible]
cc: John E [illegible]
Subject: [illegible] Hub / [illegible]

Tom

Enclosed you will find pictures of one 1[illegible] Freightliner belonging to Dick Simon Trucking of S.L.C. Utah
SN 1FUY[illegible]
17,[illegible] miles
Copies of all service records are also enclosed.
The truck bursed to the ground and was towed to Laramie, WY. on [illegible] and from Laramie to S.L.C.
on
[illegible].
The driver pulled over to the side of the road with a brake drag on the right front axle. He sat on the side of the
road until the driver cooled. He then backed of the brakes and continued on down the road until the right front
tire burst into flames at which time he pulled over and was unable put out the fire. The damage is clearly shown
in the attached pictures.
The hub was still on the spindle when arriving in Dick Simon's yard. I arrived 10 minutes after the hub was removed
with two light rope with a chisel. Only the inner race of each bearing remained on the spindle, held by both lock nuts
and washers. One bearing roller was inside the Drum and five rollers lay on the lower Brake Shoe, all other Rollers
were missing. The lower right Brake Shoe and Drum are severely worn as the weight of the vehicle was supported at
that point and it appears a Brake fire may have started as a result.

Contact at Dick Simon Trucking: Hans Vandenoeve Director of Maintenance [illegible]
5175 west 2100 South
West Valley City, Utah [illegible] (Salt Lake City)

I was contacted to inspect the vehicle, as was Freightliner, no comments were made and no contact with the fleet after
inspection. The front axle can be removed and shipped to Troy if needed. Please contact me on Phone Mail at 1315
or call Phone [illegible] if further action is needed.

George Walrath

[illegible]

SKF 00001

SKF

SKF North American Technical Center
Plymouth, MI 48170

MATERIALS LABORATORY FINAL REPORT

Report No.:	AT99A184	To:	Bruce Weeks
Project Code:	p-AD 711	From:	Nelson Barigalupo
Registration No.:		Copies:	John Ramirez
Reference:	RLS 100216		Jerry Meyer
			Jim Smithson
			Angela LaFleur
Date Received:	10/21/99	Date:	12/14/99

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CONFIDENTIAL
This report contains proprietary information of SKF USA Inc. Employees are expressly to [illegible] in [illegible] SKF Group. [illegible]

Title: Failure Analysis of Burnt Truck Axle Hub Bearing Units

Background:

Application:	Truck Axle	No. of Samples:	2
Customer:	Mariner	Service Life:	17,000 miles
Product No.:		Service Loading:	
Manufacturing Facility:	Alton	Operating Temperature:	
Alloy/Material:	Grade 55 (OR) and Grade 3 (IR)	Speed:	
Lubricant:		Environment:	

Data Requested: Determine Metallurgical Attributes and Root Cause of Failure

Abstract: The passenger side (right) THU bearing components from a truck steering axle appeared to have been overheated during service. The hardness values of the right THU components were significantly reduced by the high temperature exposure. The hardness reduction was more significant on the outer ring than either the inboard or outboard inner rings. This indicates that the heat source may have been a faulty brake. The driver side (left) THU bearing components did not suffer heat damage. The hardness values of the left THU bearing components were within specification. Both THUs were manufactured on the same day. The manufacturing date and serial numbers (0101604 and 0101547) were stamped on the flange OD of both the left and right THUs.

The chemical compositions of both the right and left THU bearing components were within specification. Also, both the right and left THU bearing components are believed to have been heat treated in accordance to SKF requirements. Some microstructural deterioration of the right THU components was observed. This was consistent with the part having experienced overheating. The microstructures of the left THU components were within specification.

The exact failure initiation mode could not be determined with certainty due to the extent of damage to the bearing components. It is theorized, however, that the right side brake generated excessive heat causing the seals to burn and the grease to leak out. This would have caused the bearing components to run unlubricated and fail prematurely. No spalls were observed on the bearing raceways indicating that apparently the material did not contain defects which could have resulted in a fatigue failure.

Nelson Barigalupo
Author

John Ramirez
Reviewed and Understood by

Hardness

Introduction

A fire damaged truck front axle assembly was received for analysis of the truck hub units (THUs). In its "as received condition, the right (passenger) side THU exhibited high temperature damage. This THU had been disassembled prior to being received at the NATC. Figure 1 shows the truck axle in its "as received" condition. The left (driver) side THU bearings appeared to be in relatively good condition. Figure 2 shows the left brake and THU assembly. Figure 3 shows the right (damaged) THU outer ring and inner rings. The truck was put into service in May 20, 1999 and had approximately 17,000 miles.

The right THU was severely damaged by high temperature, metal to metal contact and water damage. The rollers were missing and the (inner and outer) ring raceways contained dents, smeared metal, were dark blue in color and were rusted. The outboard inner ring contained cracks and was fractured. No grease samples could be extracted from of the right THU. Figure 4 shows photos of the damaged inner rings. The rings contained roller dent marks, fractures and dark blue color from exposure to heat. The rust is believed to have occurred as a result of water use during the fire extinguishing.

The left THU contained the bearings, both seals and grease. No damage or abnormalities to these bearing components were observed upon disassembly and inspection. The grease from the bearings was found to be in good condition. Moisture and particulate content in the grease were within specification. Refer to Chemistry Lab report ATF9C313 (attached). Table 1 provides additional background information gathered during disassembly of the truck axle THUs.

Table 1

Dick Simon Truck Axle Disassembly Comments

	Left THU	Right THU
Bearings	good condition	not available
End Play	0.00mm	not available
Outer Race Nut Removal	approx. 250 ft.lbs	not available
Inner Nut Removal	350 to 450 ft.lbs.	not available
Mfg. Date	April 6, 1999	April 8, 1999
Serial Number	0101454	0101547
Grease wt.	39.02 grams	not available

Hardness

The right THU bearing components contained obvious signs of having been exposed to elevated temperatures (well above 200C). Figure 4 shows the dark blue color of the right THU inner rings. The hardness values of the bearing components were reduced from their original levels by the exposure to heat. The inner rings, which were manufactured through hardened, lost between 6 and 10 Rockwell C hardness points. The outer ring, on the other hand, appeared to have lost 20 to 25 Rockwell C hardness points from its induction hardened raceways. This indicates that the outer ring reached higher temperatures than the inner rings. The microstructure of the outer ring bore material (non-heat-treated sections) is composed of primarily pearlite. As expected, this microstructure did not change in hardness or appearance.

The left THU bearing components did not appear to have been heated above 150C. The hardness values of all the left THU bearing components were within SKF requirements. Table 2 gives the hardness values of the various THU bearing components and the estimated temperature exposure levels.

Table 2

Hardness and Estimated Temperature Exposures of Left and Right THUs

THU	Component	Hardness	Specification	Est. Temp. Exposure °F (C)
Left	Outer Ring Raceway	65 HRC	60-64 HRC	<300 (<150C)
	Inboard Inner Ring	61 HRC	60-64 HRC	<300 (<150C)
	Outboard Inner Ring	na	60-64 HRC	---
	Outboard Roller	case 61 HRC	59-65 HRC	<300 (<150C)
	Inboard Roller	na	59-65 HRC	---
Right	Outer Ring Raceway	53 HRC	60-64 HRC	800 to 1000 (425C to 540C)
	Inboard Inner Ring	51 HRC	60-64 HRC	500 to 600 (260C to 315C)
	Outboard Inner Ring	55 HRC	60-64 HRC	450 to 550 (230C to 290C)

na = not applicable. Hardness of samples from these components were not obtained. The components were considered in good condition. Microstructures on the other components from the same THU were obtained for comparative purposes.

Microstructures

Analysis of the microstructures on the available bearing components (all rings and driver side THU rollers) indicated that the parts were heat treated in accordance with SKF specifications. Both the left and right THU outer ring raceways (inboard and outboard) were induction hardened. The inner rings (both left and both right THUs) were through hardened. The left THU rollers were case carburized. The hardened rings and rollers (induction hardened outer ring raceways, through hardened inner rings and case carburized rollers) consisted of tempered martensite. The through hardened inner rings contained carbides which were evenly distributed throughout the steel matrix. The outer ring bore microstructures (remote away from the induction hardened raceways) consisted of fine pearlite. This microstructure is consistent with SKF requirements.

The right THU components exhibited signs of high temperature tempering, attributed to post heat treatment high temperature exposure. This is believed to have occurred during service as a result of a dragging brake. The microstructures are described in Table 3. Figures 5 through 7 show the microstructures of the right THU bearing components. The martensitic microstructures indicate that the components had been hardened as required.

Table 3

Microstructures and Heat Treatments of the Left and Right THU Bearing Components

THU	Component	Microstructure	Specification	Heat Treatment
Left[a]	Outer Ring Raceway	AFT3	AFT2 - AFTT4	Induction Hardened
	Outer Ring Core	Pearlite & Ferrite	Pearlite & Ferrite	As Forged
	Inboard Inner Ring	MT2; TG1; TN1	≤MT4; ≤TG3; ≤TN3	Through Hardened
	Roller case	SH2	≤SH4	Carburized [illegible]
	Roller core	CS5	CS4 to CS6	Carburized [illegible]
Right[b]	Outer Ring Raceway	AFT3 (GB style)	AFT2 - AFTT4	Induction Hardened
	Outer Ring Core	Pearlite & Ferrite	Pearlite & Ferrite	As Forged
	Inboard Inner Ring	MT2; TG1; TN1	≤MT4; ≤TG3; ≤TN3	Through Hardened
	Outboard Inner Ring	MT2; TG1; TN1	≤MT4; ≤TG3; ≤TN3	Through Hardened

a = GB inserting was not examined. The left THU was submerged and the GB inserting microstructure was obtained primarily for comparison.
b = Damage from overheating was observed on all components. The microstructures were derived from the best samples obtained.

Roller Case Depths

The THU roller case depth was found to be within specification. The value, obtained from an outboard roller, was determined to be 0.043" (1. [illegible]). The minimum case depth requirement is 0.039". Case depths are the depth to 50 HRC hardness.

SKF [illegible]

Chemical Composition

The chemical composition of the THU bearing components were within specifications. Table 4 gives the chemical composition of the left and right THU bearing components. The composition of the rollers were not obtained. However, based on the microstructures, the left THU rollers appeared to be carburized SAE8620 steel.

Table 4

Chemical Composition (wt%) of the Left and Right THU Bearing Components [a]

THU	Component	Grade	C	Mn	P	S	Si	Cr	Mo	Ni	Al	Ti
Left	Outer Ring	55	0.60	0.78	0.013	0.017	0.18	0.10	0.01	0.06	0.032	0.001 [b]
	IB Inner Ring	3	0.99	0.32	0.018	0.012	0.29	1.34	0.04	0.16	0.04	0.001 [b]
Right	Outer Ring	55	0.60	0.78	0.015	0.024	0.21	0.08	0.02	0.06	0.032	0.001 [b]
	IB Inner Ring	3	0.93 [c]	0.43	0.013	0.007 [c]	0.21	1.46	0.05	0.21	0.01	0.001 [b]
	OB Inner Ring	3	0.96	0.45	0.015	0.007 [c]	0.25	1.48	0.05	0.21	0.01	0.001 [b]
Specifications		55	0.55 to 0.60	0.60 to 0.90	0.030 max	0.018 to 0.034	0.10 to 0.30	0.20 max	0.10 max	0.20 max	0.01 to 0.05	0.003 max
		3	0.95 to 1.10	0.25 to 0.45	0.025 max	0.015 max	0.15 to 0.35	1.35 to 1.65	0.10 max	0.25 max	0.01 to 0.05	0.003 max

a = Elemental analysis performed by an independent A2LA accredited Laboratory (A2LA certification # [illegible])
b = Data obtained at NATC. The independent lab equipment accuracy for readings of these elements was limited to a minimum value of 0.001
c = Carbon content considered as low in the low end of the specification range.
d = Chemical analysis performed by NATC.

Fractured Inner Rings

As discussed above, the right side THU was severely damaged by high temperature, metal to metal contact and water damage. The rollers were missing and the (inner and outer) ring raceways contained dents (see figure 4), compacted metal, were dark blue in color and were rusted. The carburized inner ring contained cracks and was fractured circumferentially (see figure 4). The fractures and cracks are believed to have occurred as a result of the bearing operating without lubricant after the seals were burnt. No spalls were observed on the raceways. Typically, inner or outer rings that crack during service also spall as a result of the stresses imposed by the rolling elements. The fractures and cracks are likely to have occurred within the last few minutes of operation.

Root Cause of Failure

It is theorized that an initial condition of excessive heat caused the right THU bearing to lose its lubricant and fail. The source of heat, which appears to have affected the localized levels of the right THU bearing components, may have been a result of the brake pads dragging against the brake drum during operation. This is believed to have caused the seals on the ring to burn and the bearing lubricant to be lost. Thus, the unlubricated condition of the bearing caused an premature failure.

The right THU outer ring appears to have reached higher temperatures than the inner rings. This indicates that the source of the heat source was outside of the right THU, namely the brake components. Reportedly, the driver of the truck noticed that the right brake drum had overheated and stopped the vehicle to allow the brake drum to cool. During this stop, the brakes were adjusted to restore wheel rotation. Continued operation of the truck resulted in the right wheel to burst into flames.

The right brake drum and brake pads appear to have been worn disproportionately compared to the left brake drum and brake pads. All the brake pad surfaces (including surfaces on the top brake pad) of the right side brake exhibited heavy wear and discoloration compared to the brake pads on the left side brake. The wear seen on the bottom brake pad surface of the right side brake is likely to have occurred after the bearing was damaged. This is believed to have occurred as a result of the loss of support that the bearing is designed to provide. The wear seen on the top surface of the right side brake, however, is believed to have occurred as a result of the brake pads dragging prior to the bearing becoming damaged. A faulty brake mechanism could have caused the brake pad to be in contact with the brake drum continuously during operation of the truck causing the brake components to heat and the brake pads to wear. Figure 8 shows the right brake drum and pads. Figure 9 shows the left THU brake drum and pads for comparison.

SKF 02002

Conclusions

1. The microstructure and chemical compositions of the TRU bearing components from both the right and left sides of the tank axle were within SKF specifications. The components are believed to have been heat treated in accordance to SKF requirements.
2. The hardness values of the right TRU bearing components were reduced due to exposure to elevated temperatures. The source of heat is believed to be primarily from a faulty (dragging) brake. The hardness values of the left TRU bearing components were within specifications. These components were not affected by heat.
3. The root cause of failure could not be determined with a high degree of confidence due to the extent of damage to the bearing components. It is theorized that high temperature exposure to the right TRU caused the bearing seals to burn and the lubricant to leak out. This would have caused the bearing to operate unlubricated and fail prematurely.
4. The inner ring fractures, cracks and dents are likely to have occurred during the last few minutes of operation as the bearing was operating without lubricant and metal to metal contact between the ring and rollers occurred.

Figures

Figure 1a. Driver (left) side brake and TIEU assembly of a truck axle in its "as received" condition. The axle was burnt in a fire.

Figure 1b. Passenger (right) side brake assembly of the truck axle in fig. 1a. The right TIEU was severely damaged by metal to metal contact and heat. The brake pad crumbled to loose compound the brake drum

Figure 2. Close up view of the driver (left) side TIEU and brake assembly of a truck axle after a fire. The housing, which is made of aluminum, was in good condition.

Figure 3a Right side THU outer ring from a front truck front axle. The component was severely damaged by heat, metal to metal contact and rust.

Figure 3b Right side THU inner rings from the truck axle shown in figure 3a. The rings were severely damaged by heat, metal to metal contact and rust.

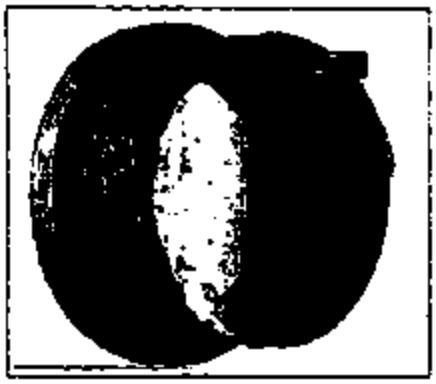

Figure 4a Inboard inner ring from the passenger side THU of a damaged truck axle. The ring was fractured circumferentially.

Figure 4b Inboard inner ring raceway. Debris appears to have been created by the retaining rollers. The blue color indicates exposure to high temperatures.

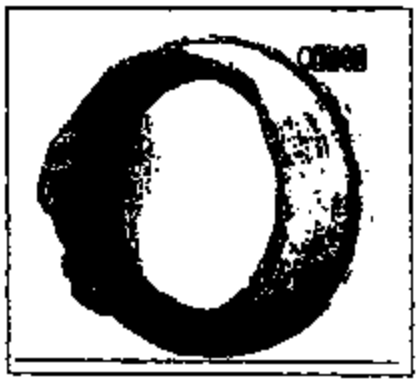

Figure 4c Outboard inner ring from the passenger side THU of a damaged truck axle.

Figure 4d Outboard inner ring from the passenger side of a damaged truck axle. The unbalanced appearance of the bearing is believed to have caused the ring to heat, crack and fracture.

Figure 5a Martensitic microstructure of the driver (left) side THU inboard IR. Mag 1,000x

Figure 5b Martensitic microstructure of the driver (left) side THU outboard hardened OR recovery. Mag. 1,000x

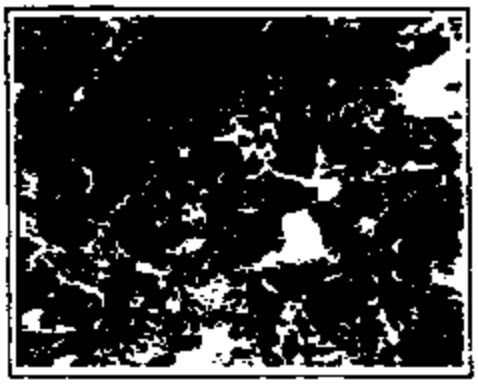

Figure 5c Fine pearlite and grain boundary ferrite microstructure of the driver (left) side THU OR base material. Mag 1,000x.

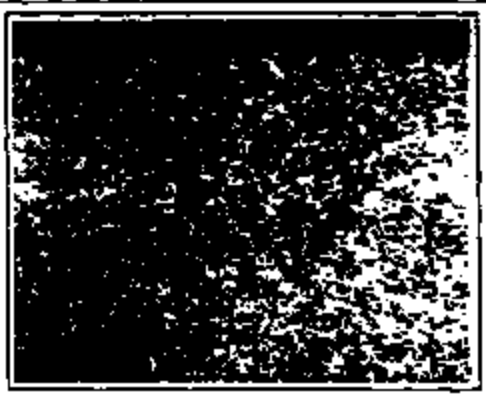

Figure 6a Martensitic microstructure of the passenger (right) side THU inboard IR. Mag. 1,000x. The carbides indicate that the ring was hardened as required.

Figure 6b Martensitic microstructure of the passenger (right) side THU inboard IR. Mag 1,000x. Heat damage is apparent.

Figure 6c Fine pearlite and grain boundary ferrite microstructure of the passenger (right) side THU OR (near the inboard raceway) base material. Mag. 1,000x. Heat damage is apparent.

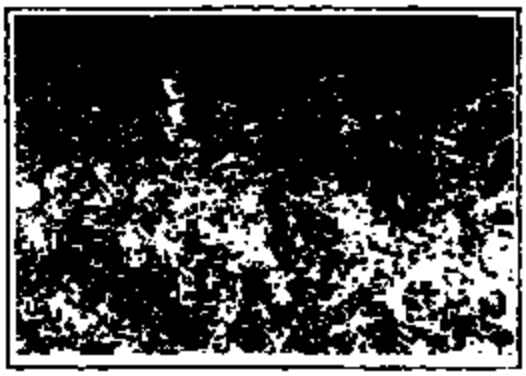

Figure 7a Martensitic microstructure of the passenger (right) side THU outboard IR. Mag. 1,000x. The carbides indicate that the rim was hardened as received.

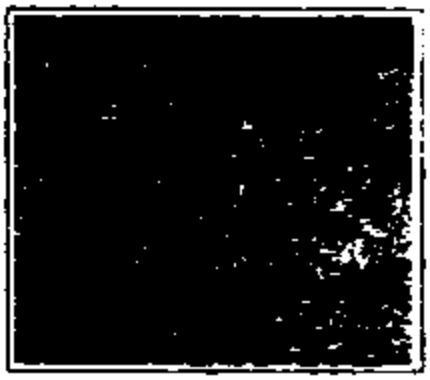

Figure 7b Martensitic microstructure of the passenger (right) side THU outboard IR. Mag. 1,000x.

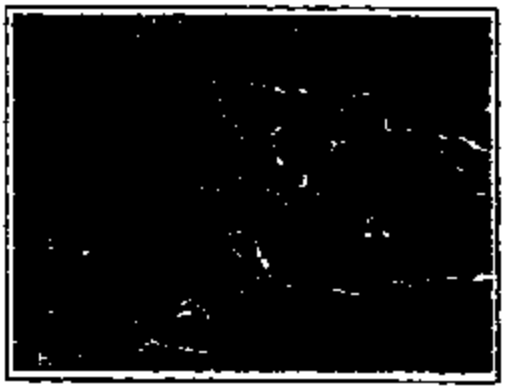

Figure 7c Fine pearlite and grain boundary ferrite microstructure of the passenger (right) side THU OR (near the outboard raceway) base material. Mag. 1,000x.

Figure 8a. Close up view of the bottom brake pads of the right side truck axle THH. The pads were significantly worn.

Figure 8b. Brake drum of the truck axle THH in figure 8a. significant wear of the braking surface (ID) was observed.

Figure 8c. Close up view of the top brake pads of the right side truck axle THH. The pads were worn and disengaged.

Figure 8d. Close up view of the top brake pads of the right side truck axle THH. The pads were worn and disengaged.

Figure 9a Close up view of the bottom brake pads of the left side truck axle THU. The pads appeared relatively new.

Figure 9b Close up view of the top brake pads of the left side truck axle THU. The pads appeared relatively new.

Figure 9c Close up view of the top brake pads of the left side truck axle THU. The pads appeared relatively new.

SKF 00003

SKF

SKF North American Technical Center
Hanover, MD USA

CHEMISTRY LABORATORY FINAL REPORT

Report No.:	AT99C313	To:	N. Bangalore, B. Wasko
Project Code:	G-AD 711	From:	D. Pallister
Registration No.:		Copies:	J. Kaminez
Reference:	RLS 100216		Laboratory
Date Received:	11-10-99	Date:	11-18-99

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Title: THU failure investigation, evaluation of lubricant from operational THU from failed truck axel.

Background:

Application:	THU	No. of Samples:	2
Customer:	Dick Simon Trucking Co.	Service Life:	17000 miles
Product No.:		Service Load(s):	
Manufacturing Facility:	Aiken	Operating Temperature:	
Alloy/Material:		Speed:	
Lubricant:	Caliphin EP 2	Environment:	

Data Requested: Dirt Analysis, FTIR Analysis, Water Content

Identification:

Chem Lab #	Sample Identification
99C313A	Outboard Sample
99C313B	Inboard Sample

Results:

Chem Lab#	Dirt Content	Water Content	Microscopic Filtrate Evaluation
99C313A	0.23 %	1225 PPM	Debris filed consists of mostly red and black iron oxide particles.
99C313B	0.14 %	1537 PPM	Debris filed consists of mostly red and black iron oxide particles.

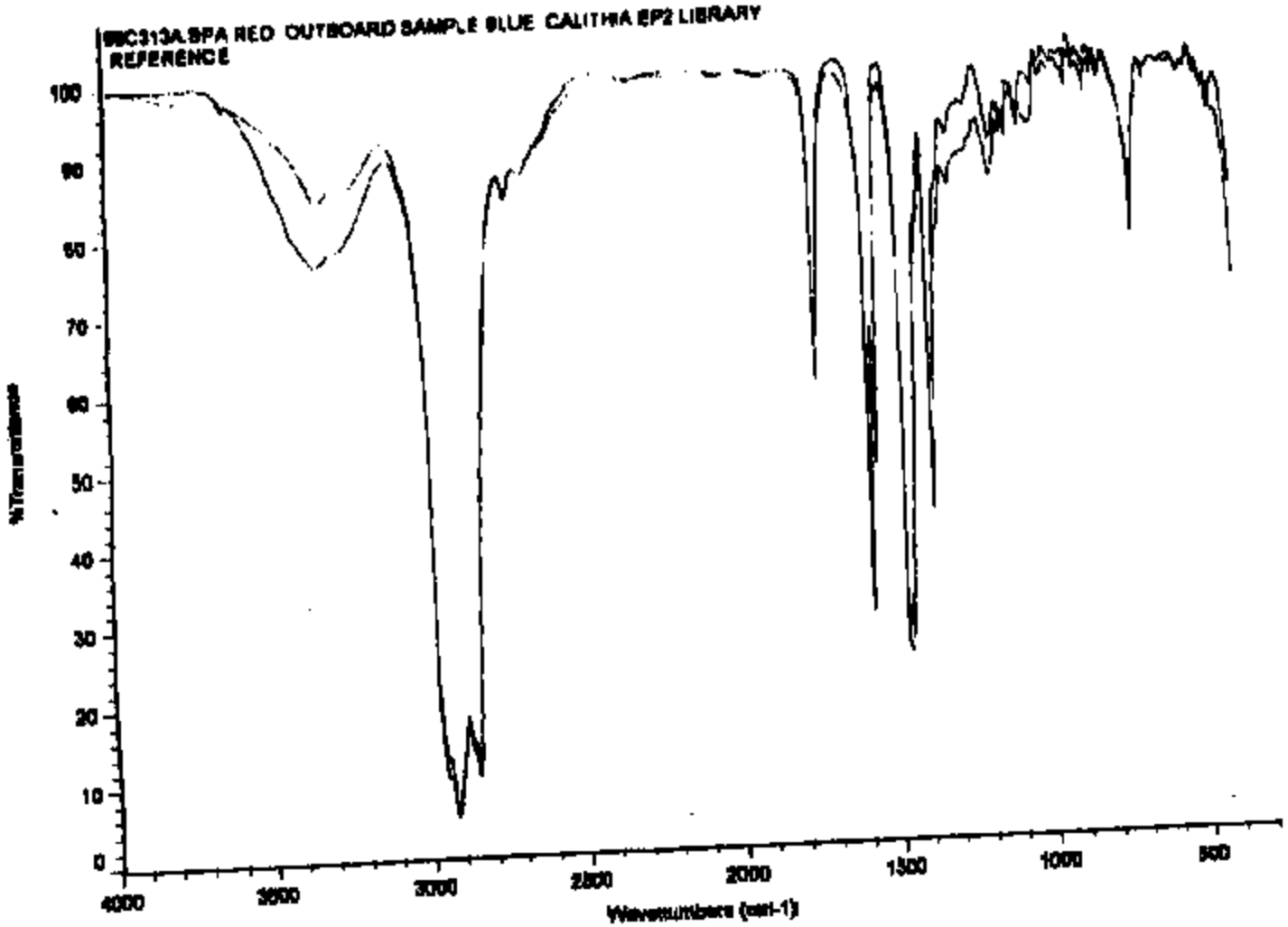
Chem Lab#	FTIR File	FTIR Spectrum Evaluation
99C313A	99C313A.SPA	FTIR spectrum appears normal
99C313B	99C313B.SPA	FTIR spectrum appears normal

Conclusion:

The dirt and water contamination content of the grease appears normal for the service life of the lubricant sample. Microscopic examination of the grease contamination did not produce any evidence for deleterious particles in the contamination filtrate.

Author

Reviewed and Understood by


99C313A.SPA REO OUTBOARD SAMPLE BLUE CALITHIA EP2 LIBRARY REFERENCE
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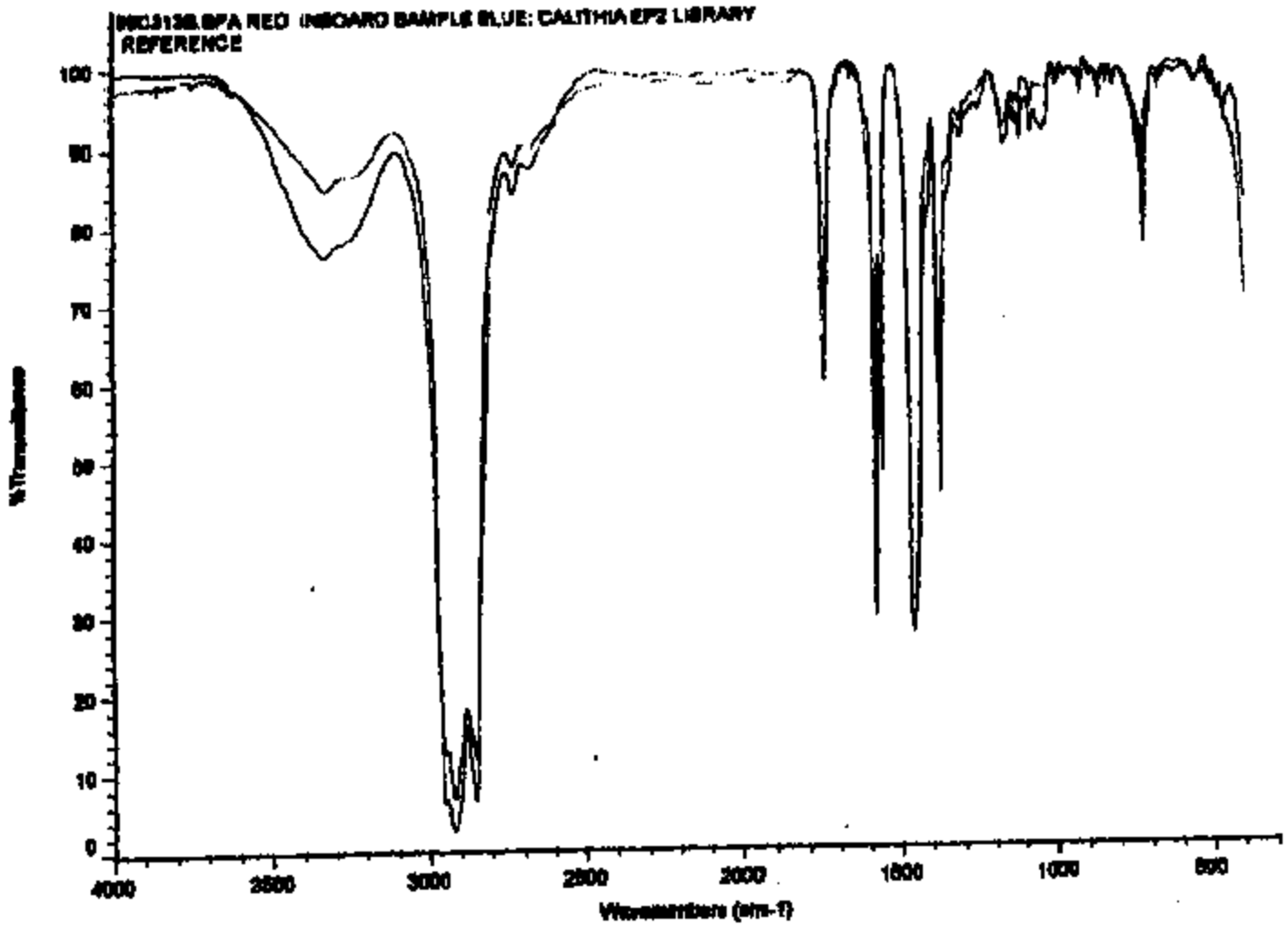
Wavenumbers (cm-1)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cc: S. Bernard
M. Lewis
B. Brown
D. Bogdan

FACSIMILE

To:	B. Wesler M. Lewis	From:	B. E. Erickson
Company:	SKF Plymouth, MI	Company:	Mentor Automotive Troy, MI
Fax:	734-414-6850	Fax:	
Talk:	[redacted]	Talk:	[redacted]
Pages:	2 (including cover)	Date:	August 30, 1999
Subject:	Hub Unit		

☐ Urgent ☐ For Review ☐ Please Comment ☐ Please Reply ☐ Please Recycle

---

Begin message here

Bob Bondy requested that I forward the attached to your attention. The Freightliner tractor was destroyed by the fire. Please call as we can discuss.

Regards,

Bruce

The information contained in this facsimile message is confidential, may be privileged, and is intended for the use of the individual or entity named above. If you, the reader of this message, are not the intended recipient, the agent, or employee responsible for delivering this transmission the intended recipient, you are expressly prohibited from copying, disseminating, distributing, or in any other way using any of the information contained in this facsimile.

AUG 30 '99 09:39 FR MENTOR ENG TECH CTR 248 435 8682 TO 917344146850-239 P.01/02

[illegible] 02:27 PM
George [illegible]

To: [illegible]
cc: John E [illegible]
Subject: [illegible] Hub / FF[illegible]

Tom

Enclosed you will find pictures of one [illegible] Freightliner belonging to Dick Simon Trucking of S.L.C. Utah.
[illegible]
17,[illegible] miles
Copies of all service records are also enclosed.
The truck burned to the ground and was towed to Laramie, WY. on [illegible] and from Laramie to S.L.C. on
[illegible].
The driver pulled over to the side of the road with a brake drag on the right front axle, he sat on the side of the
road until the drum cooled. He then backed of the brakes and continued on down the road until the right front
the front tire flames at which time he pulled over and was unable put out the fire. The damage to clearly shown
is the attached pictures.
The hub was still on the spindle when arriving in Dick Simon's yard. I arrived 10 minutes after the hub was removed
with two light rays with a chisel. Only the inner race of each bearing remained on the spindle, held by both lock nuts
and washers. One bearing roller was inside the Drum and five rollers lay on the lower Brake Shoe, all other Rollers
were missing. The lower right Brake Shoe and Drum are severely worn as the weight of the vehicle was supported at
that point and it appears a Brake fire may have started as a result.

Contact at Dick Simon Trucking: Hans Vandenhaas Director of Maintenance [illegible]
[illegible] west [illegible] South
West Valley City, Utah [illegible] (Salt Lake City)

I was contacted to inspect the vehicle, as was Freightliner, no comments were made and no contact with the fleet after
inspection. The front axle can be removed and shipped to They if needed. Please contact me on Phone Mail at 1315
or call Phone [illegible] if further action is needed.

George Walrath

SKF 0000136

Automotive Division

SKF

July 13, 2000

Plymouth, MI
USA

Kevin Balling
Director, Worldwide Procurement
Arvinmeritor Inc
2135 West Maple Road,
Troy, MI, 48084-7186

Dear Mr. Balling:

As a follow-up to your letter of June 16, 2000 and our meeting of July 5, 2000 regarding the Dick Simon fire, we agreed that another meeting is required to address the entire issue of compensating fleets. You discussed setting up a meeting with Brad Arnold.

Here's what I believe must be addressed:

- We cannot continue to pay for the end user's decision to "operate to drive" after experiencing brake drag. This is a dangerous precedent that camouflages the fleet and driver responsibilities to safely and responsibly operate a vehicle. How do we stop this now?
- The FF981 axle provides a much safer failure mode than a conventional wheel end. Driving under these conditions on a conventional configuration will result in a wheel off while the FF981 configuration prohibits a wheel off. If the driver continues to drive FF-981 axles on a deteriorating hub, there may be a fire. How do we communicate this to the market?
- It puts SKF in a difficult position when unilateral decisions are made to pay fleets and the resulting expectation is that SKF support the cost. How can we jointly come to an agreement within a reasonable time in situations of this type?

We cannot accept total responsibility for the events that led to the Dick Simon fire. In the hub analysis, it is clear that the raceway was not hardened which resulted in an early mortality. However, per G. Weinelt's report (14 August 2000) " the driver pulled over to the side of the road, let the drum cool, adjusted the brake, and then continued down the road until the right front tire burst into flames" which clearly illustrates driver negligence. Had the driver exercised the practice with a conventional wheel end, there would have been a wheel off situation. With the spindle-hub-lockout configuration the wheel stayed on the truck, which is a much safer mode. The driver should have stopped the vehicle at the first sign of trouble. For him to continue to drive demonstrates a clear lack of customer understanding of the product.

If the market dictates that we compensate customers for collateral damages, regardless of responsibility, we need to look at different ways to support the cost of reimbursement. In the past we have always worked together to do what is best for both of us. I'm confident that we can find a mutually viable solution.

Sincerely,

Steven C. [redacted]
Director, North American Truck Business Unit

[redacted]

[redacted]
Telephone [redacted] Fax [redacted]
An SKF Company

Printed for: MICHAEL LEWIS
09/21/2001, 11:43:13 AM, 1

Michael D Lewis
09/17/2001 02:39 PM

To: William J Farrell/ELG/SKF@SKF
cc:
Subject: INFO; Steer THU Warranty Semi-Quarterly Report

FYI, Warranty data as promised. Bruce is trying to put together some projections for next year.

Mike

---------- Forwarded by Michael D Lewis/DET/SKF on 09/17/2001 02:28 PM ----------

Bruce Weeks 08/28/2001 03:16 PM

To: Michael D Lewis/DET/SKF@SKF, Steven F Brown/DET/SKF@SKF, Robert J Bondy/DET/SKF@SKF
cc: Mario G Winkler/AKN/SKF@SKF, Kevin Cannon/AKN/SKF@SKF, Christopher Jones/AMER/SKF@SKF
Subject: INFO; Steer THU Warranty Semi-Quarterly Report

Gentlemen,

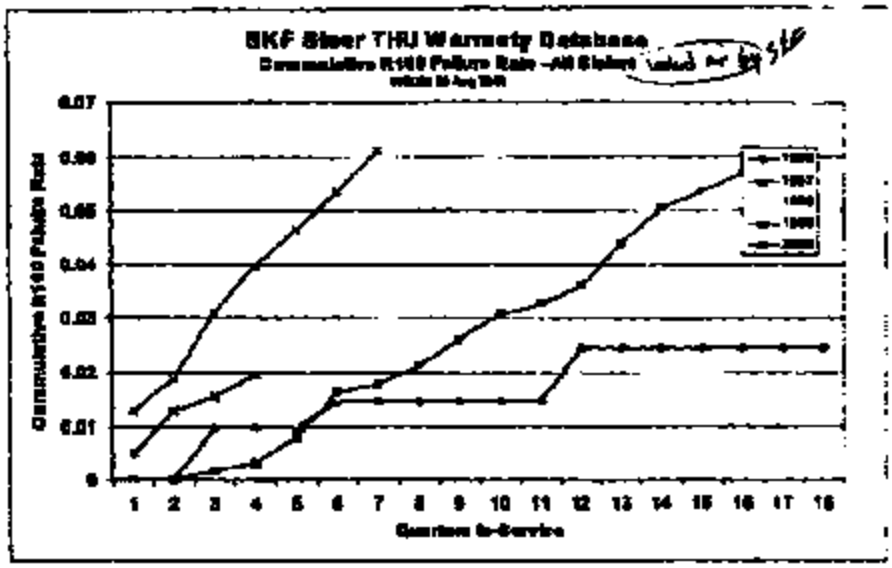
Since we had gotten so many claims (92) in the last 4-6 weeks, I thought I would publish a brief semi-quarterly
report to see where we are. These 92 claims represent approximately 25-30% of the total ArvinMeritor
has received. Latest estimate of total claims is about 1400-1500 out of about 370,000 produced.

For all claims included, the same trends are as in the last quarterly report, mainly that 1998 claims are
going up after 8 quarters service, mostly due to inboard seal ingres leaks. 1997 claims trend up smoothly and 1999 claims are high because of the unhardened raceway situation at Arlen. 2000

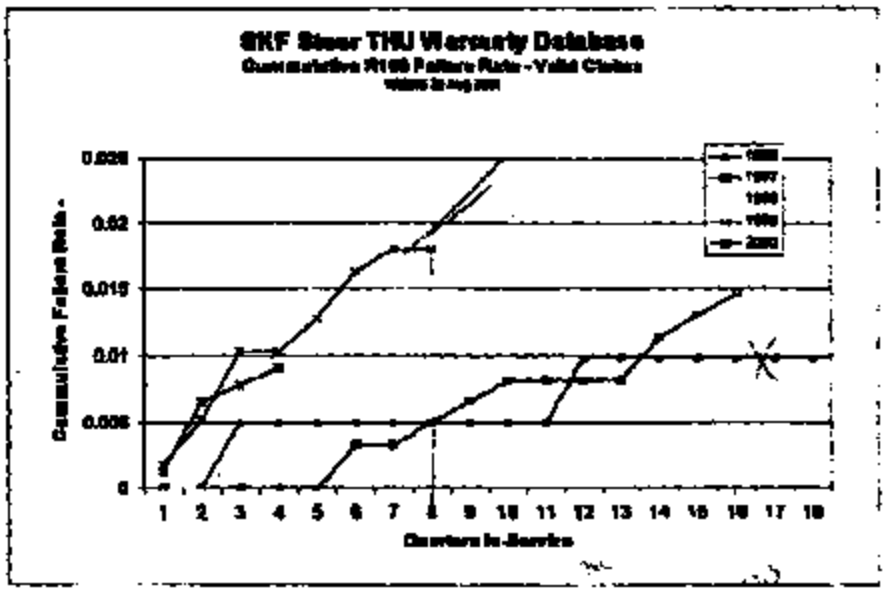
claims start high also because of the unhardened raceways. We was an addition of four claims for unhardened raceways in the last 6 weeks.

WEEKS 27 Aug 2001

Root Cause
Wheel Nut Washer on Brake Drum
IB Seal Ingress Leak
No Problem Found - Brake Drag
Low Clamp Load
Low Clamp Load
Low Clamp Load
Tampering - Regreased
Wheel Nut Washer on Brake Drum
Low Clamp Load
IB Seal Ingress Leak
IB Seal Ingress Leak
Inconclusive
Inconclusive
Low Clamp Load
IB Seal Ingress Leak
Lost Hubcap
Hubcap Lost or Damaged
Water Ingress Along Spindle
Water Ingress Along Spindle or Hubcap
Removal Damage



If we look at only valid claims, the trend lines are closer together due to the validity ratio, 25% for these last 6 weeks. 1999 & 2000 remain high for unhardened raceways and 1998 spikes after 8 quarter service.



A Pareto of claims follows:

92 Total Claims
- 23 Valid Claims
  - 13 IB Seal Leak - Ingress
  - 4 Unhardened Raceways
  - 2 OB Seal Leak - Egress

Arvinmeritor Trailer THU Failures Summary

Fleet	Location	Mileage	Fail Date	Trailer Mfr Date	Hub Mfr Date
Allied	Massachusetts	NA ~10,000	~ Aug 99		17-Apr-99
Allied	Quebec	~240,000	~ Sep 99		24-Oct-97
Allied	Florida	NA <250	~ Sep 99		14-Apr-99
Cassens	Detroit	4,035	Oct-99		7-Aug-99
Smith Transport	NY		~ Mar 00		
Allied	Brampton	306,885	Aug-00		22-Jan-00
Andres Crouse	David City NE		~ Oct 00	24-Aug-99	29-Jun-99
Jack Cooper	NA		~ Jan 01		7-Aug-99
Dickson	NA		~ Jan 01		1-Jun-00
RGA 6075	NA		~ Jan 01		
X443586	NA		~ Jan 01		
Allied	Quebec	213,021	~ Feb 01	18-May-99	
Allied	Quebec	431,573	~ Feb 01	30-Apr-99	
Allied	Quebec		~ Feb 01		
Allied	Quebec				
V.E.Lee	NA				
Allied	Marysville	220,444	~ Jun 01		
Allied	Winnepeg		~ Jul 01		
Express Welding	Escanaba		~ Jul 01		
Utility Mfg	OEM		~ Jul 01	26-Jun-01	5-Dec-00

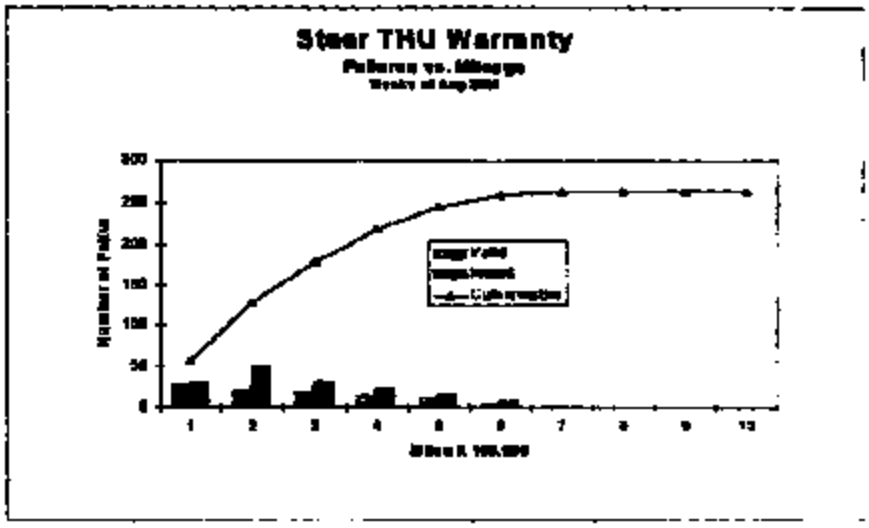
1 IB Seal Leak - Egress
1 Inner Ring Spall - Undetermined Origin
1 Missing Component - IB seal not installed at Factory
1 Oil Separation

57 Invalid Claims
27 No Problem Found
11 Insignificant Leak
6 Impact Damage
6 Removal Damage
3 Water Intrusion Along Spindle
2 Low Clamp Load
1 Hubcap Lost
1 Tampering - Regreased

4 Open Claims

8 Inconclusive Claims - Cannot determine origin of failure

Looking at mileage to failure, we see that the number of valid claims steadily goes down with mileage. Partially due to fewer trucks with higher mileages out there and lower failure rate after infant mortality.



Looking at months-in-service, there is a spike at 30 months (10 quarters) mostly due to inboard seal ingress leaks. The number of invalid claims also rises at 24 months, possibly due to brake service or king pin repair.

Arvinmeritor Trailer THU Failures Summary

Fleet	Location	Mileage	Fail Date	Trailer Mfr Date	Hub Mfr Date
Allied	Massachusetts	NA ~10,000	~ Aug 99		17-Apr-98
Allied	Quebec	~240,000	~ Sep 99		24-Oct-97
Allied	Florida	NA <250	~ Sep 99		14-Apr-99
Cassens	Detroit	4,035	Oct-99		7-Aug-98
Smith Transport	NY		~ Mar 00		
Allied	Brampton	305,895	Aug-00		22-Jan-00
Andrea Crouse	David City NE		~ Oct 00	24-Aug-98	29-Jun-98
Jack Cooper	NA		~ Jan 01		7-Aug-98
Dickson	NA		~ Jan 01		1-Jun-00
RGA 5076	NA		~ Jan 01		
X449569	NA		~ Jan 01		
Allied	Quebec	213,021	~ Feb 01	18-May-98	
Allied	Quebec	431,875	~ Feb 01	30-Apr-99	
Allied	Quebec		~ Feb 01		
Allied	Quebec				
V.E.Lee	NA				
Allied	Marysville	220,444	~ Jun 01		
Allied	Winnipeg		~ Jul 01		
Express Welding	Escanaba		~ Jul 01		
Utility Mfg	OEM		~ Jul 01	20-Jun-01	5-Dec-00

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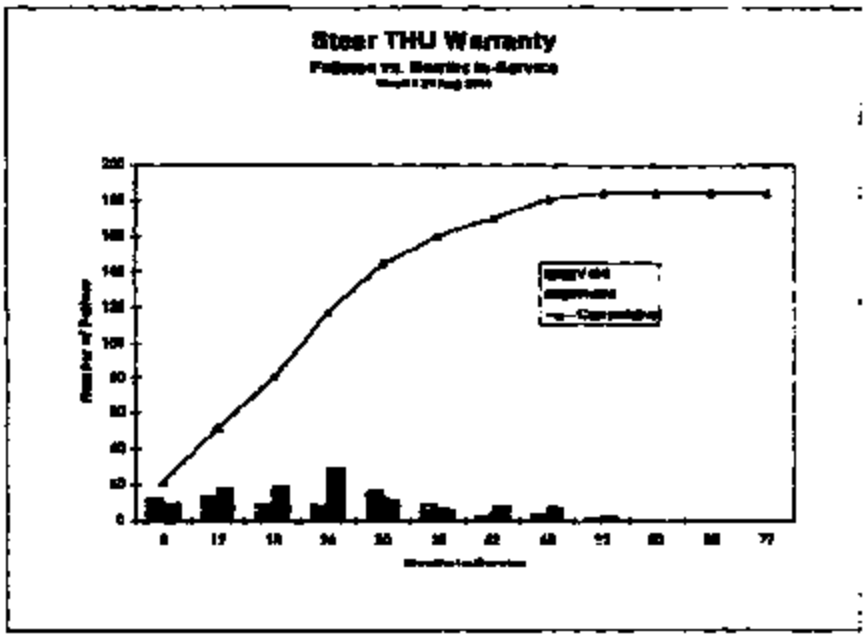
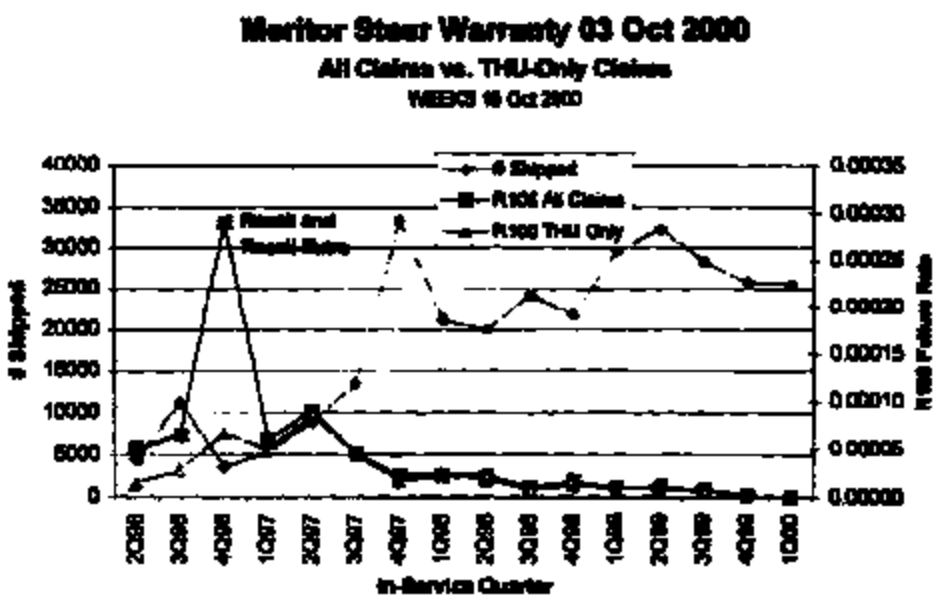


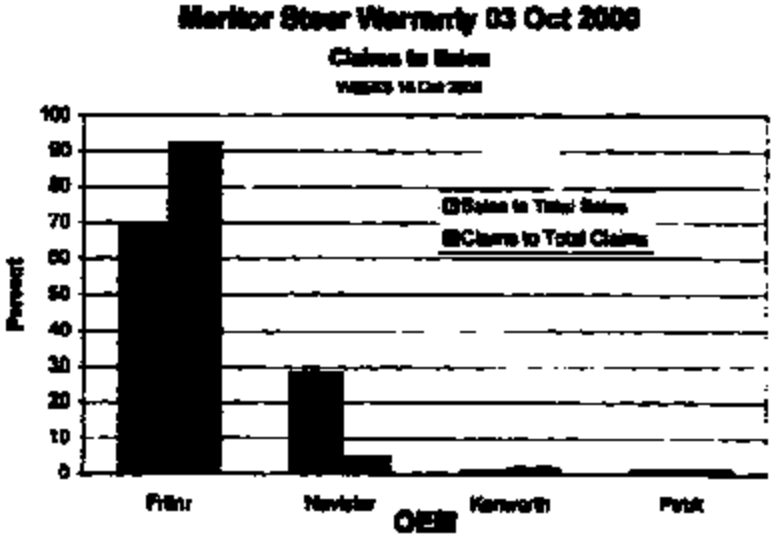
WEEKS 27 Aug 2001

Root Cause
Wheel Nut Washer on Brake Drum
IB Seal Ingress Leak
No Problem Found - Brake Drag
Low Clamp Load
Low Clamp Load
Low Clamp Load
Tampering - Regreased
Wheel Nut Washer on Brake Drum
Low Clamp Load
IB Seal Ingress Leak
IB Seal Ingress Leak
Inconclusive
Inconclusive
Low Clamp Load
IB Seal Ingress Leak
Lost Hubcap
Hubcap Lost or Damaged
Water Ingress Along Spindle
Water Ingress Along Spindle or Hubcap
Removal Damage

out of the total 734 in the database. The R100 rates for all claims and THU only related claims after the recall campaign closely match.



Having the largest volume of sales, Freightliner has the largest number of warranty items as well, with Un-named OEMs a relatively close second. Interestingly, Freightliner has more claims in proportion to its sales volume than third place Navistar. No theory is postulated here to explain this seeming incongruity.

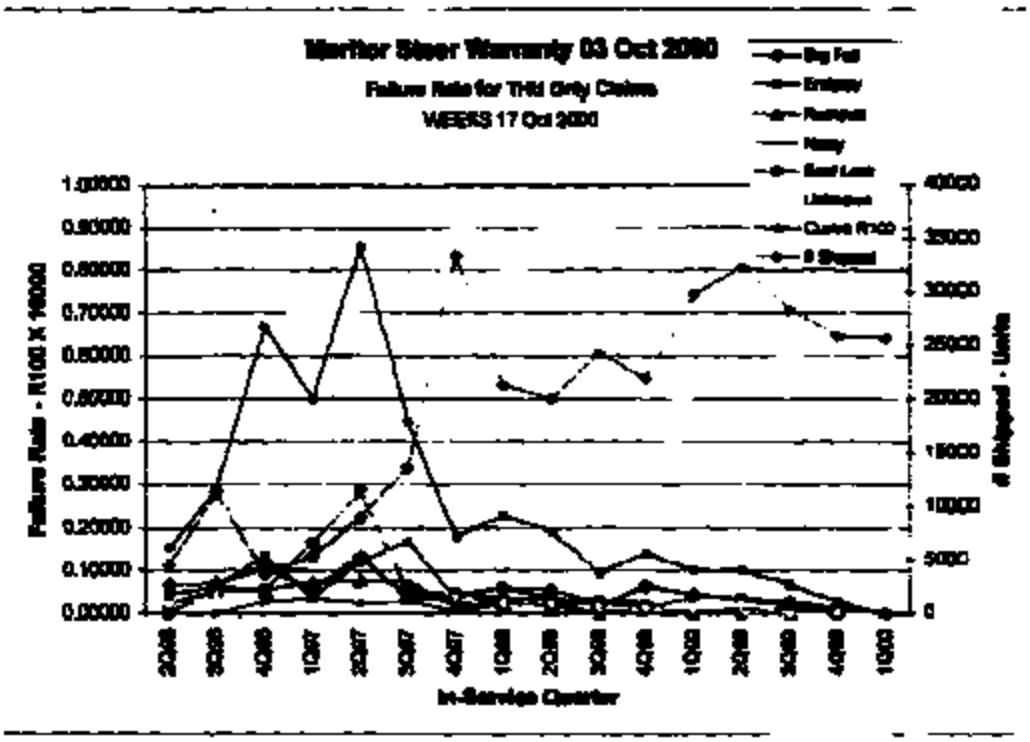


Rank order of failure type is then,

1. Seal Leakage
2. Bearing Failure/Burn-up
3. Unknown causes
4. Endplay
5. Removal/Disassembly issues
6. Noisy

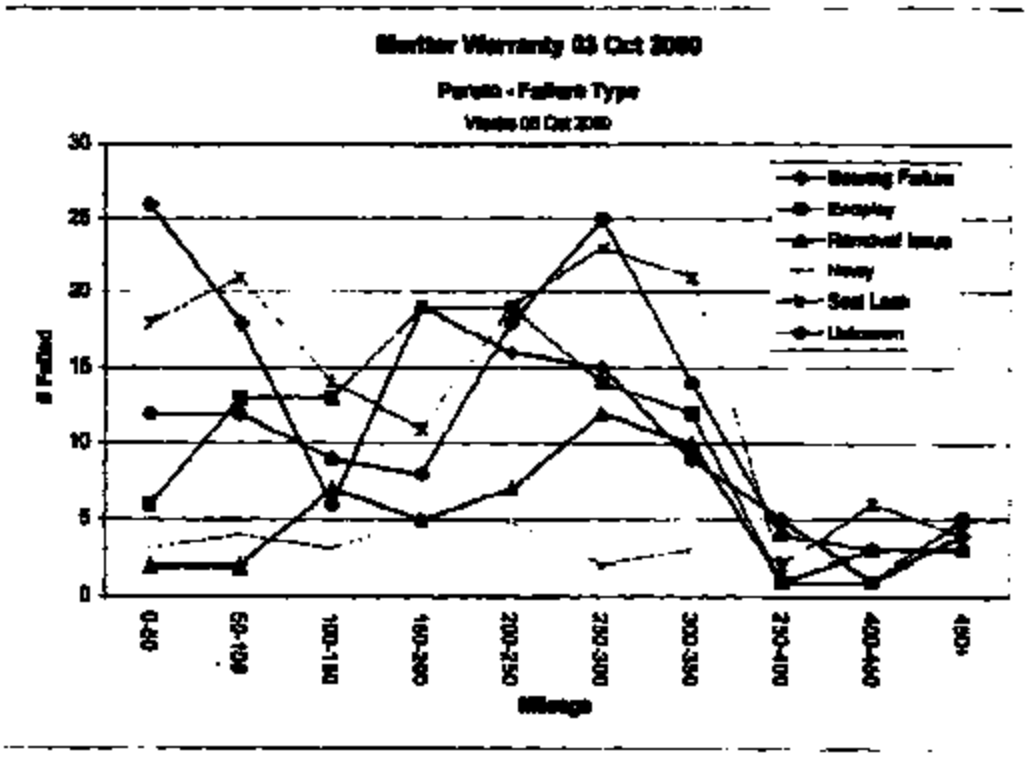
Because the unknown type of claim is large in comparison to the other categories, a complete analysis of the data is somewhat hampered. Removal/disassembly issues cloud the data as well since responsibility cannot be accurately assigned. Questions such as "Did the THU become frozen to the spindle due to fretting, etc? Or was it handled roughly causing the clip ring to disengage?" make assignment of these claims to SKF, ArvinMeritor or the end user impossible. SKF continues to work with ArvinMeritor to limit future claims of this type with recommendations of anti-fretting pastes and the possibility of adding a seal to exclude water entry into the spindle/bearing interface. The data points for removal issues were included here for informative purposes.

The six issues related to the THU were then plotted along with total shipped volume for comparative purposes.



The large peak in the cumulative failure rate between 4Q96 and 3Q97 is due in part to the recall and unrelated warranty claims from that issue, and a relatively low shipping volume during that period. Secondary causes are the seal leak claims and claims of unknown type. The failure rate drops off in the later in-service quarters, as this data is not yet mature.

Another way to look at this data is through mileage at failure. A graph is presented here.



An analysis of this graph was done by comparison to the SKF warranty database. Bearing failure claims peak at 0-50K miles mostly due to the ten unhardened raceways from Alton. A secondary peak occurs from 150-300K miles. These are primarily a result of low clamp load on the bearing. Endplay claims also peak from 150-300K miles, again mostly due to low clamp load. Seal leak claims are prevalent throughout the mileage ranges. Removal claims are often associated with other reasons for hub unit removal, such as king pin or camshaft bearing replacement. It is not necessary to remove the hub unit for other repairs unless the hub unit itself needs replacing for another reason, which it should have then been categorized under. Unknown claims peak at 250-300K miles, these cannot be accurately analyzed. Noisy claims are low throughout the range considered.

Field education here is required to avoid returns for outboard seal grease seepage that is considered within normal limits (<2.0 g) in the future. A Field Service Bulletin is under development in conjunction with ArvinMeritor to educate mechanics about permissible seal seepage levels.

If we are to consider that the hub unit must survive a loss of the hubcap, then the outboard seal must be upgraded to a more robust exterior grease seal design at increased cost. SKF will study the situation and make a recommendation in the first quarter of 2001.

Another possibility in retaining the hubcap may be to add an O-ring seal to the cap. The THU already has a correct chamfer to accept the O-ring. The additional sealing capacity may replace the red Loctite currently in use at very little incremental cost. Also the compressibility of the O-ring may serve to keep the cap from turning against the rotation of the hub unit.

Endplay: Of the other types of claims, endplay is the next highest number of claims and peaks in 3Q97. A number of these endplay claims for which SKF has reviewed parts revealed low clamp loads across the inner rings (4 of 21). One possible cause of the failure in many of these cases was that the THU was not rotated to seat the rollers during torque-up to the axle spindle. This creates excess clearance in the bearing, resulting in low clamp load across the inner rings and allowing the rollers to skew. Instead of rolling, the rollers are in a sliding motion. This prevents the formation of the normal oil film that separates the rollers and the raceway, resulting in metal-to-metal contact and high wear rates on the bearing components. This skewing of the rollers can induce enough torque to cause the inner rings to spin on the spindle if not properly clamped.

There also exists the possibility that the inner spindle nut may not be properly torqued before installation of the outer jam nut. Tests show that should this occur, the inner nut cannot be tightened by rotation of the outer nut as they are separated from the inner nut by a locking tabbed washer. This locking washer is restrained from rotation by engagement of the "D" flat on the spindle. As such, the rotational friction is not transferred from the outer jam nut to the inner spindle nut.

The maximum amount of endplay possible, if the rollers are as far from the guiding flange as possible, calculates to be 0.023" for the hub unit. This is far in excess of the 0.005" maximum allowable endplay for single row tapered roller bearings as shown on page 63 of ArvinMeritor Maintenance Manual MM-99120. This amount of endplay is more than sufficient to cause the conditions outlined above. Of course this amount of endplay will not exist on every THU that is not rotated during torque-up, but statistically, some large amount of endplay will exist on some units.

Some hub units are returned that do not have sufficient endplay to justify their return. Current standards are stated in Maintenance Manual No. 2A MM-99120 where on page 7 it says, "If the endplay is greater than 0.005-inch, recheck the torque on the inner wheel bearing nut...Repeat ... If the endplay reaches 0.009-inch... replace the truck hub unit." SKF has reviewed nine warranty claims of endplay and found seven to be well within the 0.009-inch standard. In five cases the hub units did not have any measurable endplay.

For BTF-0052 ends later designs, SKF has redesigned the clip ring increasing the thickness from 0.8 to 1.2 mm, and increased the height of the engagement "noses". This has increased the strength of the clip ring to resist pulling forces 1.6 times over the old design. Most of the removal disassemblies that SKF has reviewed (5 of 6) have occurred on older product manufactured before the change.

Bearing Failure/Burn-up: Bearing failure claims are often the most difficult to analyze as the THU is nearly completely destroyed. Unless something obvious is found such as an unhardened raceway, low clamp load, etc., the claim may be dispositioned to be inconclusive or unknown in nature. Since SKF has not had the opportunity to review the vast majority of the listed 539 THU related claims, we are not in a position to make an accurate determination of the root cause. For purposes of this report, the disposition of ArvinMeritor personnel is accepted as factual.

Bearing failure claims peak at 0-50,000 miles, most likely due to the unhardened raceway problems at Aiken (10 parts confirmed) and Luechow (2 parts). Bearing failure peaks again at 150-200,000 miles. Notice also that unknown claims peak at 200-300,000 miles. It is at about this mileage range that failures due to low clamp load begin to show up. From the SKF warranty database, claims that have been determined to be due to low clamp load range from 105,089 to 275,212 miles. Some endplay claims also should be included in low clamp load, some of those having been returned with only 0.004-0.005" endplay, less than the established value for replacement of 0.009". Signs of inner ring rotation have been noted on several endplay claims (4 of 21).

Bearing Failure/Burn-up Corrective Actions: Unhardened raceways have been addressed at Luechow and Aiken manufacturing facilities. The root causes for these claims are different between Luechow and Aiken. In Luechow, the root cause was lack of monitoring of power consumption in the induction-hardening equipment. Addition of monitoring devices cured the issue in that case. In Aiken, the monitors were in place and parts were becoming mixed due to handling issues. This affected parts made from Dec 1998 until April 2000.

The Aiken induction-hardening machine previously directed defective parts to a discharge chute. Should the manufacturing channel after the induction-hardening machine stop for any reason, overflow production also came out this discharge chute. Parts were then mixed and not always sorted properly. Aiken has addressed this situation with five corrective actions:

1. All personnel have been informed about the problem.
2. The induction-hardening machine has been programmed to stop when a defective part is detected by improper power flux measurements. This forces the operator to physically remove the defective part and place it in a designated area for dispositioning. Overflow continues to exit at the discharge chute.
3. All parts that meet standards are now marked at the induction-hardening machine's output.
4. Final inspection personnel are instructed to look for the induction-hardening machine's marking.
5. All manufacturing personnel have been trained in the new procedures.

Bearing failure/burn-up claims that have been determined to be the result of low clamp load are being addressed by Asheville through the addition of automatic torque-up equipment. This new equipment to be installed soon rotates the hub unit during torque-up approximately 5 times. Recent bearing run-down tests performed at NATC, Plymouth have determined that at least 3 rotations must occur during torque-up to insure seating of the rollers against the guiding flange.

Unknown Claims: Claims for unknown causes cannot be addressed adequately as the exact nature of the claim is not stated, nor are the parts available for analysis.

Unknown Claim Corrective Actions: Insure field agents are trained to send as much information as possible with a claim. Insure that all components from a field return are included.

Noisy Claims: Claims for Noisy bearings are low and usually associated with a spalled raceway from a small, undetectable material defect, or from impact damage such as a curb strike. These impacts locally brinnell the surface of the raceway at the loaded zone. Consequent rolling over these dents causes increased stress at the edge of the dent, and eventual flaking off of the surface, much as a pothole in the street grows. These impact damages are easily detected by the fact that the spalls are spaced exactly the same as the rollers. Material defect spalls are few in number (5) and most often are lone occurrences with single locations on the raceway.

Some Noisy claims are determined to be low clamp load also. As the bearing components wear, endplay increases and roller skewing causes lubricant breakdown. Wear particles eventually degrade the grease further resulting in noisy operation.

SKF has only reviewed three claims of noise, one was an inner ring spall, probably from a hidden material defect, two were found not to have any discernable problems, one of those having been disassembled before return to SKF. This last was probably a removal issue, as covered above.

Noisy Corrective Actions: Raceway spalls as a result of hidden material defects are infrequent and SKF has material specifications that are designed to reduce these to a minimum. Reduction ratios are a particular standard that helps eliminate these material defects, making them show up in the forging operation.

Impact damage is low in occurrence (2) and is a driver issue and is probably unavoidable.

Title: AxleMaster Steer THU Warranty Analysis page 11 of 14

Appendix: Summary of SKF Steer THU Warranty Claims Database for THU Related Claims in AxleMaster Warranty Database.

This list is sorted by nature of complaint and subsequent SKF determination of root cause of claim.

Seal Leakage

Total Claims	19
Valid	6
Oil Separation IB	1
Oil Separation OB	1
Purge IB	3
Purge OB	0
Water Intrusion IB	1
Water Intrusion OB	0
Invalid	13
Within normal limits	10
No Problems Found	2
Tampering	1

Bearing Failure/Burn-up

Total Claims	36
Valid	16/B
Seal Leak IB	4
Unhardened RW	9
Spalling	2
Seized	1
Unknown	2
Invalid	16
No Problem Found	4
Low Clamp Load	3
Tampering	3
Impact Damage	2
Hubcap Lost	1
Unknown/Inconclusive	2

Endplay

Total Claims	22
Valid	7
Endplay	2
Seal Leak IB	3
Unhardened RW	1
Spalling	1
Invalid	15
No Problem Found	10
Low Clamp Load	4
Inconclusive	1

Removal/Disassembly Issues

Total	4
Valid	1
Spall	1
Invalid	3
No Problem Found	2
Low Clamp Load	1

Noisy

Total	3
Valid	1
Spall	1
Invalid	2
No Problems Found	2

Title: ArvinMeritor Steer THU Warranty Analysis page 12 of 14

SKF Steer THU Warranty Database Breakdowns by Type – THU Related Claims Listed by SKF Determination of Root Cause

Please note that there are more claims here than above. This is because this list is sorted by SKF determination of root cause.

Total Claims	**114**
Total Valid Claims	**42**
Performance Issues	
Inboard Seal Leaks – Ingress or Egress	15
Outboard Seal Leaks – Ingress or Egress	1
Oil Separation	1
Conformance Issues	
Unhardened Raceways	10
Spalling	6
Endplay	2
Indeterminate	
Seized	2
Unknown	5
Total Invalid Claims	**72**
Conformance Issues	
Low clamp Load	11
Performance Issues	
Seal Leak within normal limits	12
Abuse Issues	
Tampering	5
Hubcap Lost	3
Assembly Damage	2
Impact Damage	2
Other Issues	
No Problem Found	18
Endplay – None Found	8
Removal Issues	6
Inconclusive	5

ArvinMeritor Steer THU Warranty Root Cause/Corrective Action Summary

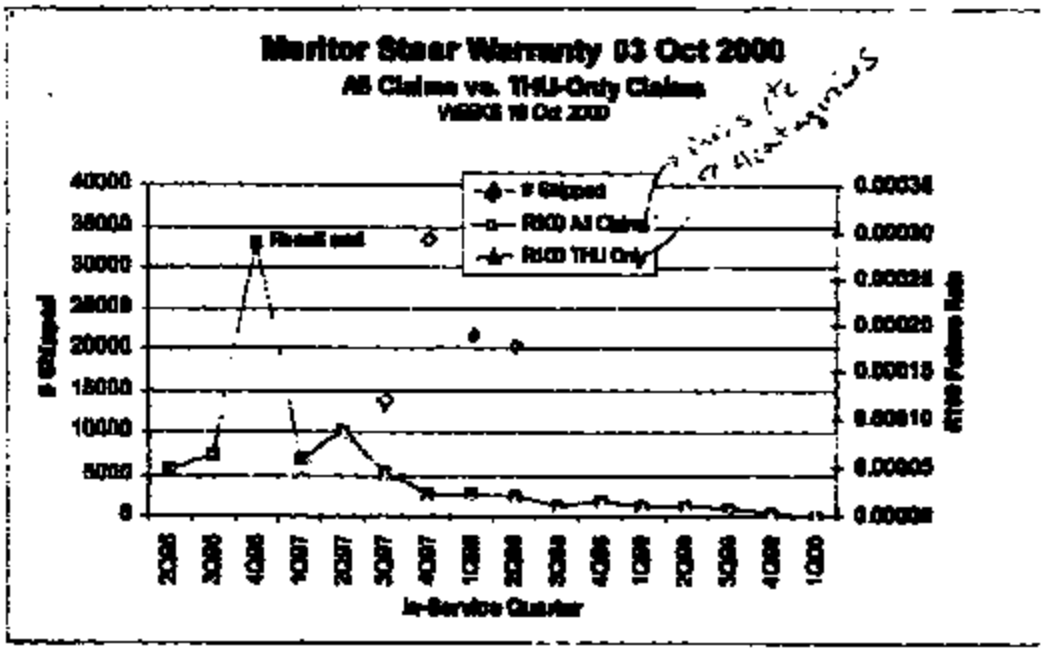
CATEGORY	SUB-CATEGORY	POSSIBLE ROOT CAUSE	POSSIBLE CORRECTIVE ACTION	TEST METHOD	PROJECTED COMPLETION TASK ASSIGNMENT	FIELD RETROFITABILITY
Seal Leaks	- IB Egress	- Oil Separation	- Use [redacted]	- Drop & Bleed Points	April 2000 - SKF COMPLETE	NO
		- Grease purge	- Use [redacted]	- NLGI Stiffness	April 2000 - SKF COMPLETE	NO
		- Seal design	- Use R-Seal	- 13 wk mud slurry	April 2000 - SKF COMPLETE	NO
		- Overpressure	- Use R-Seal	- Pressure test	April 2000 - SKF COMPLETE	NO
	- IB Ingress	- Seal Design	- Use R-Seal	- 13 wk mud slurry	April 2000 - SKF COMPLETE	NO
	- OB Egress	- Misdiagnosis	- Field Bulletin		Jan 2001 - SKF/AM	YES +
			- Training		Mar 2001 - AM	YES +
		- Oil Separation	- Use [redacted]	- Drop Pt/Bleed Pt	April 2000 - SKF COMPLETE	NO
		- Seal Design	- New Design	- High Temp Test	Mar 2001 - SKF	NO
		- Seal Anchorage	- Metal cage	- Pressure test	4Q00 - SKF COMPLETE	NO
	- OB Ingress	- Hub Cap Retention	- Hub Cap Design	- ?	Mar 2001 - SKF	YES
			- Add O-Ring seal	- Pressure test	Jan 2001 - SKF/AM	YES +
Bearing Failure	- Unhardened RW	- Equipment	- Fall Sales	- Final Inspection	April 2000 - SKF COMPLETE	
		- Operator	- Training/Marking	- Final Inspection	April 2000 - SKF COMPLETE	
	- Spun inner rings	- Improper Torque-up	- Automatic Equipment	- Endplay check	Dec 2000 - AM	NO
	- Seal Ingress	(As Above)	(As Above)	(As Above)	(As Above)	NO
	- Assembly Damage	- Handling	- Training		Dec 2000 - SKF/AM	
	- Impact Damage	- Driver Error	- Training		? (End User)	YES
		- Accident	- ?		?	
[illegible]ary	- Misdiagnosed	- Training	- Training		? (End User)	YES
			- Field Bulletin		Jan 2001 - SKF/AM	YES
	- Seal Ingress	(As Above)	(As Above)	(As Above)	(As Above)	
	- Unhardened RW	- Equipment	- Fall Sales	- Final Inspection	April 2000 - SKF COMPLETE	
		- Operator	- Training/Marking	- Final Inspection	April 2000 - SKF COMPLETE	
	- Inner Ring Spall	- Material	- Material Specs		SKF COMPLETE	
		- Design Inadequate	- Design Rules		SKF COMPLETE	
[illegible]oval Damage	- Frozen to Spindle	- Fretting Corrosion	- Anti-Fretting Compounds	ERC Report	Oct 2000 - COMPLETE	YES
		- Water intrusion [illegible] spindle	- Shoulder seal		Mar 2001 - SKF/AM	YES ?
[illegible]	- RW Spalling	- Material	- Material Specs		SKF COMPLETE	NO
		- Design Inadequate	- Design Rules		SKF COMPLETE	NO
	- Impact Damage	- Driver Error	- Training		? (End User)	YES
		- Accident	- ?		?	
	- Unhardened RW	- Equipment	- Fall Sales	- Final Inspection	April 2000 - SKF COMPLETE	
		- Operator	- Training/Marking	- Final Inspection	April 2000 - SKF COMPLETE	
[illegible]own	- Incomplete Data	- End User	- Training/Warranty rules		AM	
		- Field Service Reps	- Training/Warranty rules		AM	

ArvinMeritor Steer THU Warranty Root Cause/Corrective Action Summary – Non-THU Related Claims

CATEGORY	SUB-CATEGORY	POSSIBLE ROOT CAUSE	POSSIBLE CORRECTIVE ACTION	TEST METHOD	PROJECTED COMPLETION TASK ASSIGNMENT	FIELD RETROFITABILITY
Hubcap Issue	- Loss of hubcap	- Low initial torque	- 100% check			NO
		- Torque loss	- Higher initial torque	- Torque loss	Aug 2000 - AM	NO
			- O-ring gasket	- Torque loss	1Q01 - AM	YES
Hub Recall & Recall Extra	- Frozen to Spindle	- Fretting Corrosion	- Anti-Fretting Compounds	- ERC Report	Oct 2000 - COMPLETE	YES
		- Water intrusion along spindle	- Shoulder seal		Mar 2001 - SKF/AM	YES?
Runout	- Lateral	- Machining Error	- 100% Check	- 100% Check	SKF COMPLETE	NO
	- Radial	- Machining Error	- 100% Check	- 100% Check	SKF COMPLETE	NO
Tone Ring Issue	- Loose	- Machining Error	- 100% check	- 100% Check	SKF COMPLETE	NO
	- Poor Signal	- Molding Error	- 100% Signal Check	- 100% Signal Chk	?	
		- Handling Damage	- Protector	- 100% Signal Chk	July 2001 - SKF/AM	NO
Wheel Stud Issue	- Loose	- Oversize Hole	- 100% check	- 100% Check	SKF COMPLETE	
		- Handling Damage	- Training	- Visual Inspection	Jan 2001 - SKF/AM	NO
	- Missing	- Machine Error	- 100% Visual Inspection	- Visual Inspection	SKF COMPLETE	NO
		- Handling Damage	- Training	- Visual Inspection	Jan 2001 - SKF/ AM	NO
	- Damaged Threads	- Handling Damage	- Training	- Visual Inspection	Jan 2001 - SKF/AM	NO
e Issue	?					

SKF 003050

out of the total 734 in the database. The R100 rates for all claims and THU only claims after the recall campaign closely match.



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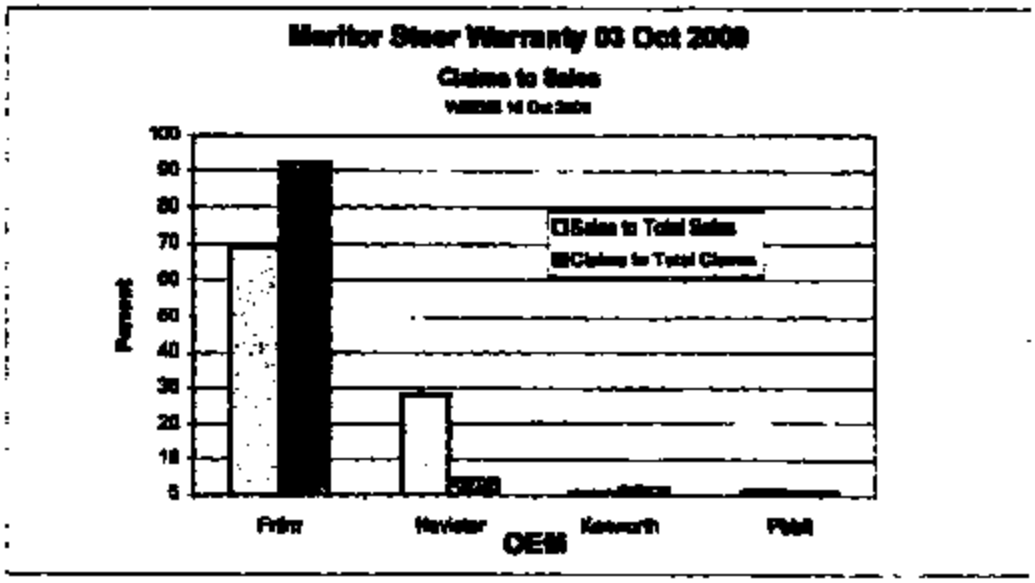

Title: ArvinMeritor Steer THU Warranty Analysis page 3 of 10
ArvinMeritor Steer THU Warranty Analysis page 3 of 7
Rank order of failure type is then,

1. Seal Leakage
2. Bearing Failure/Burn-up
3. Unknown causes
4. Endplay
5. Removal/Disassembly issues
6. Noisy

Because the unknown type of claim is large in comparison to the other categories, a complete analysis of the data is somewhat hampered. Removal/disassembly issues cloud the data as well since responsibility cannot be accurately assigned. Questions such as "Did the THU become frozen to the spindle due to fretting, etc? Or was it handled roughly causing the clip ring to disengage?" make assignment of these claims to SKF, ArvinMeritor or the end user impossible. SKF continues to work with ArvinMeritor to limit future claims of this type with recommendations of anti-fretting pastes and the possibility of adding a seal to exclude water entry into the spindle/bearing interface. The data points for removal issues were included here for informative purposes.

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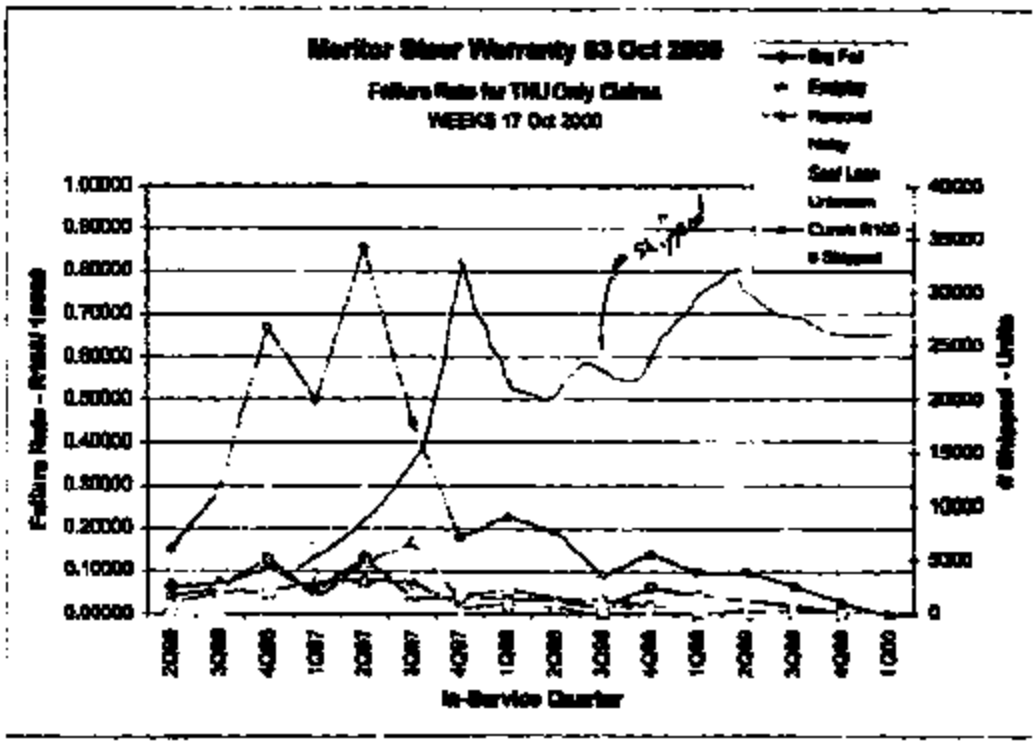

Eventually the lubricant breaks down at the guiding face and end wear on the rollers becomes significant, even to the point of grinding away the end of the roller and leaving a peg end where the guiding flange does not touch the roller. This causes gross endplay and can lead to ejection of the rollers from the bearing. The claim then may be classified as a bearing failure. By this time enough evidence on the surface of the inner rings is destroyed leaving only the bore and inner ring side face evidence as discussed above. If the spindle is available, often the inner rings will have worn the shaft in the area of contact as well.

SKF continues to work with ArvinMeritor to insure rotation of the THU during torque-up. Asheville will soon be installing automatic equipment to accomplish this.

Removal/disassembly issues have two main mechanisms at work. First, close metal joints such as the slip fit of bearing to journal, cause fretting of metal particles due to microscopic movement between the two surfaces during operation. These small particles easily corrode in the presence of oxygen. It has also been observed that water is entering the joint between the inboard inner ring large side face and the bearing back-up on the steering knuckle. Due to the relative movement of the components, the water is pumped through the journal/bore interface. Water as been found in the grease at the center of the bearing as an indication of this pumping action. The presence of this water also causes corrosion in the bore/spindle interface. The corrosion product swells to fill the clearance between the components. When a mechanic attempts to remove the THU from the spindle, it is found to be "seized" or "frozen" to the shaft. Hammers or pullers are employed to remove the recalcitrant THU but the clip ring is the first to go leaving the inboard inner ring assembly and seal on the shaft.

Occasionally, mechanics disassemble the THU, either accidentally by rough handling during the removal, or to see if it can be repaired locally. The THU is a precision device that requires care in handling and all mechanics should be cautioned to treat the THU carefully. Disassembly will void the SKF warranty.

Removal issues are currently under study in conjunction with ArvinMeritor. A new anti-fretting paste is being used at the Asheville plant that was recommended by ERC, MolyKote D. This paste is superior in preventing fretting corrosion. Additionally, we are studying whether the addition of a seal arrangement at the bearing mounting shoulder would be of advantage in preventing water intrusion.

Bearing failure claims are often the most difficult to analyze as the THU is nearly completely destroyed. Unless something obvious is found such as an unhardened raceway, lack of clamp load, etc., the claim is usually dispositioned to be inconclusive or unknown in nature. Since SKF has not had the opportunity to review the vast majority of the listed 539 claims, we are in no position to make an accurate determination of the validity. For purposes of this report, the disposition of ArvinMeritor personnel is accepted as factual.

If caught early enough, sometimes coming to us as an endplay claim, some of the evidence could be:

1. Circular smears on the end faces of the inner rings obliterating the manufacturing grind marks.
2. Roller ends that are polished on the outermost diameter only, or with epicycloidal scratches from the wear debris in the bearing.
3. If severe enough, the roller ends will be completely worn away leaving peg ends where the guiding flange does not touch the roller center.
4. Possibly there will be some chipping of the outermost edge of the guiding flange.
5. Loaded zones in the inner rings that extend 360 degrees.
6. If the spindle is available, there may be wear on the shaft or bearing back-up.
7. Grooves worn in the clip ring where the small side faces of the inner rings touch it.

However, if the driver of the vehicle continues to operate it, eventually the rollers will skew so badly that they will be ejected from the hub unit and the centering function will be compromised. At this point, the hub unit will be retained on the vehicle only by the large washer under the spindle nuts. The weight of the vehicle will bring the brake drum into contact with the brake shoes and generate intense heat. Should the driver ignore the brake drag as a signal of impending disaster, the heat generated will catch the tire on fire, possibly involving the entire vehicle. This also may destroy some evidence of the exact failure mechanism.

Seal ingress of contaminants can only be detected if seal of grease remains are present. The grease can be analyzed for the nature of the debris to determine if it is internally generated or of external origin. If the seal is intact, wear rates and grooving can be examined as well. Often though, a bearing burn-up destroys the seal completely.

Impact damage/brinnelling can be determined if raceway spalling is evident, and if arranged in lines at the spacing of the rollers. Comparison to a cage is easy. Sometimes the guiding flange is also chipped at or near the spall locations.

Hub cap loss is evidenced by very rusty hub cap threads and machined area between the cap and the outboard seal. If progressed enough to cause roller ejection, often the threads are deformed from contact with the spindle retention washer.

Assembly damage is rare but occurs when the clip ring is out of place being dislodged from one or both of its grooves. If the inner rings are separated far enough, the clip ring "noses" can lie between the inner rings and still be assembled to the spindle. When this occurs, the "noses" keep the inner rings from coming into contact and excess clearance is created with all that entails as stated above.

Unknown causes: This group is nearly impossible to analyze simply due to the lack of data. Establishing clearer guidelines for warranty submission may help gather the data for future claims.

Endplay: Many of the endplay claims are the result of an impending bearing burn-up/failure that was caught very early. Most of the same signs exist as for bearing failure as stated above. And most of the same corrective actions apply as well.

However, some hub units are returned that do not have sufficient endplay to justify their return. Current standards are stated in Maintenance Manual No. 2A where on page 7 it says, "If the endplay is greater than 0.003-inch, recheck the torque on the inner wheel bearing nut...Repeat ... If the endplay reaches0.009-inch... replace the truck hub unit." SKF has reviewed nine warranty claims of endplay and found seven to be well within the 0.009-inch standard, in most cases the endplay measured is actually 0.000-inch.

Field education is the only method to reduce claims of this type. SKF is working with ArvinMeritor to develop a field service bulletin to accomplish this education.

Removal/Disassembly Issues: These claims have often been associated with hub unit removal for another cause. The hub unit is removed for servicing king pins to make the knuckle assembly lighter and easier to handle, and for camshaft bushing repairs or the recall. Early installations did not use any anti-fretting paste and later ones used a light grease. Neither seems to be completely satisfactory in eliminating fretting corrosion. This corrosion is the source of exfoliation rust that fills up the small clearance space between bearing bore and spindle shaft. By filling the space, the inner rings become frozen to the shaft and the hub unit is difficult to remove. Sometimes, when brute force is needed to remove the hub unit, the inboard inner ring stays with the shaft breaking the clip ring and dismounting the inboard seal. Mechanics are told not to attempt to rebuild the hub unit as it is a matched set and so it is returned under warranty.

SKF has also determined that in spite of an 8-10 ton clamping load across the inner rings, water is able to enter the inner ring/back-up interface and creep down the spindle shaft. This wicking is assisted by capillary draw and a pumping action from the microscopic movement of the inner rings due to the clearance between bore and shaft. This also causes corrosion products to fill this space leading to difficult removal of the hub unit.

Asheville has recently adopted SKF's recommended anti-fretting paste, MolyKote D, which is superior to all other pastes SKF has tested in reducing fretting corrosion. SKF is also cooperating with ArvinMeritor to develop a seal that will be installed at the shaft to bearing back-up joint to eliminate water ingress at this point.

Noisy: This type of claim can be associated with raceway spalls that cause rough rotation. Or it may be a symptom of excessive endplay or improper torque-up. SKF has only reviewed three claims of noise, one was an inner ring spall, probably from a hidden material defect, two were found not to have any discernable problems, one of those having been disassembled before return to SKF. This last was probably a removal issue, as covered above.

Noisy claims that are a result of improper torque-up or removal issues can be reduced as above. Raceway spalls as a result of hidden material defects are infrequent and SKF has material specifications that are designed to reduce these to a minimum. Reduction ratios are a particular standard that helps eliminate these material defects, making them show up in the forging operation.

SKF

SKF North American Technical Center
Plymouth, MI USA

STEER THU WARRANTY REPORT FIRST QUARTER 2000

Report Title: Steer THU Quarterly Warranty Report 1Q2000
Project Code:

To: Mike Lewis
From: J. Bruce Weeks
Copies: R. Bondy,V. Mueller, M. Lewis, W. Heckert, S. Brown, A. Mueller, J. Diedin
Date: 15 Apr 2000

Date Received: 30 Mar 2000

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BACKGROUND: Warranty returns are analyzed and summarized in a Lotus database. The results are reported quarterly in the graphical form as R100 failure rates and number of failures related to months in-service and mileage. The following defines and summarizes the format of the graphs.

DISCUSSION:

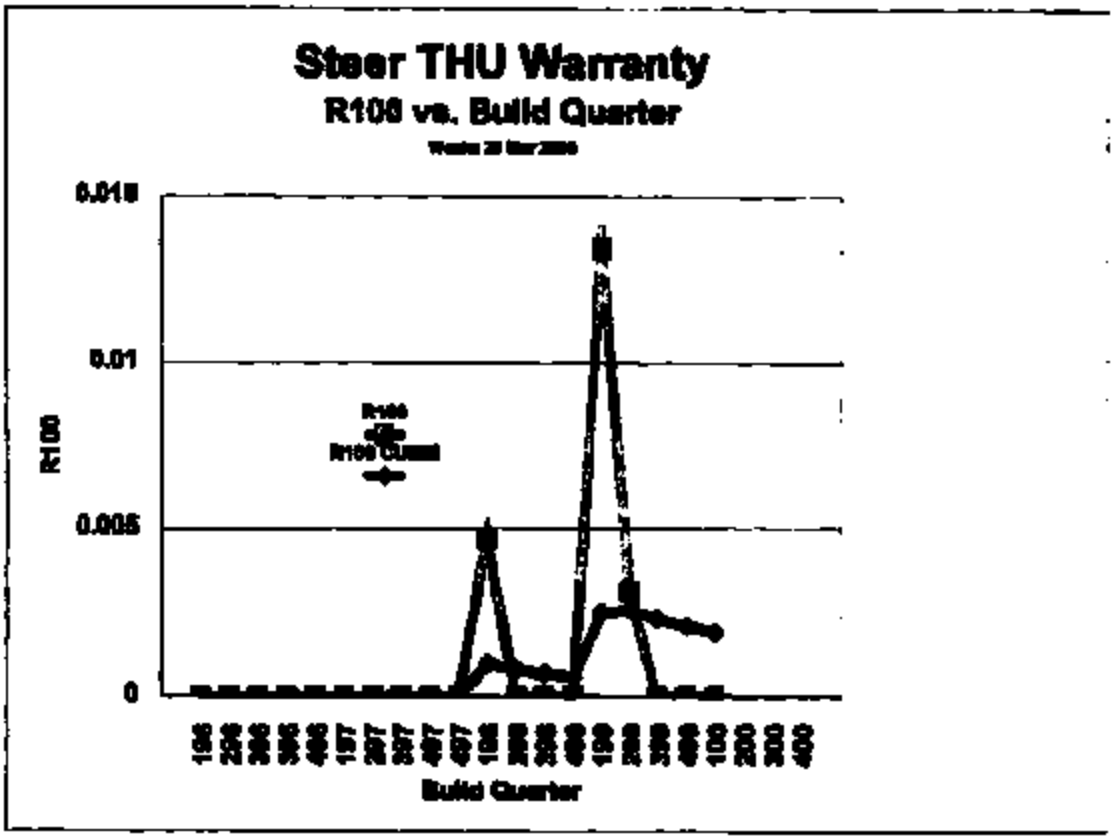
Definition of R100:
The R100 failure rate is the number of failures per unit built expressed as percent.

R100 vs. Build Quarter:
This graph indicates the current failure rates to date versus the quarter in which the failed units were built. For units received early in the return process, some data that would be needed to support this database was not recorded. These units have been discarded and that data is not retrievable by other means. Particularly the date of build is missing. As this affects the R100 calculation, these parts are not included in any R100 figure that is tied to a particular build quarter. These early units are only used in the total R100 figure where all parts can be included.

R100 vs. Build Quarter: Current Results
First quarter 1996 through third quarter 1998 there are currently no failures that were known to have been built in any particular quarter. This is partly due to the lack of recorded data from the earliest failures. The lack of data for the earlier quarters should not be construed as not having failures, but rather as a lack of complete data collection.

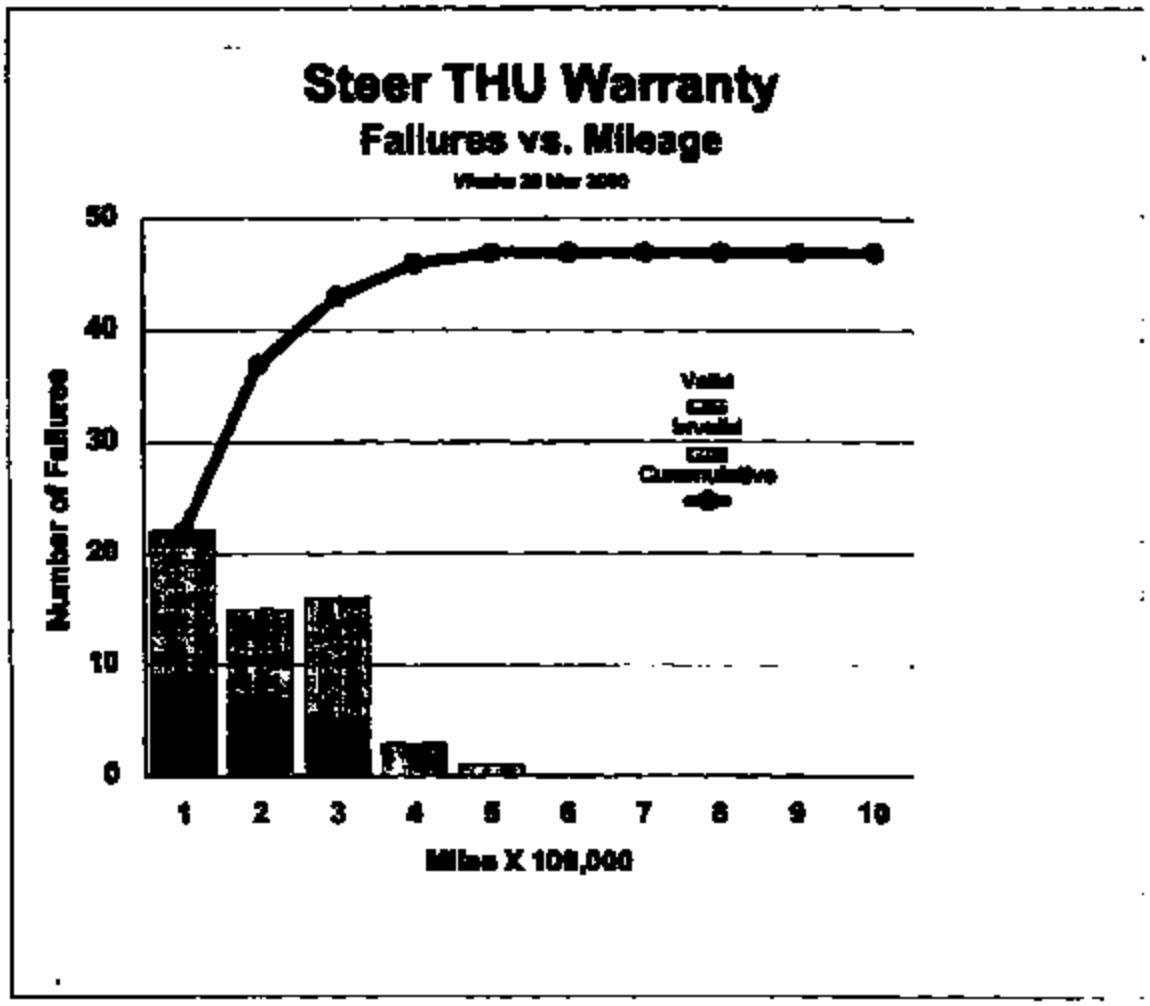
The spike for first quarter 1999 individual R100 is a collection of parts on which we were able to determine the build dates. Two units had outer rings that were not properly hardened (valid claims), one unit experienced oil separation and oil leakage past the inboard seal (valid claim) and a fourth unit was overheated by a dragging brake (invalid claim). As we continue to receive returns in the future, the early quarters will to fill in with data and the curve will begin to smooth out.

Note that the cumulative R100 for parts in which the build date is known is quite low at approximately-0.0035%. Our total returns to 1Q2000, both valid and invalid, have been 60 pieces out of 311,295 pieces built between both plants for an R100 of 0.02%.



Number of Failures vs. Mileage:
This graph represents the current failures vs. the mileage before failure. Even for early data, nearly all the mileages were recorded and are shown here. The "Valid" data includes only claims which were considered valid by SKF. The "Invalid" data is for of all returns which were not considered valid, and for which we have mileage data. The cumulative line indicates the total number of failures up until that mileage, inclusive of all data for which we have mileages. The approximate mileage on vehicles in the field is low (<500,000 miles) due to the short time frame from the beginning of production. As we receive future claims, both lines will grow, especially in the higher ranges.

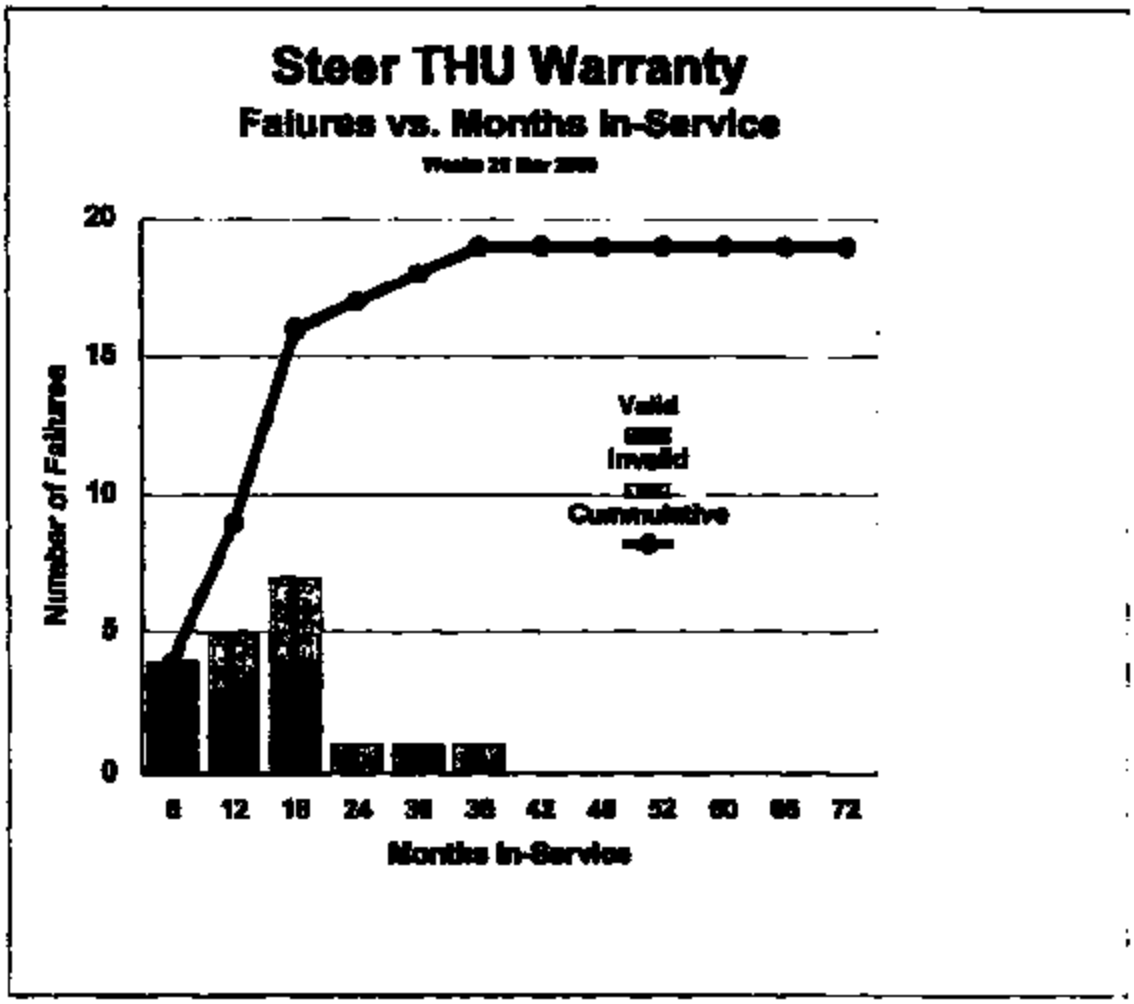
This graph can be interpreted several ways. First if we see low mileage failures, we need to look at design issues and/or any production problems that may have occurred. Second, a downward trend of the number of failures vs. individual quarters would indicate improved production quality and/or design changes effecting overall life. Thirdly, a downward trend may indicate as in this case, that the number of trucks in the field with high mileages are small in comparison with those trucks with low mileages.



Number of Failures vs. Mileage: Current Results
Infant failures due to unhardened raceways (two Luechow, two Aiken) caused the number of failures to be high in the low mileage ranges. Some seal failures (4 Luechow, 4 Aiken) occurred as well in the mid ranges (200,000 - 300,000 miles). Further, there are few trucks with mileages exceeding 400,000 miles to provide data points in the higher ranges at this time.

Our controls on raceway hardening should have been able to prevent these claims. As stated earlier, a PIC was issued requiring an 8D analysis. The results will be reported here at a later date. We may receive more claims for this issue as we cannot be certain of the total number of parts that may have been made with unhardened raceways.

Number of Failures vs. Months In-Service:
This graph is similar to the mileage graph except it uses the number of months the unit has been in-service as its basis instead of mileage. It is set up much the same as the mileage graph and the same conclusions can be drawn.



Number of Failures vs. Months In-Service: Current Results
Again, several infant failures due to non-hardened raceways caused the number of failures to be high in the low time ranges. Seal failures show up in the mid-mileage range numbers.

Corrective Actions to Reduce Number of Invalid Claims

In order to reduce the number if claims for grease purge which have an insignificant amount of lubricant seeping past the seals, and for endplay below the 0.000" limit established with Meritor, an inspection procedure was issued to Meritor Training through Frank Cookson. This comprehensive procedure includes step by step instructions for determining when a unitized hub is to be taken out of service. A copy is attached for review.

Concerning lost hub caps, Meritor Steer Axle Engineering in Asheville, NC has recently increased the torque requirement on the hub cap from 250 ft-lbs to 350 ft-lbs.

These two measures will reduce the amount of invalid claims by about 50% in the future.

SKF

SKF North American Technical Center
Plymouth, MI USA

METROLOGY LABORATORY RESULTS REPORT

Report No.:	AT99D003	To:	M. Lewis
Project Code:		From:	Jeff Dukes
Registration No.:		Copies:	J. Ramirez
References:	RLS 100306		
Date Received:	1/22/99	Date:	3/2/99

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Title: Warranty Returns - Meritor

Background:

Application:	Front steer axle	No. of Samples:	11
Customer:	Meritor	Service Life:	
Product No.:		Service Load(s):	
Manufacturing Facility:		Operating Temperature:	
Alloy/Material:		Speed:	
Lubricant:		Environment:	

Data Requested: Warranty analysis

Results:

Claim #	VIN	Mileage	SKF P/N	Complaint
NLFD0098I238T	1FUYSSZBXVP821840	305,975	BTF 0032	Grease leakage - both front hubs

FINDINGS:
Both front hub unit bearings were returned due to grease leakage. Hub unit 1 showed minimal grease leakage at outboard seal. Unable to quantify due to presence of dirt. Removed cone and roller assembly and found normal grease fill remaining. Hub 2 was received as outer ring only. Outer ring shows no evidence of insufficient lubrication. Claim is determined invalid.

Claim #	VIN	Mileage	SKF P/N	Complaint
RO# 57208	1FUYSXYB2WL824013	253,431	BTF 0032	Seals leaking - both front hubs

FINDINGS:
Both front hub unit bearings returned due to seals leaking. Small amount of grease purge found at seal areas. Hub 1 grease leakage amount was 0.31 grams. Hub 2 grease leakage amount was 0.87 grams. Normal production grease fill amount is 60 grams. Grease leakage determined to be insignificant. Claim is invalid.

SKF SKF North American Technical Center Kenworth, MI USA	METROLOGY LABORATORY RESULTS REPORT

Report No.:	AT99D019	To:	Bruce Weeks
Project Code:	G-ad 711	From:	Jeff Diskin
Registration No.:		Copies:	J Rumiers
References:	RLS 100351		
Date Received:	9/1/99	Date:	10/1/99

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Title: Investigation of Meritor Warranty Returns

Background:

Application:	Steer axle	**No. of Samples:**	10
Customer:	Meritor	**Lubricant:**	
Product No.:	BTF0032		

Claim #	VIN	Mileage	SKF p/n	Complaint
CBX00216	2FUYDSEB9WA843925	233,177	BTF 0032	Outboard seal leak

FINDINGS:
Grease seepage from outboard seal weighed 0.54 grams. The inboard seal showed no seepage.

Claim #	VIN	Mileage	SKF p/n	Complaint
CDA03590	1FUW3MCAOXL987195	126,168	BTF 0032	Claim filed for reference # (?)

Outside appearance of unit was normal. There were no signs of grease seepage. Endplay measured 0.00mm.

Claim #	VIN	Mileage	SKF p/n	Complaint
CCP00294	1M1AA13Y2WW084935	126,317	BTF 0032	Inner bearing failure

FINDINGS:
Bearing was received disassembled. Inboard inner ring spalled 120 deg. Grease had elevated levels (10%) of contamination. Root cause investigation is ongoing in metallurgy.

Claim #	VIN

Claim #	VIN	Mileage	SKF P/N	Complaint
E1371162	1FUYNWEB4WP9 56257	84,911	BTF 0032	kingpin seized -check for loose hubs

FINDINGS:
Both front hub unit bearings were returned due to looseness. Both units measured for endplay and found to be in preload. No further investigation performed. Claim determined to be invalid.

Claim #	VIN	Mileage	SKF P/N	Complaint
CYED98A999	---	156,597	BTF 0049	Noise

FINDINGS:
Measured endplay and found unit in preload. Disassembled unit and found inboard inner ring spalled. Water content in grease found to be 0.16% at outboard seal area and 0.11% at inboard seal area which is in specification. Root cause analysis initiated on cone. Claim determined to be valid.

Claim #	VIN	Mileage	SKF P/N	Complaint
E1351964	1FUYSMEB3WL8 62160	94,916	BTF 0032	noisy, burnt grease

FINDINGS: Measured endplay and found unit to be in preload. Disassembled unit and inspected components. No abnormal conditions found. Grease appears normal. Claim is invalid.

Claim #	VIN	Mileage	SKF P/N	Complaint
E1349774	1FUYDSZB5WP88 7319	263,131	BTF 0032	bearing loose/froze to spindle

FINDINGS:
Hub unit received disassembled. Unable to confirm endplay. Inspected components and found no defects. Claim is invalid.

Claim #	VIN	Mileage	SKF P/N	Complaint
E1240062	1FUYNMDBXVL5 51865	233,714	BTF 0031	bearing burnt, hub tire came off

FINDINGS:
Spindle received with 2 cones seized to shaft and discolored from heat. Hub unit bearing received with claim had cone and roller assemblies mounted in outer ring. Wrong bearing received for this claim. Claim is invalid.

Claim #	VIN	Mileage	SKF P/N	Complaint
RO# 79350			BTF 0032	

No vehicle information received. Investigation pending further information.

SKF SKF North American Technical Center Plymouth, MI USA	**METROLOGY LABORATORY RESULTS REPORT**

Report No.: AT99D008
Project Code:
Registration No.:
References: RLS 100063
Date Received: 5/1/99

To: M. Lewis
From: Jeff Diskin
Copies: J. Rumsey

Date: 5/7/99

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Title: Warranty Returns - Meritor

Background:

Application:	Front steer axle	**No. of Samples:**	12
Customer:	Meritor	**Service Life:**	
Product No.:		**Service Load(s):**	
Manufacturing Facility:		**Operating Temperature:**	
Alloy/Material:		**Speed:**	
Lubricant:		**Environment:**	

Data Requested: Warranty analysis

Results:

Claim #	VIN	Mileage	SKF P/N	Complaint
E1362661	1FUYSXYB7VL823969	287,008	BTF 0032	Grease leakage

FINDINGS:
Grease amount collected at outboard seal = 0.007 grams. See attached photos. Normal production grease fill amount is 60 grams. Grease leakage determined to be insufficient. Claim is invalid.

Claim #	VIN	Mileage	SKF P/N	Complaint
E1381706	1FUYSWEB2WL957983	168,051	BTF 0049	Grease leakage

FINDINGS:
Grease amount collected at outboard seal = 1.40 grams. See attached photos. Normal production grease fill amount is 60 grams. Grease leakage determined to be insufficient. Claim is invalid.

Claim #	VIN	Mileage	SKF P/N	Complaint
E1395347	1FUYSWEB0WL9 68299	172,101	BTF 0049	Grease leakage

FINDINGS:
Grease amount collected at outboard seal = 0.39 grams. See attached photos. Normal production grease fill amount is 60 grams. Grease leakage determined to be insufficient. Claim is invalid.

Claim #	VIN	Mileage	SKF P/N	Complaint
E1362663	1FUYSSEB1WL97 1785	63,551	BTF 0049	Noise

FINDINGS:
Measured endplay and found unit in preload. Disassembled unit and found inboard inner ring spalled. Root cause is being investigated. Claim is valid.

Claim #	VIN	Mileage	SKF P/N	Complaint
CAI03383	1FUYSZYB6WL80 3516	194,273	BTF 0032	Wheel bearing casing broken

FINDINGS:
Bearing received disassembled. No broken components found. Outer ring, inner rings and rollers OK. Claim is invalid.

Claim #	VIN	Mileage	SKF P/N	Complaint
CAI03383	—	186,768	BTF 0032	Bearing loose

FINDINGS:
Endplay measured 40 microns. Endplay is within specification. Claim is invalid.

Claim #	VIN	Mileage	SKF P/N	Complaint
E1377095	1FUYSSEB4WP90 2551	52,750	BTF 0049	RF bearing failed LF bearing loose

FINDINGS:
Right side bearing destroyed from heat. Silicone sealant, dirt and corrosion present at hub cap threads.
Left bearing measured 200 um endplay. Silicone sealant, dirt and corrosion present at hub cap threads.
Evidence of severe water/dirt intrusion. Both sides appear to have lost sealing at the hub cap or were driven without a cap. Claim is invalid.

Claim #	VIN	Mileage	SKF P/N	Complaint
CAI03511	1FUYSZYB1WL97 2861	270,000	BTF 0049	Seal leaked and loose on spindle

FINDINGS:
Bearing received disassembled. Unable to verify endplay. No grease sample for analysis. Claim is invalid.

Claim #	VIN	Mileage	SKF P/N	Complaint
Hunter Keystone	1XPCDR8X4VN41 3037	158,521	BTF 0032	Both front bearings loose

FINDINGS:
Mounted bearings to spindle and torqued nut to 700 ft-lbs. Endplay measured 0.004 and 0.002 inches. Claim is invalid.

Claim #	VIN	Mileage	SKF P/N	Complaint
CFD06454	1M1AA12Y3VW0 80621	416,796	BTF 0032	Excessive endplay

FINDINGS:
Mounted bearings to spindle and torqued nut to 700 ft-lbs. Endplay measured 0.0mm. Claim is invalid.

MONSON . [illegible]

} water content (6)

Trail, Trugs

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428 L

SKF 000084

Purpose: Investigation of Failure Mode

Background: Several Truck Hub Units Second Generation (THU2) were returned from the field (tractor axle, customer: Arvin/Meritor) because of high endplay. The axle load was approximately 5.5 metric tons (12,000 lbs). One bearing (No 378) was chosen for metrological and metallurgical investigation.

Result:

1. Visual Inspection:

Outer ring raceways: Both raceways are in good condition. The surface appearance is mat, while manufacturing traces are still visible. Some thin circumferential traces are to be found, somewhat predominant on the inboard raceway.

Rollers at Vehicle Inboard Side : The raceways are showing multiple small indentations in two broad bands close to the chamfers. The surface is mat. Larger indentations are evenly distributed. The roller end faces do not exhibit even wear patterns: some show only few cycloids and scratches (see picture 1, bottom left), which can be very deep (picture 1, bottom right). Some rollers have heavy fretting wear with shiny surface and material flaking at the whole circumference (see picture 2). In most cases, this damage is limited to only a sector of the roller end, as can be seen in picture 1 (top).

Rollers at Vehicle Outboard Side : The surface shows finest indentations in two broad bands close to the chamfers (free of indentations in the middle). The roller end faces appear shiny, especially in a thin section close to the chamfer. Cycloids and scratches, some deeper, have been formed. A small deformation of the chamfer is visible.

Cages: The pockets of the dark olive polymer cages show traces of metallic particles.

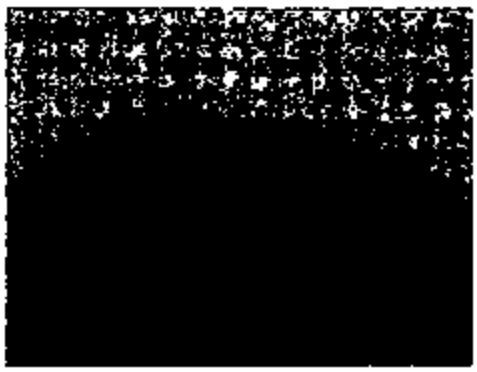
Inner Ring Outboard Side: The loaded zone is marked by very little fretting corrosion. The raceway shows virtually no reaction layer formation. The honing structure is still visible. The surface appears mat to shiny and has some small indentations. The guiding flange shows scratches and cycloids; the honing structure is almost completely worn away, the surface is shiny. The appearance is considered to be normal based on the mileage. Hints of a lubrication problem are not visible.

Inner Ring Inboard Side: The bore diameter shows brown fretting corrosion, indicating the loaded zone. The honing structure on the raceway is still visible. The surface appears mat to shiny and has small indentations, mainly in the loaded zone. Only little reaction layer formation is to be seen on the raceway. Cycloids and scratches are over the whole guiding flange surface. In the area of the loaded zone strong fretting wear is caused by the roller-flange sliding contact. The area of the undercut has a wavy deformation here.

2. Metrological Investigation

The bearing was determined to have an axial clearance of about 115 µm endplay when being clamped with 80 kN.

Picture 2: Flaking at roller end



Picture 3: Rehardened area caused by wear

Picture 4: SEM close to undercut

Picture 5: SEM close to chamfer

Sales Office

Plymouth, MI
USA

SKF Automotive Division

Failure Investigation

for

MONSON TRUCKING

Duluth, MN

Final Report

Date: 12/19/2001
By: Michael Lewis

Distribution:
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Introduction/Background

Monson Trucking of Duluth, Minnesota, experienced 4 wheel end issues in 2001. These issues occurred with SKF manufactured Truck Hub Units (THUs) used on ArvinMeritor FF-981 axles and International Trucks. These trucks were all produced in 1997.

The original failures (prior to June 5th, 2001) and their assigned root causes were:

–Unit 324R - parts were unavailable for analysis
–Unit 310L – Outboard row/hubcap thread corrosion – suspect lost hubcap
–Unit 345R - Low clamp load (IRs show severe creep) evident
–Unit 326R – Inboard seal leak

SKF, ArvinMeritor, International Trucks, and Monson began their investigation into this issue in June, 2001 with a visit to the Monson Duluth maintenance facility. During removal of some of these hubs, it was noted that there was an orange residue on the spindle. Several hub units were returned to SKF for more detailed analysis. Some of these units were also noted to have had low nut torque on the inner retaining nut (nuts which hold the unit on the spindle).

The major findings of the analysis of the parts removed in June were:

•Spindle residue is grease base oil, water, rust, and brake dust.
•No significant water was inside the units
•Although not ideal, the lower torques had not created water ingress in the hub unit and do not appear to have created any performance problem. Long term, the presence of water will increase rust and potentially cause problems with removal of hubs from spindles. This issue has been addressed with the addition of an o-ring seal at the spindle to hub interface.
•Some of the inboard seals are wearing at a rate greater than expected.

In late July 2001, SKF recommended that all of the 1997 units be returned to broaden the field of data regarding the seal wear and the condition of the bearings. The remainder of the hubs from the 50 trucks (1997) was replaced and the hubs returned to SKF. Thus, all 50 original 1997 units have been exchanged for new units.

This report will cover the findings to date of the units investigated.

General Information

The units returned were all of 1997 make (SKF Part Number BTF-0032). The trucks ranged in mileages from 450,000 miles to 550,000 miles. Monson Trucking hauls general freight, mostly in the mid-west USA and southern middle Canada. Trucks average 100,000 to 120,000 miles per year general linehaul service.

Conclusions

Seals from the Monson trucks show higher wear rates than previously seen or documented during development or with other fleets.

Although some seals showed a higher than expected wear, all seals investigated were still functional. All bearings were in good condition with no signs of distress. The grease was also in good condition with no indication of contamination present.

Measuring wear widths with vernier calipers gives an indication of wear, but does not equate well with results from sectioned seals measured with an optical comparator (as done by the seal manufacturer). In general, the vernier caliper measurements yielded larger wear widths than the optical comparator method. This is important because the baseline wear (from 1996 units) was all measured by optical comparator while much of the Monson data is from vernier calipers.

At this point in time, the higher wear rate cannot be explained by any material or process change by either seal or bearing manufacturer. No process changes occurred in the 1996 to 1997 time frame. One potential variation between Monson and other fleets is the geographic location in which they operate. Northern climates often use salt mixed with sand to treat roads in the winter snows. The sand may contribute to the increased wear rate.

In mid-2000, SKF changed the seal used in the steer hub units. The new seal (R-Safe seal) has many enhancements and has performed better than the 1997 seal in laboratory testing, yielding 2 to 3 times better life in contaminated environments (mud and salt slurry).

Recommendations

1. Mid-2000 and later units should be monitored to ensure that the seal design changes have eliminated the high wear rate in this environment. SKF would like to evaluate some units equipped with the new seal (R-safe) at 500,000 mile and 750,000 mile intervals.
2. Monson should continue their diligent monitoring and inspection program. Although some of the seals have high wear, analysis of the bearings and grease show these seals to be functional and, therefore, should remain in service

Results

Out of the 85 additional units returned to SKF, all units were disassembled and the seal wear measured with a venier caliper and the general condition of the bearings and grease examined. Although not as accurate as sectioning and measuring with an optical

comparator, this measurement gives some indication of the relative wear of the seals. If the seal wear at the main lip is characterized as low (less than 1 mm), moderate (between 1 and 2 mm) and high (2.0 mm and greater), then the seal wear is fairly evenly distributed through these ranges.

All seals examined had some degree of contamination between the inboard seal lip and dirt excluder lip. In some cases the contamination was light, in others heavy – this seemed to be directly related to the amount of seal wear. As more contamination passed the dirt excluder lip to the main lip, the main lip wear increased.

Figure 1 shows the Monson and 1996 units measured using all optical comparator data. Figure 2 shows the Monson data using vernier caliper measurements (1996 data from optical comparitor method).

The above diagram shows what is measured as "wear". It is the length of the wear flat under the main lip (the lip under the spring). This starts as a point contact and increases as the seal wears.

Figure 3 shows the new data (from the additional 1997 parts) added to Figure 2.

Photos 1 and 2 show the actual seals, the lip wear and the contamination between the seal lips.

Table 1 shows the inspection data from the additional 85 parts by Monson unit number.

In addition, several units were cleaned as well as possible, and then disassembled with care to try to prevent external debris from entering the bearing. Six samples were then selected based on varying degrees of seal wear (light to heavy). Grease samples were then taken from the inboard seal/bearing area to be analyzed for contamination. The analysis is included as Attachment 1(AT01C225). This analysis concluded that all samples were in basically the same condition (including the control sample of new grease). Although all samples were close to each other regarding contamination content, the unit with the highest amount of contamination was the one with the least seal wear. Also, all the bearings were in good condition with no denting or scratching which would occur from operating in contaminated conditions. From this information, we can conclude that all the seals are still functional.

Seal Design Details

The sketch above is the seal used from 1996 through mid-2000. The seal is basically an garter spring oil type seal with a dirt excluder lip. This seal has been used in Europe in a high volume steer hub unit since 1986 with no problems. The seal rides directly on the bearing flange outer diameter. As an oil seal, the seal has an inward pumping action which helps to keep oil in the system.

The above seal is an SKF "R-Safe" design. It incorporates a stainless steel flinger/counterface, a labyrinth, and two seal contact areas. The stainless steel counterface prevents corrosion under the seal contact areas, thereby extending life. The R-Safe seal was designed to operate in grease – The seal has an outward pumping action, which pushes contamination away from the seal and bearing. The labyrinth and flinger provide a first line protection from contamination and protection from large particles. The seal lips contact in two areas. First, an axial lip provides protection as well as the main, spring loaded lip. This seal design has been used since 1992 with no field or testing problems.

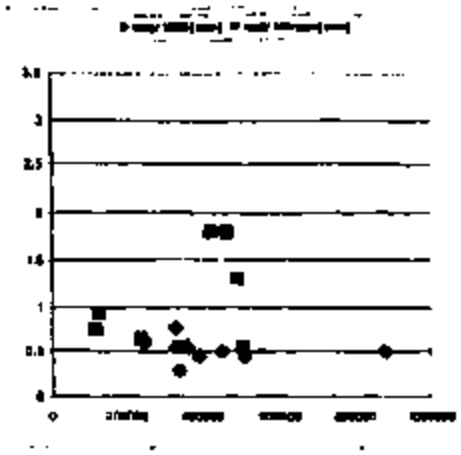


Figure 1. Optical Comparator Data

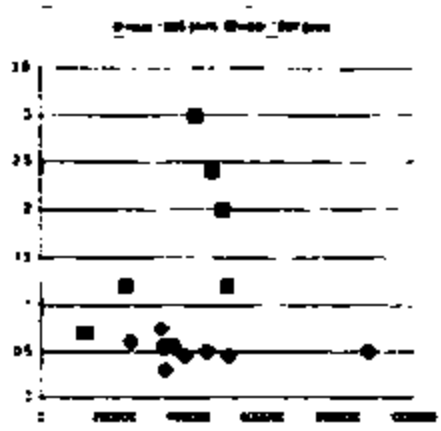


Figure 2. Vernier Caliper data

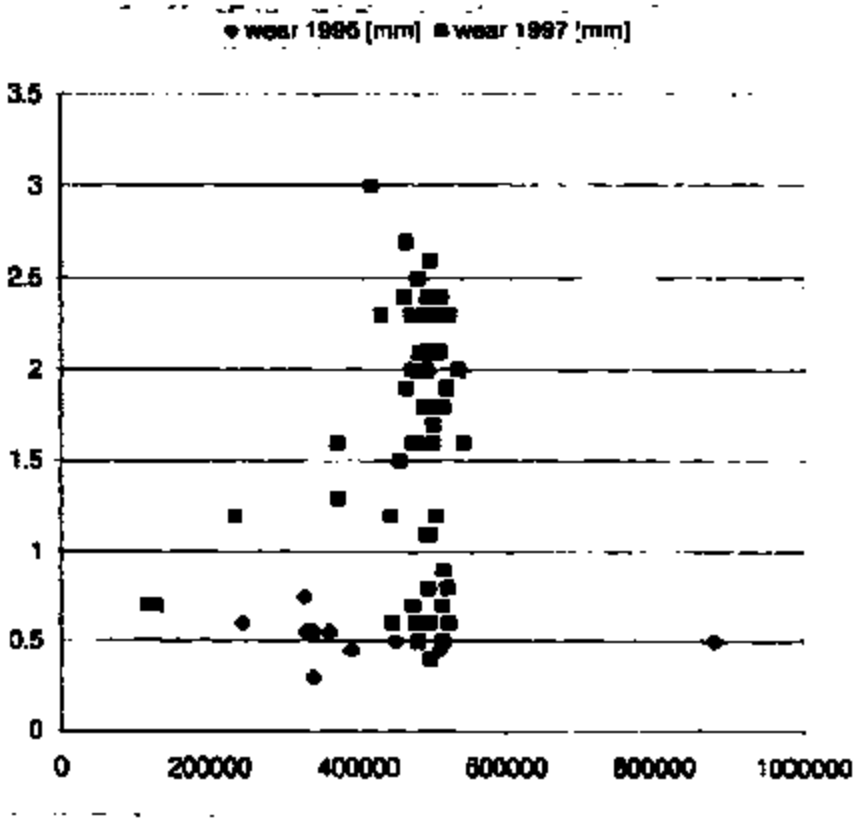


Figure 3: Vernier Caliper all MONSON Data (with 1996 units)

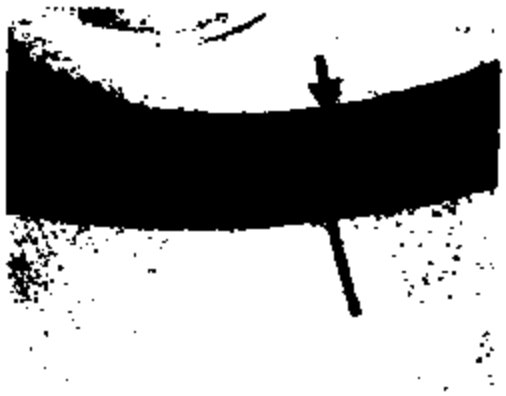


Photo 1: Unit 311 inboard seal - shows wear of dust lip (longer arrow) and main lip (short arrow)

Photo 2: Unit 311 inboard seal - Contamination between dust and main lips indicating that the dust lip has passed material

TABLE 1: Data from units returned August 2001 - 1997 units

Unit Number	Side	Mileage	Wear Width (mm)	Contamination between lips of seal	Dust lip Cond	Comments
301	R	472,299	2	Yes, Moderate	Grooves mostly gone	Brg/Grease Good Cond
302	R	493,761	2	Yes, Heavy	Grooves gone	Brg/Grease Good Cond
302	L	493,761	2.4	Yes, Moderate	Grooves gone	Brg/Grease Good Cond
304*	L	477,097	0.8	Light	Grooves mostly gone	Brg/Grease Good Cond
308*	R	513,359	2.3	Yes, Heavy		Brg/Grease Good Cond
308*	L	513,359	0.5	Light	Grooves mostly gone	Brg/Grease Good Cond
309	R	488,117	1.8	Yes, Moderate	Grooves still visible	Brg/Grease Good Cond
313	R	542,639	1.8	Yes, Moderate	Grooves mostly gone	Brg/Grease Good Cond
315	R	472,167	2.3	yes, Heavy	Grooves mostly gone	Brg/Grease Good Cond
315	L	472,167	0.7	Yes, light	Grooves mostly gone	Brg/Grease Good Cond
316	R	480,467	1.6	Yes, Moderate	Grooves mostly gone	Brg/Grease Good Cond
316	L	480,467	0.5	Light	Grooves mostly gone	Brg/Grease Good Cond
321	L	491,425	2.3	Yes, Heavy	Grooves mostly gone	Brg/Grease Good Cond
326*	L	514,002	1.8	Yes, Moderate	Grooves mostly gone	Brg/Grease Good Cond
327*	R	501,461	1.6	Yes, Moderate	Grooves mostly gone	Brg/Grease Good Cond
329*	R	474,483	1.6	Yes, Moderate	Grooves mostly gone	Brg/Grease Good Cond
329*	L	474,483	0.7	Yes, Moderate	Grooves mostly gone	Brg/Grease Good Cond
330	R	486,208	2.7	Yes, Heavy	Grooves gone	Brg/Grease Good Cond
330	L	486,208	1.9	Yes, Moderate	Grooves mostly gone	Brg/Grease Good Cond
331	L	444,048	0.8	No	Grooves still visible	Brg/Grease Good Cond
331	R	444,048	1.2	Yes, Moderate		Brg/Grease Good Cond
332	R	512,864	0.7	Yes, light	Grooves mostly gone	Brg/Grease Good Cond
332	L	512,864	2.4	Yes, Heavy	Grooves mostly gone	Brg/Grease Good Cond
333	L	505,088	1.7	Yes, Heavy	Grooves mostly gone	Brg/Grease Good Cond
335	R	495,188	2.3	Yes, Heavy	Grooves mostly gone	Brg/Grease Good Cond
335	L	495,188	0.8	Yes, light	Grooves mostly gone	Brg/Grease Good Cond
336	R	496,248	1.5	Yes, heavy	Grooves still visible	Brg/Grease Good Cond
336	L	496,248	0.6	Yes, light	Grooves mostly gone	Brg/Grease Good Cond
337	R	493,583	2.3	Yes, heavy	Grooves mostly gone	Brg/Grease Good Cond
337	L	493,583	2.1	Yes, heavy	Grooves mostly gone	Brg/Grease Good Cond

TABLE 1: Data from units returned August 2001 - 1997 units (cont.)

Unit Number	Side	Mileage	Wear Width (mm)	Contamination between lips of seal	Dust lip Cond	Comments
338*	L	534,445	2	Yes, heavy	Grooves gone	Brg/Grease Good Cond
338	R	497,536	1.1	Yes, light	Grooves mostly gone	Brg/Grease Good Cond
339	L	497,536	0.4	Yes, light	Grooves still visible	Brg/Grease Good Cond
341	L	491,259	2	Yes, Heavy	Grooves mostly gone	Brg/Grease Good Cond
341	R	491,259	1.1	Yes, light	Grooves mostly gone	Brg/Grease Good Cond
342	R	498648	2.1	Yes, Heavy	Grooves mostly gone	Brg/Grease Good Cond
346	R	520,660	1.9	Yes, Heavy	Grooves mostly gone	Brg/Grease Good Cond
346	L	520,660	0.8	Yes, light	Grooves still visible	Brg/Grease Good Cond
348	R	372,473	1.6	Yes, heavy	Grooves mostly gone	Brg/Grease Good Cond
348	L	372,473	1.3	Yes, light	Grooves mostly gone	Brg/Grease Good Cond
349*	R	523,497	2.3	Yes, Moderate	Grooves mostly gone	Brg/Grease Good Cond
349*	L	523,497	0.6	Yes, light	Grooves mostly gone	Brg/Grease Good Cond
350*	R	496588	2.6	Yes, light	Grooves gone	Brg/Grease Good Cond
Unknown			0.5	Yes, light	Grooves mostly gone	Brg/Grease Good Cond
303	L	486667	1.5	Yes, Light	Grooves still visible	Grease sampled
307*	R	481923	2.5	Yes, Heavy	Grooves gone	Grease sampled
318	R	477233	2.3	Yes, Heavy	Grooves gone	Grease sampled
320	R	511211	2.1	Yes, Moderate	Grooves mostly gone	Grease sampled
326*	R	614,002	0.6	Yes, Light	Grooves still visible	Grease sampled
360	L	486369	2.3	Yes, Heavy	Grooves gone	Grease sampled

*Indicates mileage from July file data.

SKF [redacted]

SKF North American Technical Center

Investigation Report

Date: June 15, 2001

Customer: [redacted]
SKF NATC
Plymouth, MI

Reference: g-AD-711

SKF Report Number: AT01C123 RLS 100253

Investigation: Evaluation of Meritor THU Warranty Returns
Revision Number: 0

Reported by:

David M. Pallister, Ph.D.

Reviewed by:

John Hickling

Copies to: John Rumierz, Bruce Weeks, Bob Boady . Chemistry Laboratory

46815 Port Street
Plymouth, MI 48170

Telephone: (734) 414-6800
Fax: (734) 414-6854

[redacted]

Identification:

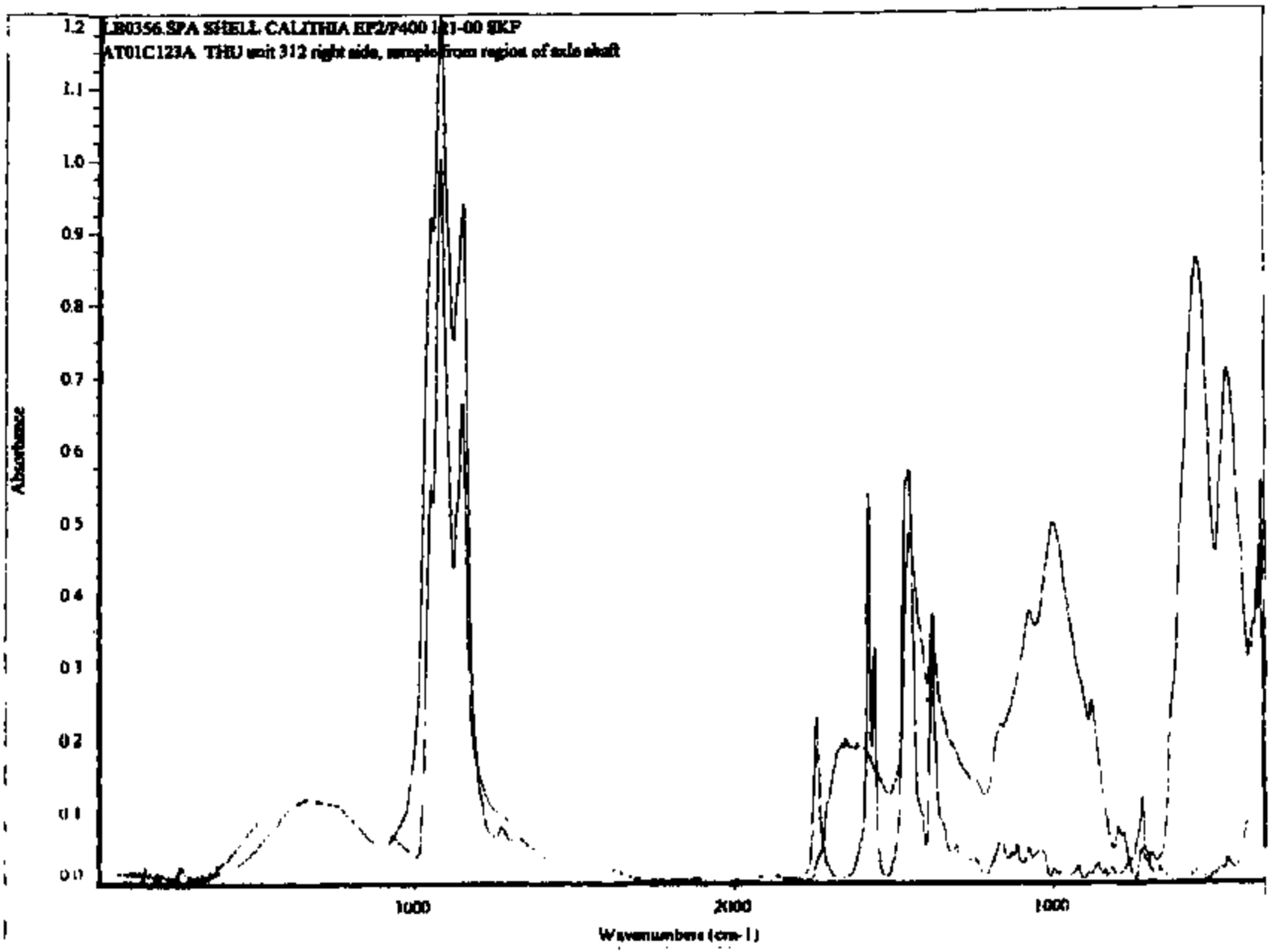
Chem Lab #	Sample Identification	FTIR File
AT01C123A	Mariner Unit 312 right side	AT01C123A.SPA
AT01C123B	Mariner Unit 312 left side	AT01C123B.SPA
AT01C123C	Mariner Unit 313 left side	AT01C123C.SPA
AT01C123D	Mariner Unit 324 left side	AT01C123D.SPA
AT01C123E	Mariner Unit 328 left side	AT01C123E.SPA
AT01C123F	Mariner Unit 378 left side	AT01C123F.SPA
AT01C123G	Mariner Unit 414 left side	AT01C123G.SPA
AT01C123H	Mariner Unit 428 left side	AT01C123H.SPA
AT01C123I	Mariner Unit 311	AT01C123I.SPA

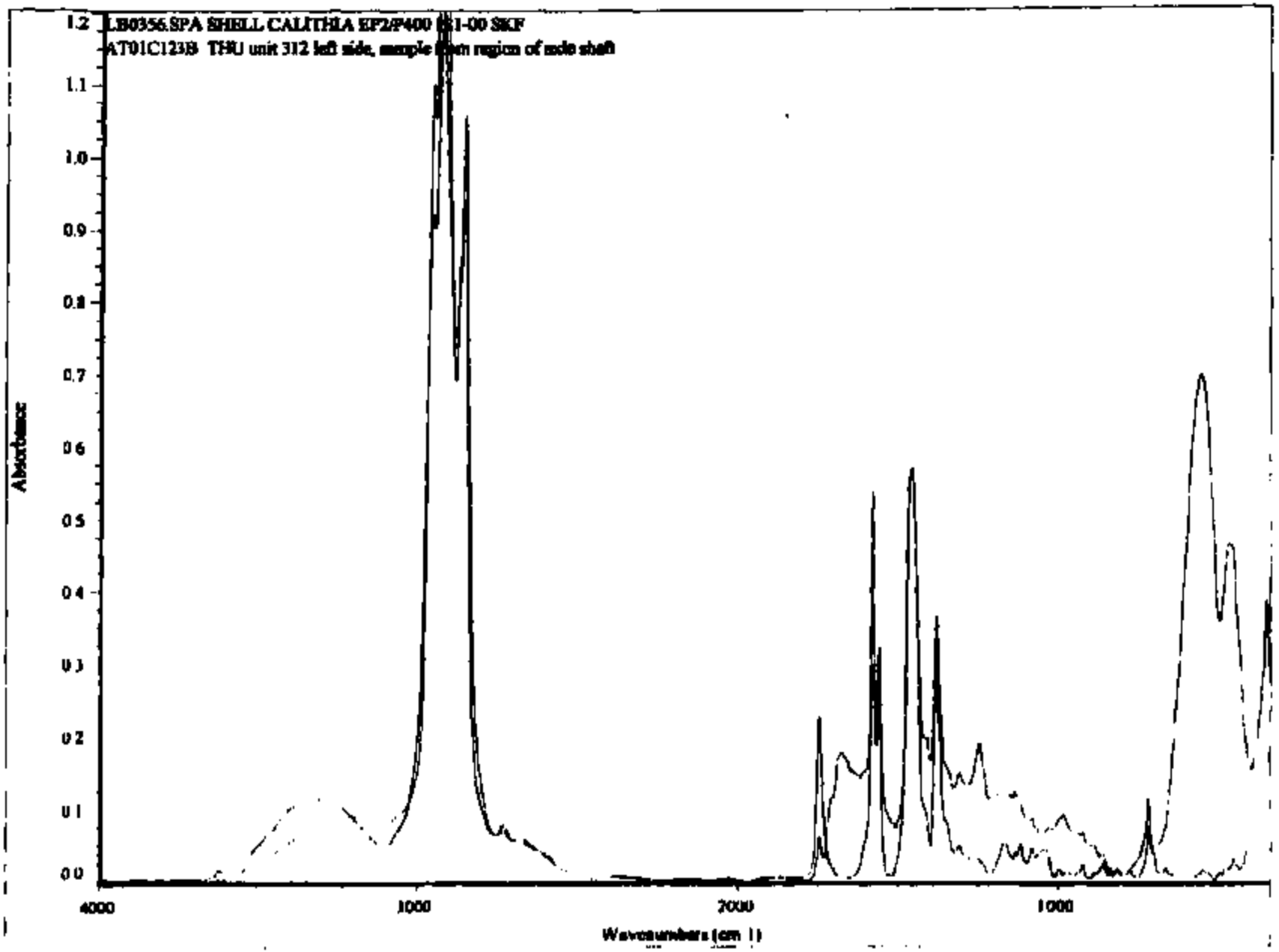
Results:

Sample Description	*Chemistry No*	*Water Content Inboard Seal*	*Water Content Bearing Cavity*	*Water Content Outboard Seal*	*Water Content Outboard Seal*	*Water Content Inboard Side*	*FTIR Analysis Spindle Residue*
Colchis KF 3 control	*LB0356*	*2000 PPM Max.*	*NA*	*NA*	*NA*	*NA*	*FTIR control*
Mariner Unit 312 Right	*AT01C123A*	*5301 PPM*	*1977 PPM*	*NA*	*NA*	*NA*	*Spindle residue is mostly oil contaminated with high levels of rust, water acidic organic material and brake dust.*
Mariner Unit 313 Left	*AT01C123B*	*8520 PPM*	*4634 PPM*	*NA*	*NA*	*NA*	*Spindle residue is mostly oil contaminated with high levels of rust, water and acidic organic material. Low levels of brake dust contamination*
Mariner Unit 313 Left	*AT01C123C*	*3858 PPM*	*1624 PPM*	*NA*	*32710 PPM (3.27 %)*	*25882 PPM (2.59 %)*	*Spindle residue is mostly oil contaminated with high levels of rust, water and acidic organic material. Low levels of brake dust contamination*
Mariner Unit 324 Left	*AT01C123D*	*4170 PPM*	*3003 PPM*	*NA*	*16481 PPM (1.65)*	*30042 PPM (3.00 %)*	*Spindle residue is mostly oil contaminated with high levels of rust, water and acidic organic material. Low levels of brake dust contamination*
Mariner Unit 328 Left	*AT01C123E*	*4954 PPM*	*2589 PPM*	*NA*	*NA*	*NA*	*Spindle residue is mostly oil contaminated with high levels of rust, water and acidic organic material. Low levels of brake dust contamination*
Mariner Unit 378 Left	*AT01C123F*	*4617 PPM*	*458 PPM*	*NA*	*NA*	*NA*	*Spindle residue is mostly oil contaminated with high levels of rust, water, acidic organic material and brake dust.*
Mariner Unit 414 Left	*AT01C123G*	*3829 PPM*	*1200 PPM*	*3257 PPM*	*18270 PPM (1.83 %)*	*NA*	*Spindle residue is mostly grease contaminated with low levels of rust, water acidic organic material and brake dust.*
Mariner Unit 428 Left	*AT01C123H*	*3119 PPM*	*2946 PPM*	*NA*	*NA*	*NA*	*NA*
Mariner Unit 311	*AT01C123I*	*7130 PPM*	*2140 PPM*	*NA*	*NA*	*NA*	*NA*

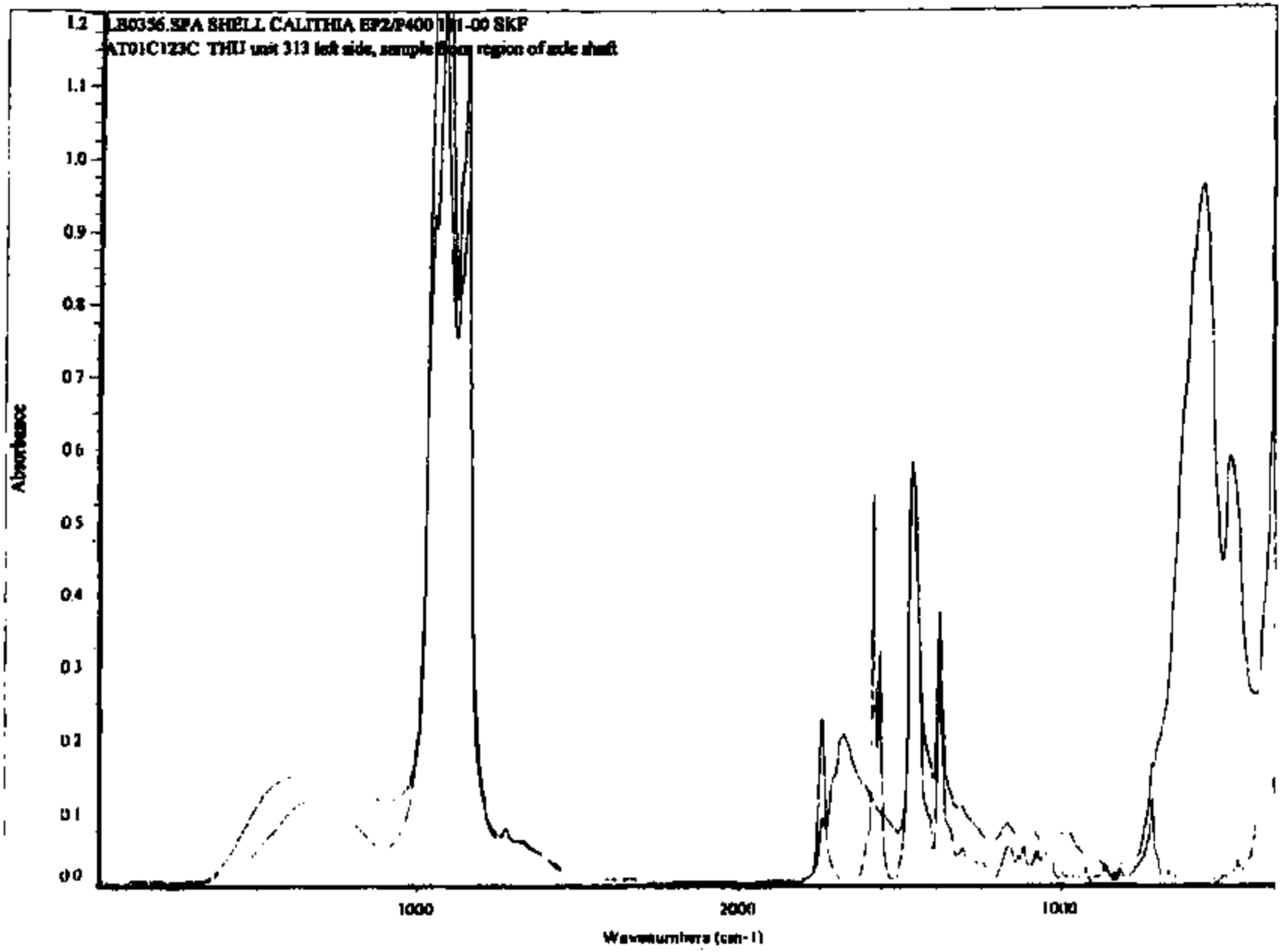
Conclusion:

Water ingress into THU appears to occur from the spindle-bearing interface on the inboard side

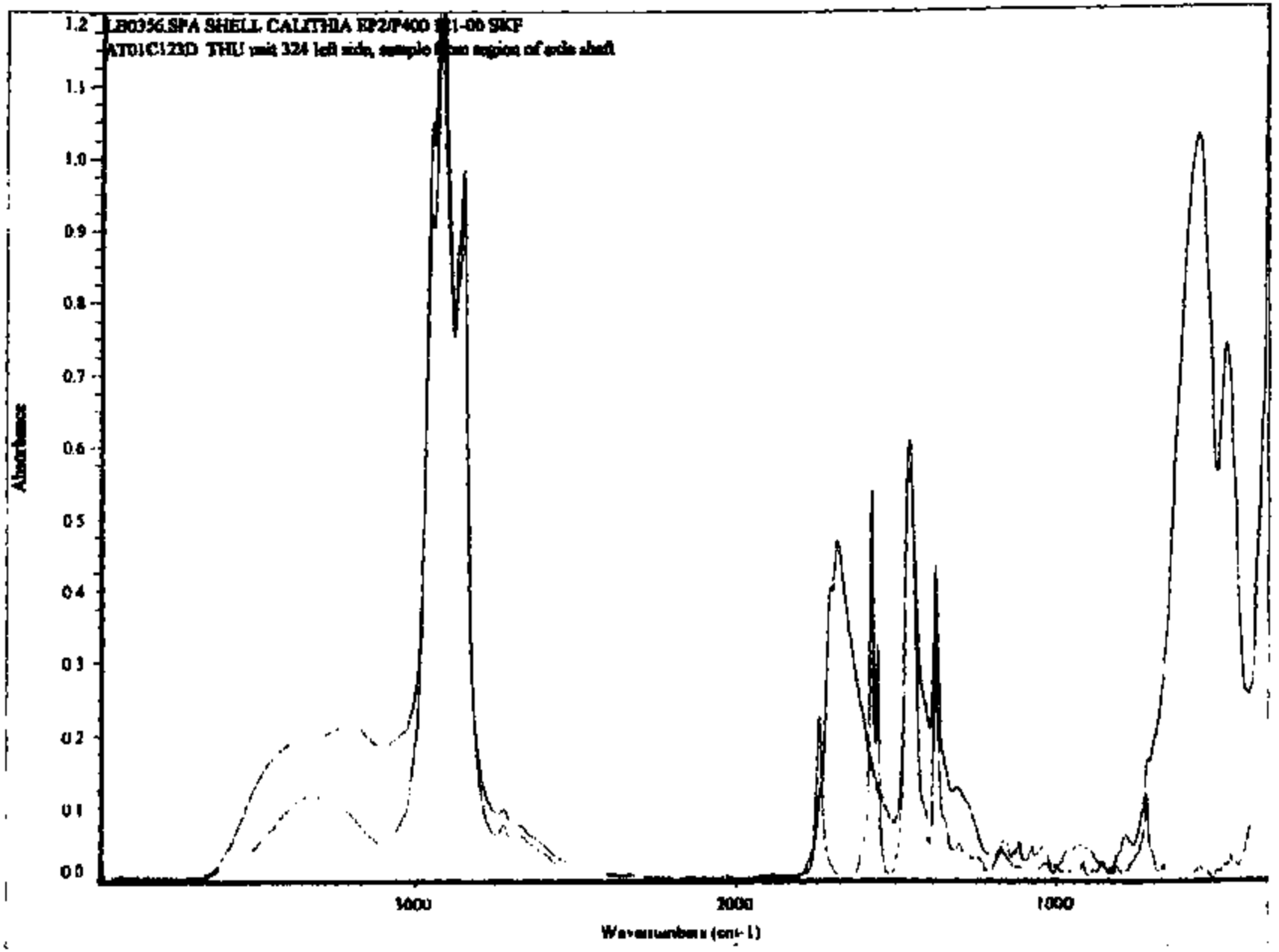

LB0356.SPA SHELL CALITHIA EP2/P400 121-00 SKF
AT01C123A THU unit 312 right side, sample from region of axle shaft
Absorbance
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1000
2000
3000
Wavenumbers (cm-1)


LB0356.SPA SHELL CALITHIA EP2/P400 01-00 SKF
AT01C123B THU unit 312 left side, sample from region of axle shaft
Absorbance
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
4000
3000
2000
1000
Wavenumbers (cm-1)

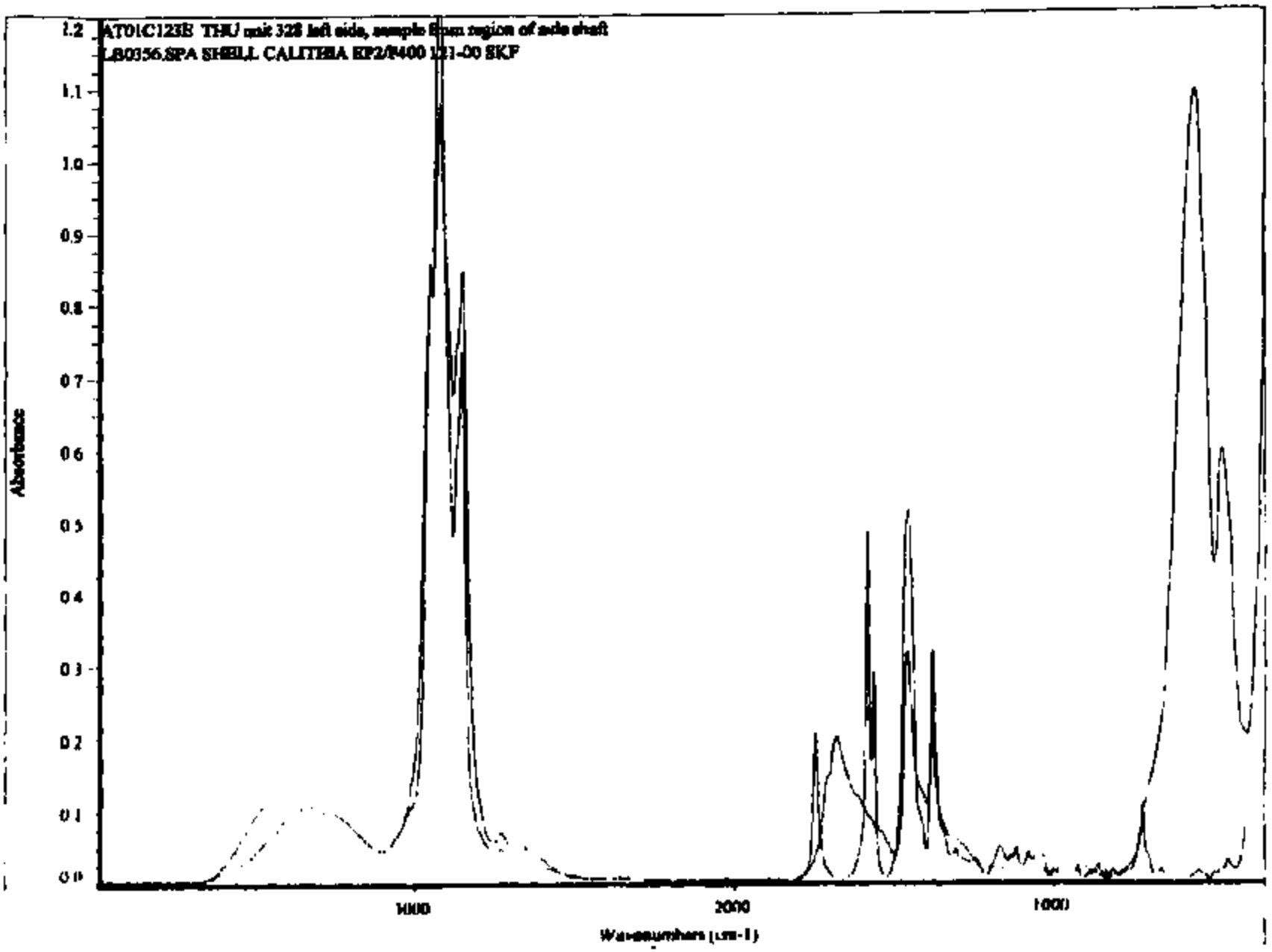
SKF 000476


LB0356.SPA SHELL CALITHIA EP2/P400 101-00 SKF
AT01C123C THU unit 313 left side, sample from region of axle shaft
Absorbance
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1000
2000
3000
Wavenumbers (cm-1)

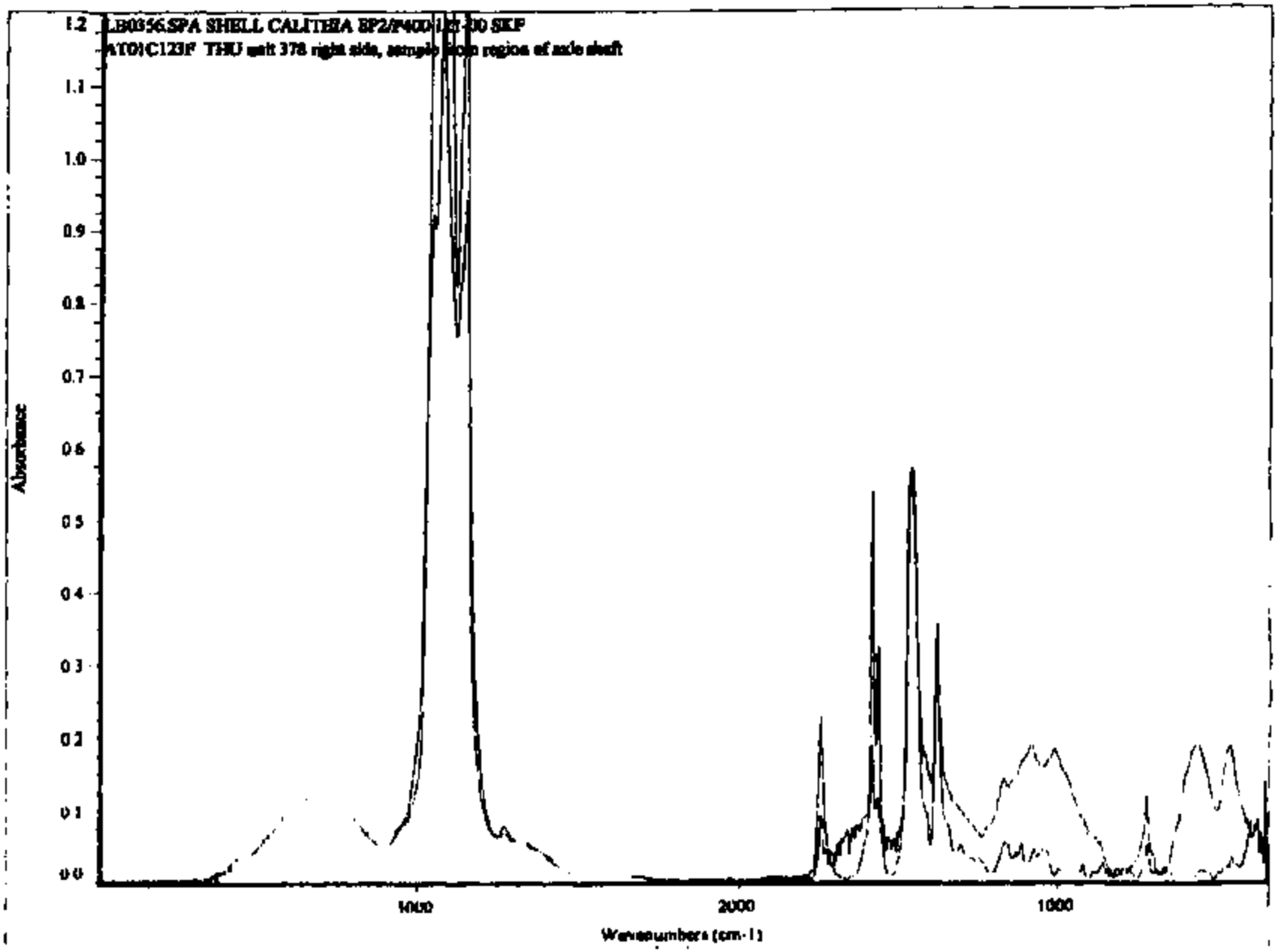
SKF 000177


LB0356.SPA SHELL CALITHIA EP2/P400
AT01C123D THU unit 324 left side, sample
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Absorbance
3000
2000
1000
Wavenumbers (cm-1)

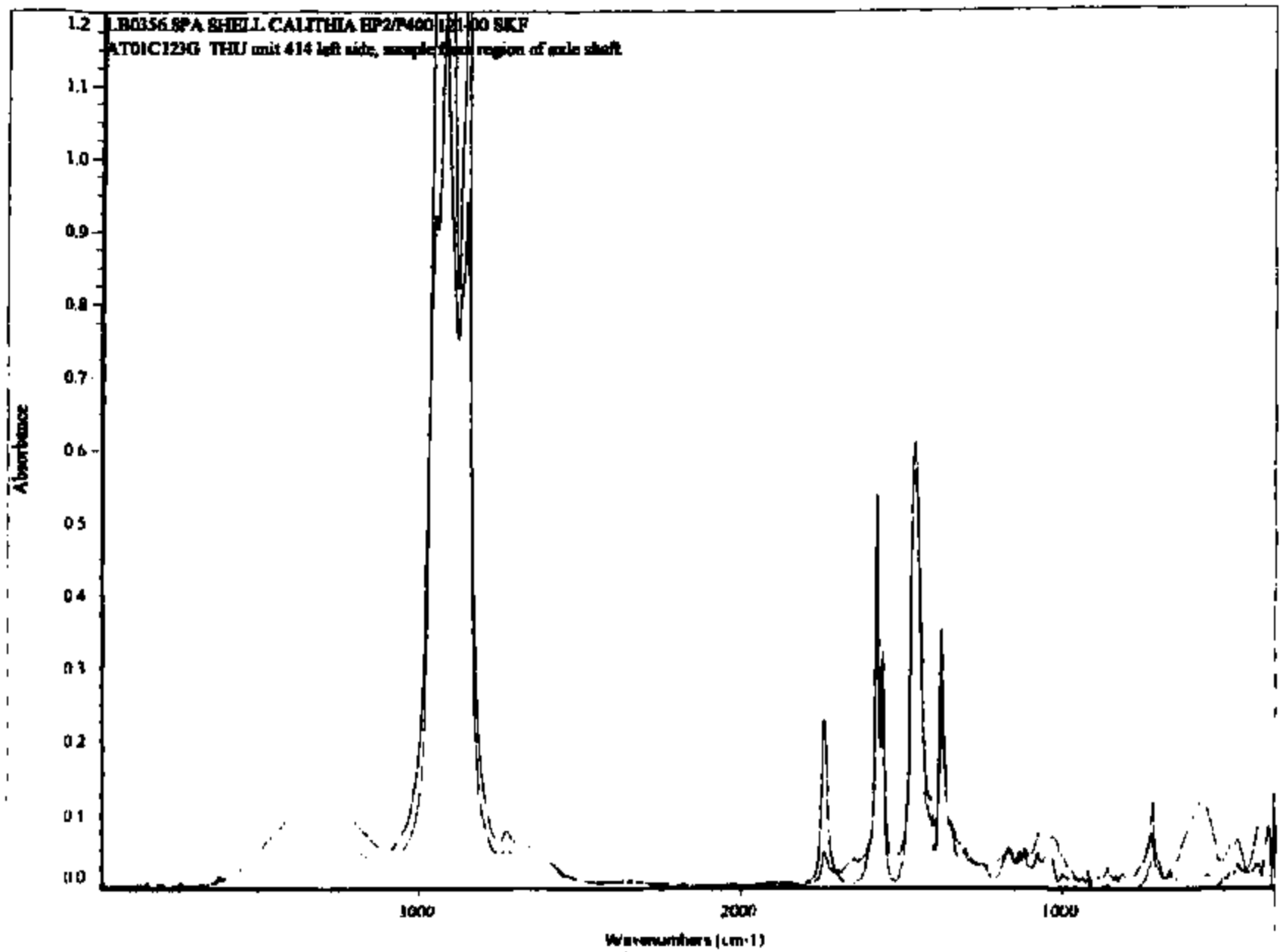
SKF 000


AT01C123E THU unit 328 left side, sample from region of axle shaft
LB0356.SPA SHELL CALITHIA EP2/N400 121-00 SKF
Absorbance
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3000
2000
1000
Wavenumbers (cm-1)

SKF 600179


LB0356.SPA SHELL CALITHIA EP2/P400
ATOIC123F THU unit 378 right side, sample from region of axle shaft
Absorbance
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3000
2000
1000
Wavenumbers (cm-1)

SKF 000180


LB0356.SPA SHELL CALITHIA HP2/P400 121-00 SKF
AT01C123G THU unit 414 left side, sample from region of axle shaft
Absorbance
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1000
2000
1000
Wavenumbers (cm-1)

SKF 000181

Review of Units Returned from Monson Trucking

June/July 2001

M. Lewis
B. Weeks
S. Brown

SKF

SKF 00112

UNIT NO.	MILEAGE	HUBODOMETER
305	743904	

MONSON TRUCKING, INC.

DATE	ORDER
10-28-02	1744[illegible]

MECHANICAL REWORK: YES ☐ NO

PARTS

QTY.	PART NO.	DESCRIPTION	COST	
1	HEFU OOTS 34	Steer Hub	608	91
or	2500572 C92			

TOTAL PARTS

TYPE	QTY.	GREASE & OIL	COST	

TOTAL GREASE & OIL

ANTIFREEZE AND MISC.

QTY.	DESCRIPTION	COST	

TOTAL ANTIFREEZE & MISC

JOB DESCRIPTION

1. Right steering hub making grinding noise.
2. VIN & 2HSFMAKR4VC034765 D.I.S. 3-31-97
3.
4. Hub [illegible]iously replaced. Date: 08 Aug 01
5. Mileage: 526,254
6. Note: End play not measured. Can feel grinding by rotating bearing by hand.
7.

COST SUMMARY

01.	LABOR	55
02	PARTS	608
03	OIL & GREASE	
04	ANTIFREEZE & MISC	
	SUBTOTAL	
05	SHOP SUPPLIES – 2%	
06	SALES TAX	
07	TOTAL	664

MONSON TREG DUL

SKF 00018

Unit 313

Background

Side:	Left
Mileage:	523,912 miles
Inner nut on torque:	375 ft. lbs (as measured by Monson prior to June 5th)
End Play:	Customer measured 0.0025"
	SKF/ARM measured 0.000" at 600 ft. lbs.

Observations:
Came off easily.

Unit 324

Background

Side:	Left
Mileage:	464,000 miles
Inner nut on torque:	450 ft. lbs (as measured by Monson prior to June 5th)
End Play:	Customer measured 0.000"
	SKF/ARM measured 0.000" at 600 ft. lbs.

Observations:

Unit came off easily. Right side was original wheel off in 2000. Left side returned for examination.

Unit 414

Background

Side:	Left
Mileage:	126,536 miles
Inner nut on torque:	600 ft. lbs (as measured by Monson prior to June 5th)
End Play:	Customer measured 0.004"
	SKF/ARM measured 0.003" at 600 ft. lbs.
	NATC measured 0.003" at 700 ft. lbs.

Observations:
Unit had plastic hubcap (inappropriate for truck production date). Original aluminum hubcap was lost at 88k miles for an estimated 150 miles. Unit came off easily.

June 7, 2001
Monson Truck Lines
FP981 Hub Issue

Summary of activities to date

- Approximately 15 months ago the right front wheel end came off Unit # 324. Repairs were made at Northwest IHC and vehicle put back into service. Parts not available for analysis
- Monson experienced 2 additional wheel end separations. The left wheel end separated on unit # 310, and the right side of unit 345.
- Parts for unit 310 and 345 were returned to ArvinMeritor for analysis by ARM (ArvinMeritor) and SKF. Additionally the right hub from unit 326 was returned at the same time due to end play findings of .004"
- Analysis of the hub from unit 310 exhibited corrosion in the outer bearing, caused by water ingression.
- Hub from unit 345 exhibited advance deterioration of the bearings. Root cause was not determined due to damage.
- Analysis of the hub from unit 326 exhibited water ingression in both bearing rows.

May 30, 2001

Mac Whittemore and Greg Anderson from ArvinMeritor held a meeting at Monson's headquarters to discuss the above findings. Present at that meeting were:

Mark Monson	Monson Truck Lines
Gene Scholz	ITE
Pat Galvin	Northwest International (via conference call)

Conclusion of the discussions were to do 1 or the other of the following:

- Replace all hubs on remaining 48 units
- Provide written document stating it is OK to operate remaining 48 units after the completion of fleet program to re-torque all wheel ends to 600 Lb Ft and measuring/ recording of end play.

May 31,2001

Mac Whittemore / Greg Anderson contacted ARM engineering for guidance. Jack McKenzie, Chief Engineer ARM axles, suggested formation of an investigation team to consist of ARM, SKF, and ITE personnel. Investigation to begin on or about June 4, 2001 Contacts made, team assembled including the following people:

From ARM:

J.P.Pan	Steer Axle engineer Asheville Plant
Mac Whittemore	Regional Service Manager
Greg Anderson	District Service Manager

From SKF

Mike Lewis	Manager Truck Applications Engineering

From IHC

Gene Scholz	Field Service Engineer

7-Step Corrective Action.

7-Step Initiator/Team Leader: Christopher Jones	**Phone:**(803) 663-8652	**Status**: Closed
	Fax:(803) 663-8611	**Issue Date**:07/26/02
Supplier: SKF USA Inc.	**Supplier Code**: 77248	**Revision Date**: 07/26/02
Location: SKF Automotive / Aiken 1084 International Pl. Graniteville, SC 29829	**Date of Occurrence**: 06/05/02	**Date Root Cause Ident** 07/20/00
Part No.& Description: BTF-0052	**Date PCA Identified:** 06/05/02	**Date PCA Implemented** 06/05/02
Source of Complaint: ArvinMeritor	**Date PCA Verified:** 07/01/02	**Date Closed**: 07/24/02
Line Affected: THU	**N/C Ticket Number**	**Referral Number** AK02THU004

8D Team: Chris Jones Quality Assurance Manager, Kevin Cannon Quality Engineer, Mario Winkler Channel Manager, John Thomas Electrical Engineer.

1. **Problem Description**

Two bearings were returned to Arvin Meritor from the field for warranty analysis. During the investigation it was found that both bearings did not contain any identification marks on the side of the outer ring flange. SKF has visually examined only one of the two bearings and determined that based on the seal installed in the bearing (Freudenburg) it is a BTF 0052 and therefore manufactured before April 6 Th. 2000 when a seal change was introduced. After further investigation it was also found that bearing did not contain the pin marked number placed on the outer ring after heat treatment. This fact means the bearing was produced before March 1 St. 2000 which is when the pin marker was introduced into the channel process as a corrective action. The second bearing has not been seen and therefore not even a rough manufacturing date can be determined.

2. **Interim Action / Containment:**

Total Bearings in house are 4,166 and the number break down is as follows:

2,562 BTF-0065 A (HUFFOUTS 32)

1, 604 BTF-0065 B (HUFFOUTS 34)

*** All bearings with operations conducted outside of the normal channel flow is logged into a rework log book by serial number and this provides an excellent opportunity to verify all markings are present.
All the above bearings have been inspected for bearing marking and found to be in full conformance

7-Step Corrective Action.

3. Root Cause. –

During the normal channel process the marking of the bearing on the flange outer diameter is the third operation from the final packing station. This means all turning , grinding and assembly operations are complete and in specification, the bearing is fully assembled with exception of the studs and ABS ring

After a detailed investigation it is felt that the bearings were not marked due to fault with the marking machine. The bearings continued through the remaining channel process having the studs and ABS ring fitted and passed visual inspection without the lack of marking being noticed.

Based on the results from visual inspection the below corrective action was implemented in 07/20/00. this will verify every cycle that the marking operation is complete prior to releasing the bearing to the next operation.

4. Corrective Actions:

* Implement in controller (machine logic) that an electrical feedback is given to the plc

(Programable logic controller) verifying the marking operation has been completed on every cycle.

Completion Date : 07/20/00.

* Modify channel program logic to eliminate any possibility to manually bypass the marking operation

Completion Date : 06/0502.

* Implement daily TPM check for stencil condition for damage and ware.

Completion Date : 07/24/02.

* Update PFMEA.

Completion Date : 07/31/02.

5. Verification:

Since the channel logic has been changed a total of 4543 bearings have been produced and verified for their marking. The serial numbers of these bearings have been recorded to ensure full verification.

6. Control

The channel program logic can only altered by two trained certified engineers, no operator intervention can occur to remove the verification and bypass over rides currently installed in the system

7. Prevention:

The measures outlined in this corrective action report will be considered permanent.

Chris Jones
Quality Assurance Manager
SKF Automotive Division
Aiken.

4

7-Step Corrective Action.

7-Step Initiator/Team Leader: Christopher Jones	**Phone:**(803) 663-8652 **Fax:**(803) 663-9611	**Status:** Closed
Supplier: SKF USA Inc.	**Supplier Code:** 77248	**Issue Date** 04/09/02
Location: SKF Automotive / Aiken 1084 International Pl. Graniteville, SC 29829	**Date of Occurrence:** 01/10/02	**Date Closed:** 07/18/02
Part No.& Description: BTF-0065	**Source of Complaint:** ArvinMeritor	**N/C Ticket Number**
Line Affected: FF-981 Easy Steer non-drive front axle		**Referral Number:** AK02THU003

7Q Team: Chris Jones - SKF Quality Assurance Manager, Mario Winkler - SKF Channel manager Kevin Cannon SKF Quality Engineer, Mike Lewis - Manager Truck Application Engineering, Bruce Weeks - Project Manager Application Engineering, Robert Bondy - Senior National Account Manager. William J Farrell - Chicago Rawhide - Sales, Roy Cinqurgrani - Chicago Rawhide Quality Control Manager, Bill Tubbs - Chicago Rawhide Quality Analyst, David Simms - Chicago Rawhide Senior Heavy Duty Application Engineer

1. Problem Description

ArvinMeritor contacted NATC in Detroit to report early failures concerning BTF-0065 units Preliminary Indication was failures were related to inboard seal flaws. Failed units serial numbers, manufacture dates, and the truck mileage are listed below:

Serial No.	Manufacturing Date	Mileage
0312174	10/17/00	109,318
0326003	01/05/01.	57,613
0332652	02/27/01.	60,934
0334602	03/09/01.	91,572
0321457	11/13/00.	89,353
0348640	07/24/01	21,093

2. Interim Action / Containment:

1.) All of the current SV-BTFB 4463269 CD R-Safe seal stock were sent to Chicago Rawhide in Elgin, for disassembly, cleaning and sorting. In addition, parts produced in CR Bethlehem that were rejected from Aiken stock and sent to Elgin have been scrapped. These parts were not sorted and/or reshipped.

2.) PPAP and purchase seal at new location (Chicago Rawhide - Elgin). Upon approval of the new seal, sorting was discontinued and only new 100% inspected product was used to replace all seals or build new bearings.

7-Step Corrective Action.

3.) Created new procedure and log book for replacing old seals with new ones, and implemented a identification plan for certified stock.

(Reference following Procedure and Log Sheet)

SKF SKF Standard & Practices Automotive Division Work Instruction (WI)	**THU 2.1** **BTF-0065 Steer** **SV-BTFB 446329 CD** **R-Safe Seal** **Rework Procedure**	Section WI 312.1 Page 2(2) Issue 1 Date 04 02 Compiled by klc Approved by cb Location SKF Aiken

1.0 PURPOSE

The purpose of this procedure is to provide guidelines for the correct rework of replacing the SV-BTFB 226329 CD inboard seal and the applicable makings required after completion of rework.

2.0 SCOPE

This procedure applies to supervisors, production team members, and anyone assisting within the THU 2.1 Channel in SKF Aiken, SC.

3.0 DEFINITIONS

3.1 Nonconformance: Product or material that does not conform to the Customer requirements or specification.

3.2 Scrap: Product or material discarded because of an individual or multiple customer specification / requirement is not met.

4.0 PROCEDURE

4.1 Carefully, remove old inboard seal and scrap it.

4.2 Clean seal bore verifying no bore tight enters the grease.

4.3 Place bearing on channel for insertion of new seal and tone ring

4.4 Remove completed bearing from channel. Place "1 inch yellow dot" on back of bearing flange using paint stick and mask.

4.5 A.) If seal is a reworked (inspected) seal. apply a $^{1}/_{8}$ x $^{1}/_{8}$ "X" between the serial number and date code and on one of the machined bosses above the brake pilot diameter and record the serial number on form SKF-THU 036 to verify rework has been completed.

B.) If seal is an new seal (new mold), apply a ⅛ x ¼ "Z" between the serial number and date code and on one of the machined bosses above the brake pilot diameter and record the serial number on form SKF-THU 036 to verify rework has been completed.

4.6 Visually Inspect

4.7 Pack bearing

6.0 REFERENCES

6.1 Qd IP 465.1 Control of Nonconforming Product

THU 2.1 BTF-0065 SF-BTFB 446329 CD R-SAFE SEAL REWORK SIGN OFF CHECK SHEET

Rework Date: _____

SERIAL #	A	B	SERIAL #	A	B	SERIAL #	A	B

Verification Signature: _____ **Date:** _____

SKF-THU 036 (04/2002)

4.) Quarantined all stock in Aiken, Statham Warehouse, and immediate return of all stock at ArvinMeritor for the replacement of old seals.

Total Number Of Bearings Reworked - 6,367
BTF-0065A - 3,347
BTF-0065B - 3,020

Total From all Meritor Facilities - 1442
From Meritor Fletcher - 810
BTF-0065A - 648
BTF-0065B - 162

From Meritor Florence - 632
BTF-0065A - 459
BTF-0065B - 173

Bearings in Aiken: Total 3,429
BTF-0065A - 1,630
BTF-0065B - 1,799

Bearings from Statum Warehouse: Total 1,496
BTF-0065A - 810
BTF-0065B - 686

3. Root Cause:

Inspection of seals produced at CR Bethlehem from the returned Aiken stock showed visible signs of potential leak defects for the following conditions: Unfills, manual knife trim damage, flowlines, and soft spots. In conversations with CR Bethlehem staff, they agree that these were major problems that the plant contended with during their production runs and any one of these defects may have caused the seal failures. The 6 seals that were returned from the field had enough wear that any of these defects may have been worn away. There is only 1 seal with remaining evidence of seal defects, which was a unfill (void) on the wiper lip. Due to the fact that all of the defects mentioned may have been worn away and each will be treated as a potential root cause of seal failure.

4. Corrective Actions:

1. Unfills (or voids) occurred on the wiper lip and on the bond tab on the side-wall of the part There are several potential reasons why this occurred on CR Bethlehem production which are reflected on the Elgin PFMEA. However, it was identified that the root cause for the unfills was the lack of proper clearance in the mold to allow the metal stamping to fit into the mold. This lack of clearance in a nonfunctional portion of the mold did not allow the metal stamping to fully seat in the mold cavity. As the rubber entered the mold cavity to fill out the seal, the proper rubber path was reduced by the unseated metal stamping. In some cases, the force of rubber never overcame this resistance soon enough and the rubber cured up before filling out the seal. This created unfills (voids) on both the wiper lip and on the side-wall of the part. The corrective action was to remove the interference point to allow the metal to seat fully in the mold This is located in a nonfunctional portion of the mold. There is no change to dimensional data, and this was confirmed with dimensional verification which was included in the PPAP to Aiken

7-Step Corrective Action.

2. Regarding the potential for Dirty Mold, we concur with the findings from original TER completed by CR Bethlehem on this part number. Elgin follows similar procedures for auditing and inspecting for dirty mold and follows a break in process with mold release to prevent Dirty Mold from causing seal defects. However, there is one addition corrective action. Micron Mold Release used during CR Bethlehem production is acceptable with 490 rubber, however there is a newer technology mold release agent that is available. This product (Chemtrend) is used for all 490 rubber during the break in and molding process. This substitute product allows the mold to run cleaner and substantially reduces the potential for this failure to occur

3. Next, the damaged to the primary lip was caused by manually trimming the part with a knife blade. The need for trimming arouse due to the high picker flash left on the part. The high picker flash is caused by damage to the gate area of the mold, but is controllable by mold release and press parameters. In Elgin production, there has not been any trouble with high picker flash thus far. Regardless, there are 2 corrective actions. One, if any picker flash does occur, the parts will be scrap, instead of reworking with a knife trim. Secondly, if picker flash does become an issue, the corrective action will be to replace any mold cavities with damage to the gate area with replacement mold inserts and re-qualify the mold internally.

4. Flowlines on the contact points is noted on both CR Bethlehem and Elgin production. Re-facing the radial grind on the lands of the mold cavity is a routine maintenance item needed to be completed when the mold arrived in Elgin. This process allows for air to escape the mold as the rubber enters the cavity. In addition, mold release can create flowlines, for which the fore-mentioned changes to mold release and re-facing of the lands helps to control this defects

5. Verification:

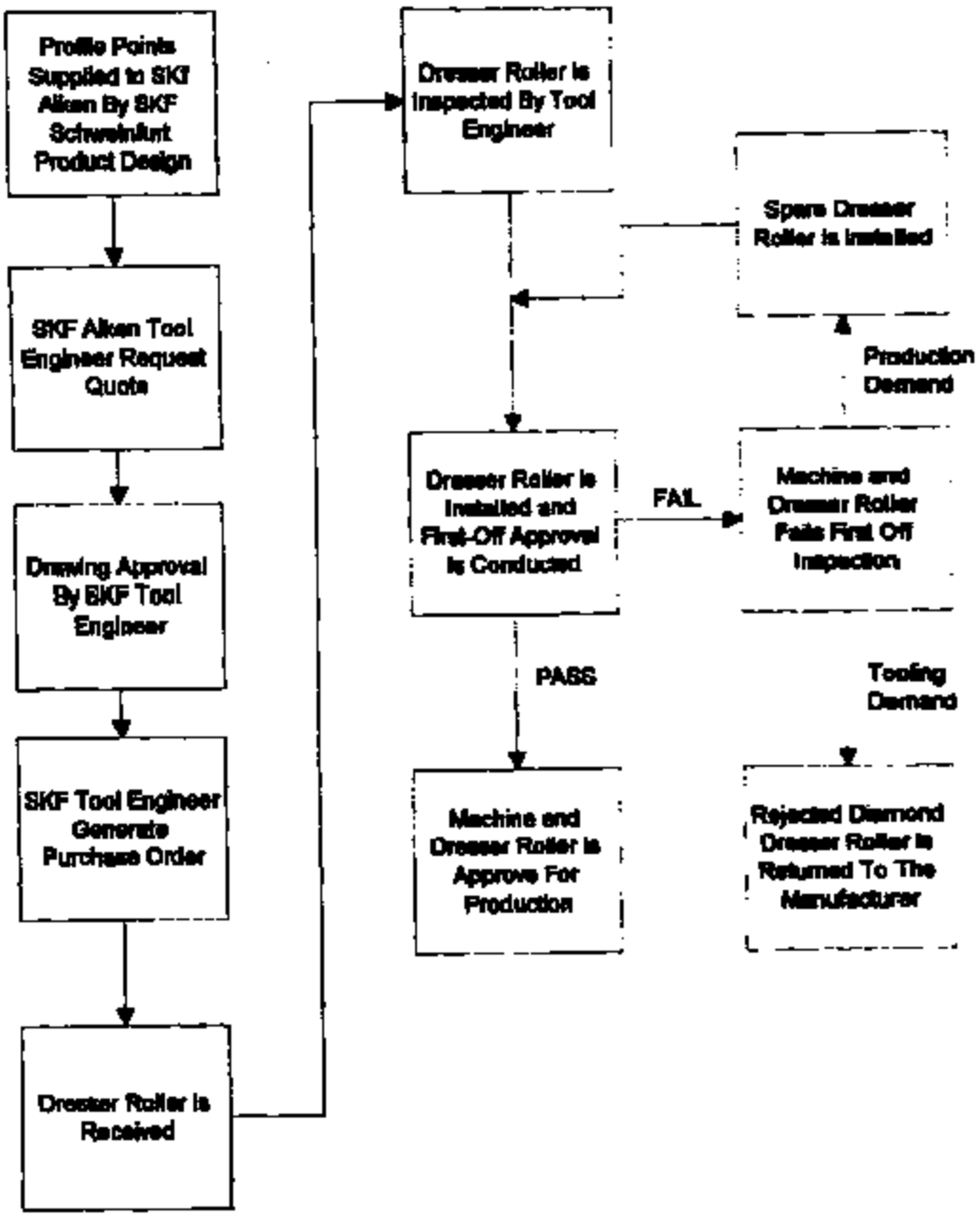
Although each of the defect conditions covered above are controllable as described, each part will be is 100% visually inspected. However, as an additional verification, a 100% functional test will be conducted on all seals. The test (Air Leak Down) will be performed before the assembly process. The Leak Down process will sort out all of the defects listed above and prevents any molding defects from being assembled and shipped. The Leak Down is performed by putting the seal into a fixture that seals at both contact points. Then, air is introduced into the fixture and the test equipment measures the rate of air pressure decay. Any leak path caused by molding defects will be detected by the lack of ability for the seal to contain the air pressure. This leak test simultaneously checks the wiper lip and primary lip of the seal MSA for Leakdown has validated the effectiveness of the test.

All corrective actions were completed before start of production in Elgin with the exception of the air Leak Down. All seals produced before implementation of Leakdown were 200% inspected to "oil seal" standards which have Zero Allowable defect size or quantity on the sealing surfaces. The Leakdown equipment is complete and will ready for production 4-25-2002. Implementation and training is being completed and from this point forward, all seals will be 100% leak down tested as an added precaution.

UPDATE 5/23/2002

The final action item for 100% leakdown testing was implemented on 4/25/2002. On 4/30/2002, the 1000 piece shipment contained only 100% leakdown tested parts, as well as all other shipments since that date.

DIAMOND DRESSER ROLLER APPROVAL FLOWCHART



BTF-(A / B / AA / BA				
Component list	Part No.	Traceability	Frequency	Tracking Process
Cage	CJ-BTF-0030	Manufacturing Date	Each Box	Operator Log entry at Change-over and when Batch Lot No. and or Product Manufacturing Date change
Grease	GREASE EP2 LF	Batch Lot No.	Each Drum	
Inner Ring Forge	JM-BTF-0030	Order & Heat No.	Each Box	
Outer Ring Forge	OF-BTF-0030	Die Code	Each Unit	
Roller	RT-502L	Manufacturing Date	Each Box	
Clip	RR-BTF-0030	Delivery Date	Each Box	
Seal	SR-BTF-0026	Manufacturing Date	Each Box	
SF Seal	SV-BT-20026EA	Manufacturing Date	Each Box	
Stud	VB-BTF-0062A	Batch Lot No.	Each Box	
Stud	VB-BTF-0062B	Batch Lot No.	Each Box	
ABS	VF-BTF-0042	Manufacturing Date	Each Box	

BTF-0065 A & B				
Component list	Part No.	Traceability	Frequency	Tracking Process
Cage	CJ-BTF-0031	Manufacturing Date	Each Box	Operator Log entry at Change-over and when Batch Lot No. and or Product Manufacturing Date change
Grease	GREASE GWZ	Batch Lot No.	Each Drum	
Inner Ring Forge	JM-BTF-0035	Order & Heat No.	Each Box	
Outer Ring Forge	OF-BTF-0075	Die Code	Each Unit	
Clip	RR-BTF-0052	Manufacturing Date	Each Box	
Roller	RT-502L	Delivery Date	Each Box	
Seal	SR-BTF-0050	Manufacturing Date	Each Box	
R-Sale Seal	SV-BTFB-446326CD	Manufacturing Date	Each Box	
Stud	VB-BTF-0062A	Batch Lot No.	Each Box	
Stud	VB-BTF-0062B	Batch Lot No.	Each Box	
ABS	VF-BTF-0031	Manufacturing Date	Each Box	

SKF 008227

Traceability documentation for BTF 0065

Part designation: **R - Safe Seal**

Part number: **SV - BTFB - 446329 CD**

Date: .....

Label:

Julien date:	Batch lot number:	Incoming release date	Remarks:

Traceability documentation for BTF 0065

Part designation: **Stud**

Part number: **VB - BTF - 0062 B**

Date: .....

Julian date:	Batch lot number:	ncoming release ate:	Remarks:

Traceability documentation for BTF 0065

Date: .....

Part designation: **Outer Ring Forge**

Part number: **OF-BTF-0075**

Label:

Julian date:	Reference to Die Code	Incoming release date:	Remarks:

NL02T903e
2002-07-10

Meritor THUs from the Field: Visual Inspection.

Gunnar de Wit

Materials Theory & Testing

SKF 006237

Meritor THUs from the Field: Visual Inspection.

NL827903e
2002-07-10

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Key Words	THU

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Meritor THUs from the Field: Visual Inspection.

Abstract There have been incidents with THUs in the USA. Three run units, taken from the field, were supplied to ERC for investigation. This visual inspection showed that the bearings had run under poor lubrication conditions. The reason for this is most likely ingress of water in the bearings. It has been defined what further investigations are needed to deliver the proof for a more definite and complete root cause for the failures.

Project background

There have been incidents with THUs in the USA. These run units, taken from the field, have been supplied to ERC for investigation and modelling. A visit to SKF Schweinfurt was made to inspect other unfailed as well as failed THUs. A remarkable fact is that the same type of THUs are functioning well here in Europe.

Objectives

To visually inspect the THUs received from the field and to define further investigations.

Main results

The three THUs delivered to ERC had not failed and could still have been used in the field. These THUs were in the ideal condition for a determination of the applied running conditions. These showed to have been tough for the bearings in term of the lubrication conditions, most likely caused by water ingress.

The unfailed THUs in Schweinfurt showed a very similar appearance as the three THUs at ERC.

The failed THUs in Schweinfurt showed the logical result of what would happen to the unfailed bearings if they had been used longer.

The detailed results of the visual inspection are shown on the following pages of this report.

Main conclusions and recommendations

Some of the conclusions are only indicative, i.e. further investigations, microscopy with higher magnification (SEM), grease analysis and X-ray analysis, are needed for confirmation and/or determination of the potential root cause for failure. Bearing this in mind the following route cause for failure is suggested as the most likely:

1. The application conditions for the THUs were not ideal.

1.a. Loose fit on the shaft, resulting in fretting corrosion in the bore of the inner rings.

1.b. High bending forces on the knuckle and/or shaft, resulting in fretting corrosion on both side-faces of the inner rings.

1.c. Poor surface finishing of the knuckle surface in contact with the inner ring (in-board) had an accelerating effect on the formation of fretting corrosion.

The recommended investigations are ongoing and are required for the confirmation of the following.

2. Water entering in to the THU on the bore/shaft position.

2.a. Resulting in found moisture corrosion.

2.b. Water entered also in to the grease, resulting in poor lubrication conditions, i.e. thin film.

3. The surface initiated spalling, as observed in eight THUs in Schweinfurt, was caused by poor lubrication resulting in adhesive wear, smearing and surface damage.

4. Modelling of the loading conditions could explain if these might have contributed to a (temporary) negative effect, e.g. during braking, on the lubrication conditions and therefore have had an accelerating effect on the failure process.

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SKF 600239

1. Results of the visual inspection.

In the report below the following abbreviations are used:
IB = in-board, OB = out-board,
IR = inner ring = cone, OR = outer ring.

The whole circumference of a ring is 360 ° with the loaded zone at 0 ° for the IRs.

The results of a short visual inspection of THUs in Schweinfurt are reported here as well and written in a different font, for clarity.

Three THUs, run but not failed, were delivered to ERC for analysis. The three THUs and some additional information are shown here below in table 1.

Case no.	Supplied IRs	Miles	Remarks
918279	IB and OB	596.184	596,___ miles was noticed elsewhere in the delivered documents.
918287	IB and OB	591.711	
317571	OB	560.228	

Table 1.

In addition to these three bearings some unfailed (7 THUs, 14 inner rings), see table 2, were inspected in Schweinfurt.

Claim no.	Marking	Miles	Remarks (by Ryder)
382038	IB, 1 of 2	484.508	One OB ring had seen starting to flake, some OB ring signs of creeping.
382038	IB, 1 of 2	484.508	
382038	OB, 2 of 2	484.508	
382038	IB, 1 of 2	484.508	
918280	OB, 1 of 2	466.773	Good condition
918280	IB, 1 of 2	466.773	
918283	RT	615.973	Inner cones sign of creeping.
918283	RT	615.973	
918283	Lf	615.973	Inner cones creeping
918283	Lf	615.973	
918285		581.925	Heavy fretting in bore.
918285		581.925	
317573	Right	543.562	No damage.
317573	Right	543.562	

Table 2. Inspected unfailed inner rings.

In addition some failed (and unfailed) THUs (8 failed and 5 unfailed inner rings, all IR, from 13 THUs), were examined, see below in table 3.

Ryder's code		Miles	Remarks
E1752375	IB	273 721	
E1750339	IB	689.347	
CWA06549	IB	385.007	
CWA07833	IB	?	Not failed
E1744715	IB	268.743	Not failed
E1752410	IB	192.639	
E1727708	IB	1.165.585	
E1755522	IB	403.298	
Ryder 33620	IB	482.615	
Ryder 33623	IB	515 339	Not failed
E1755539	IB	438 508	Not failed
Ryder 3617	IB	393 580	Not failed
E1752364	IB	308.528	

Table 3. Inspected inner rings, including failed ones.

And 2 failed THUs with different seals (R-seals), see table 4, were inspected in Schweinfurt. Due to time consideration these could only be briefly inspected.

Ryder's code		Miles	Remarks
E1752589	IB/OB	91.572	IB failed
33204	IB/OB	109.318	IB failed

Table 4. Two additional THUs, with different seals

Later a new bunchle was also delivered, from Schweinfurt to ERC, and visually inspected.

The performed inspections showed the following features.

1.1 Raceway appearances.

The raceways, contact paths, of the unfailed bearings showed in general a good appearance, i.e. the bearings could clearly have run longer.
The three bearings delivered to ERC showed running tracks being slightly shiny, see photographs in enclosure 1. The shiny appearance is an early stage of adhesive wear or surface distress. This is a strong indication of a not ideal lubrication condition. The difference between these three bearings was that the IRs of unit no. 918279 IB (in board) and no. 918287 IB were slightly more shiny and slightly discoloured. The 918287 IB inner ring had also indentations due to over rolling of particles.

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The unfailed bearings in Schweinfurt showed a very similar surface appearance as the three examined at ERC.
At 8 of the 13 bearings, in table 3, large spalls, length = approximately a quarter to a half of the circumference and full width, were present on the IR raceway. Since the spalls were very far advanced it is difficult to find the initiation point and hence the reason for failure. The spalls were in general shallow. The unspalled areas on the raceway of the rings were very shiny, i.e. advanced adhesive wear with plastic deformation of the finishing (grinding) lines and surface distress. The combined observations of the spalls and the surface appearance of the remaining raceway (i.e. the unspalled part) gave the indication that the spalling was surface initiated.

The rollers showed a (logical) corresponding appearance, i.e. for the unfailed bearings a slightly shiny surface.

For the failed bearings the damage was, logically, in a more advanced stage, i.e. stronger shiny appearance and even small spallings on the running track of the rollers.

For the appearance of the roller ends (in contact with large flange) see chapter 1.4.

1.2 Fretting corrosion.

On several surfaces fretting corrosion was observed, these were:

- inner ring bore. All investigated rings, at ERC *as well as in Schweinfurt*, fretting corrosion was found in the bore. This varied from being hardly visible to very strong in appearance. There was a clear tendency that the ring in the in-board position had stronger fretting than the ring in the out-board position. The fretting was, logically, concentrated in the loaded position. However, sometimes the fretting was present around the complete circumference, but, then mostly strongest in the loaded position.
Photographs are shown in enclosure 1, figures 1-4.

- inner ring side-face, thin section. All investigated rings, at ERC *as well as in Schweinfurt*, had fretting corrosion in this position. In some of the rings in Schweinfurt the fretting was present on the whole circumference. But the general appearance was that this fretting was concentrated (and started) at the positions 90 ° and 270 °. See photograph, figure 5, in enclosure 2.

- inner ring side-face, thick section. All investigated rings, at ERC *as well as in Schweinfurt*, showed to have fretting corrosion in this position. In some of the rings the appearance had a specific mode which could be related to the poor surface finishing of the corresponding surface on the knuckle. See photographs, figures 6-9, enclosure 2.

1.3 Moisture corrosion.

Corrosion, most probably due to the presence of water, was found in the following positions:

- inner ring bore, contact surface with shaft. This "normal" red rust was found on almost all rings. See photographs, figures 10 and 11, in enclosure 3.

- inner ring bore, thin section. This corrosion was found at the position where the load had been applied, 0°, which indicates that it occurred during stand-still. See photographs, figures 12 and 13, in enclosure 3.

- on the clamping ring. Also on these rings red rust was found. See photographs, figures 14-17, in enclosure 4.

- on the shoulder of IR large flange. *This was only found on four inner rings in table 3, of which one was not failed. On one of the shoulders the corrosion was present with a width corresponding to the full width of the seal. At the other three shoulders the width corresponded to half the seal width, i.e. the outer part and an indication of that the inner seal-lip still had functional well.*

1.4 Sliding/wear.

Sliding with resultant wear (smearing) was observed at the surface contact between the roller end and the large flange. All investigated rings, at ERC *as well as in Schweinfurt*, showed to have this. Some, not failed, showed to have small spalls, i.e. material broken out. Photographs are shown in enclosure 4, figure 18-19.
At some failed bearings this was very strong, with spalls on the roller end surfaces as well as on the flange. In two cases the flange was also blue coloured by heat.

For the sliding of the seals see next chapter, 1.5.

1.5 Seals & shoulders in contact.

As a result of the sliding of the seals on the shoulder of the large inner ring flange, shiny bands were noticed on the rings. This appeared in different severities and inspection of the seals showed corresponding wear of the seal-lips. The wear of the seal-lips was judged as slight, i.e. most of the lips are still present and no indication for not functioning could be found.
See photographs, figures 20 - 24, in enclosure 5.

1.6 Other observations.

The general appearance of the outer rings in the THUs at ERC corresponded well to what had been noticed on the inner rings, i.e. still in relatively good condition.

In general the THUs at ERC were judged as THUs which were still functioning well.

The appearance of the bolts, on the three THUs at ERC, can be seen in enclosure 6. Moisture corrosion was present as well as on the large flange of the THUs. On the part where the nuts have been positioned wear of the thread was noticed.

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On the flange, around the bolts, it could be seen that the positioning of the wheels on the THU was off centre.

The inspected, unfailed, bearings in Schweinfurt, table 2, had also been inspected by Ryder. The following discrepancies in the results of the inspections were noticed:
At one ring flaking had been noticed by Ryder but could not be found.
For some rings creeping had been observed by Ryder but was also not found.

Some photographs of the in Schweinfurt briefly inspected bearings, from table 4, are shown in enclosures 7-10.

The results of the inspections performed by SKF in Schweinfurt are conforming very well with the results of the inspections performed in ERC.

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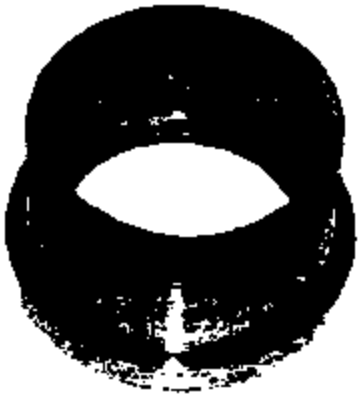

Fig. 1. 918279-B (IB) showing rather strong fretting corrosion in the position where the load had been applied. The 918279-A (OB) ring had no fretting.

Fig. 2. 918279-B-(IB) showing no fretting in the opposite position, where no load had been applied. Here the slight discolouring of the raceway, loaded zone, is visible.

Fig. 3. 918287-IB showing rather strong fretting corrosion in the position where the load had been applied. The 918287-OB ring showed a very similar appearance.

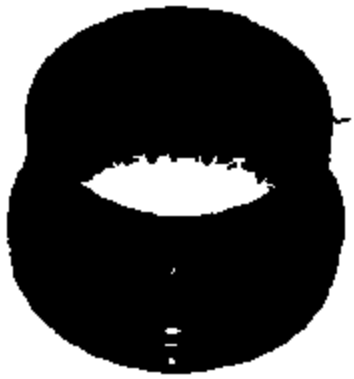

Fig. 4. 918287-IB showing slight fretting in the opposite position, where no load had been applied. Here slight discolouring of the raceway, loaded zone, is visible.

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Enclosure 2.

Fig. 5. Bearing: 918287-IB. Side-face small flange.
Fretting positioned at 90 ° & 270 ° from loaded zone.

Fig. 6. Bearing: 918287-IB. Side-face large flange.
Normal appearance of the complete circumference.

Fig. 7. Bearing: 918287-IB. Side-face large flange.
Special appearance locally. Only on the IB rings.

Fig. 8. See figure 9. Red square at higher magnificence.
This appearance was present in two positions opposite each other, approximately 180°.

Fig. 9. Red square showing position of figure 8.

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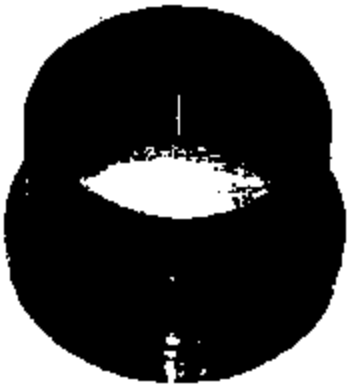

Fig. 10. Bearing: 317572-IR-OB, 90 ° from loaded zone. Showing moisture corrosion in the bore.

Fig. 11. Bearing: 317572-IR-OB, 270 ° from loaded zone Showing moisture corrosion in the bore

Fig. 12. Bearing: 918287-IB, bore is loaded zone. Showing the moisture corrosion in the bore at the thinnest section of the ring.

Fig. 13. Bearing: 918287-IB. Showing the moisture corrosion in the bore at the thinnest section of the ring, as shown in fig. 12

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Fig. 14. Clamping ring from no. 918279.
Showing the presence of moisture corrosion.

Fig. 15. Clamping ring from no. 918279
Showing the presence of moisture corrosion.

Fig. 16. Clamping ring from no. 918287.
Showing the presence of moisture corrosion.

Fig. 17. The bore of the clamping ring from no. 918287.
Showing the presence of moisture corrosion.

Fig. 18. Bearing 918287-IB-flange

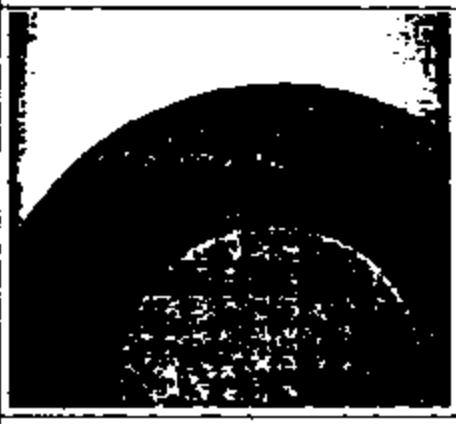

Fig. 19. Bearing 918287-IB-roller end

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Fig. 20.Bearing: 918279-B-(IB). Large flange shoulder.
Showing the wear marks where the seal-lips had been in contact.

Fig. 22. The seal out of 317572-IB.
Lips still almost as new.

Fig. 24. The seal out of 918287-IB.
Slightly worn outside lips.
The "dirt" is dark grease. Most being wiped off on the seals in figures 22 and 23 before photographing.

Fig. 21.Bearing: 918279-B-(IB). Large flange shoulder.
Higher magnification of fig. 20. Showing the wear marks where the outer seal-lips had been in contact.

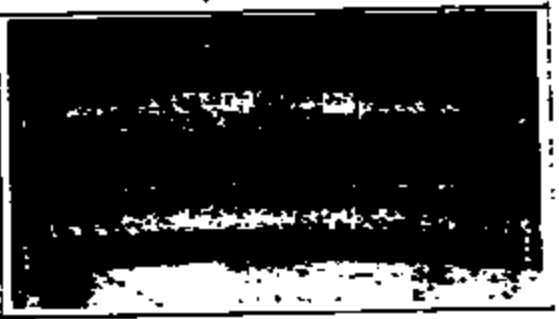

Fig. 23. The seal out of 918279-IB.
Very slightly worn outside lips. Inside lip (in position of the single white dot) hardly visible since grease is removed.

Lip inside. Single dot in fig. 23

Lips outside. Triple dot in fig 23

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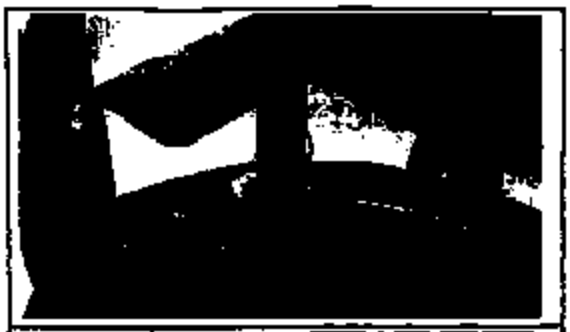

Fig. 29. Showing the appearance of bolts in THU no. 918279. Approximately half of the visible part of the bolts, closest to the flange, is showing wear of the threads.

Fig. 30. Showing the appearance THU no. 317572. The bolts being somewhat more corroded than in the other two THUs. The corroded area on the flange around the bolts are showing that the wheel has been positioned off center. This was the case for all three THUs.

Fig. 31. Showing the appearance THU no. 918287, being rather similar as no. 918279.

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Claim no.: R1752589. 91.572 miles. Failed inboard (IB) inner ring. With an O-ring on the spindle. The seal had a mounting defect.
The OB ring in this THU had only slight fretting in the bore at the loaded area, (0°), and slight wear on the flange/roller contact surfaces.

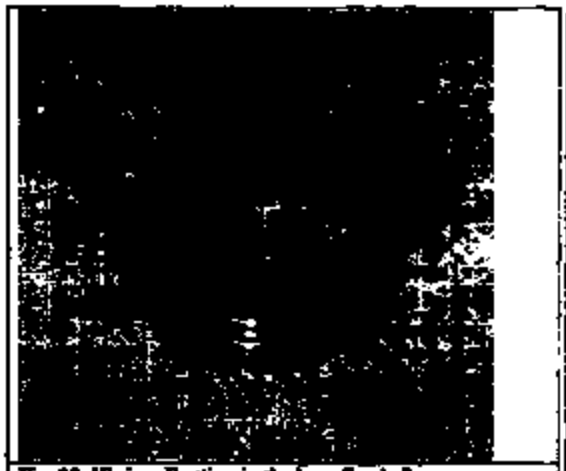

Fig. 32. IB ring. Fretting in the bore (loaded)

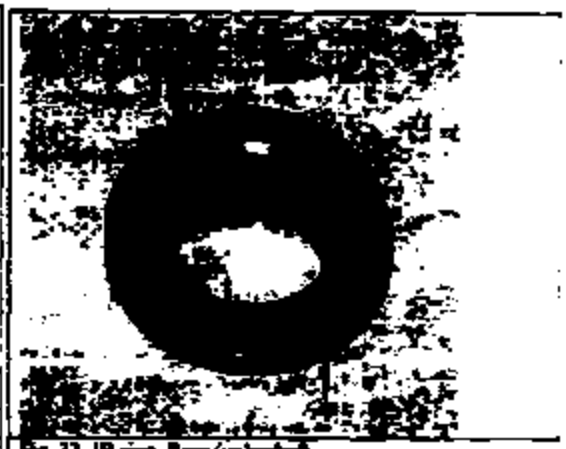

Fig. 33. IB ring. Bore (unloaded).
No fretting. No corrosion.

Fig. 34. IB ring. The scuffing (loaded).

Fig. 35. IB ring. Unloaded part.

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Claim no. 33204. 109.318 miles. Failed outboard (IB) inner ring.
The OB ring in this HUB had only slight fretting in the bore at the loaded area, (0°), and slight wear on the flange/roller contact surfaces.

Enclosure 6

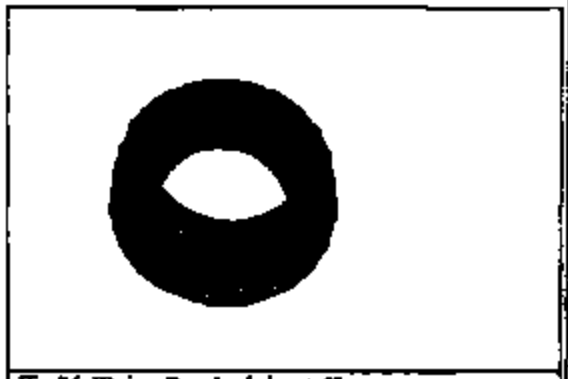

Fig. 36. IB ring. Bore loaded part, 0°.
Fretting (and possibly corrosion) present.

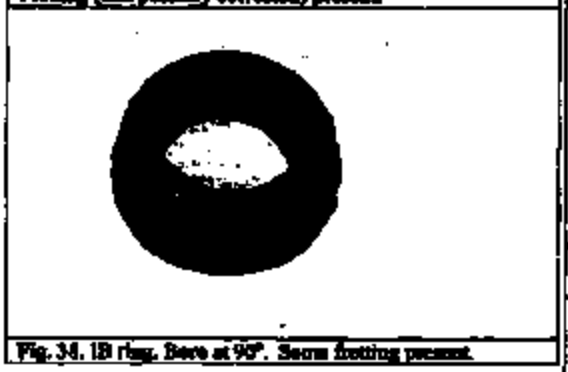

Fig. 38. IB ring. Bore at 90°. Some fretting present.

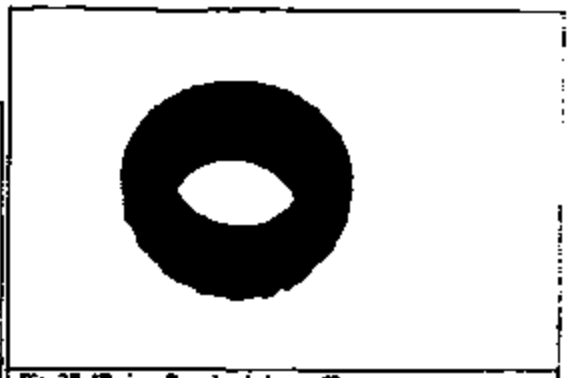

Fig. 37. IB ring. Bore loaded part, 0°.
Fretting (and possibly corrosion) present.

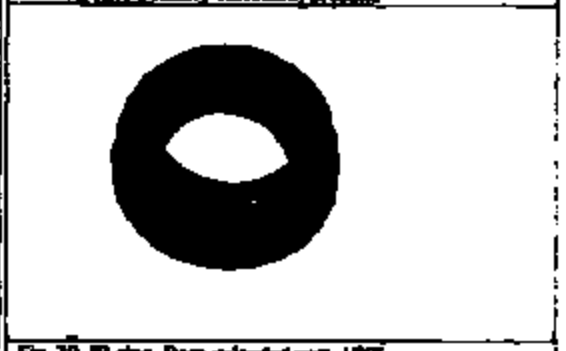

Fig. 39. IB ring. Bore unloaded part, 180°.
Fretting and/or corrosion present.

Fig. 40. IB ring. Bore at 270°. Clean area.

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Fig. 41. IB ring. Bore loaded part, 0°.
Fretting (and possibly corrosion) present.

Fig. 42. IB ring. Bore loaded part, 0°.
Fretting (and possibly corrosion) present.

Fig. 43. IB ring. Bore unloaded part, 180°.
Fretting and/or corrosion present.

Fig. 44. IB ring. Bore unloaded part, 180°.
Fretting and/or corrosion present.

Fig. 45. IB ring. The spall in loaded area (0°).

Fig. 46. IB ring. Unloaded area (180°).

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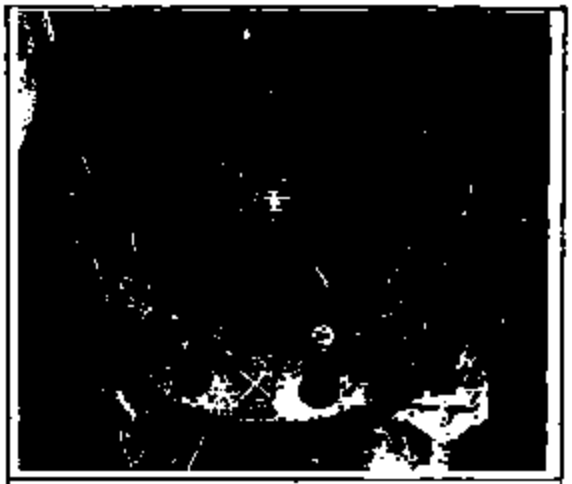

Fig. 47. Claim no.: E1752589. 91,572 miles.

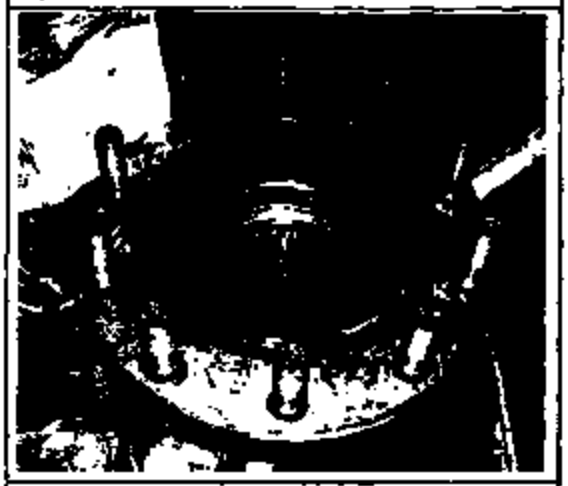

Fig. 48. Claim no. 13284. 109,318 miles.

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Supplementary Information for Interim Report NL02MT903e
2002-07-11

ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis

Aidan Kerrigan

Materials Theory & Testing

SKF 000253

EXTERNAL CUSTOMER
Report Supplement on Project No. N02 184

Supplementary Information on:

NLC2MT903e
2002-07-31

ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis

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Key Words	University of Surrey, x-ray photoelectron spectroscopy, iron oxide, corrosion, aqueous, humid

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ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis

Abstract The inner ring of a THU from the field was supplied to the University of Surrey, UK, for analysis using x-ray photoelectron spectroscopy. The objective was to determine the chemical species of various areas of the bore, which were different in appearance.

Project background

There have been incidents with THUs in the field in the USA. Examples of THUs from the field were supplied to ERC for investigation. One specific question was regarding the corrosion products seen on the bore of the inner rings. In the bore, at the highest loaded position (nominated as 0°), there was a darkened red area, which would normally be classed as fretting corrosion. However, there was also a light red area at the 180° position, which was regarded as unusual. In general, the chamfer was not discoloured but there was a free-standing red area on the chamfer i.e. in a non-contacting location.

In order to classify these products, an inner ring was supplied to the University of Surrey, UK, for analysis using x-ray photoelectron spectroscopy (XPS). This technique is used to determine the chemical species by measurement of the chemical bonding energies.

It is important to state that the University of Surrey were not given any information other than that the part supplied was a taper roller bearing inner ring and given clear instructions of the areas to analyse. No manufacturing, application or customer information was given. As a result, the investigation and report from the University (incorporated into this report in its entirety) covers more than just the oxide species.

Objectives

To determine the chemical species present in the bore of a THU inner ring returned from the field.

Main results

According to the results and interpretation from the University of Surrey, the products in the bore of the THU inner ring at the 0° and 180° positions were an Fe(III) compound, most probably FeOOH, which were formed in a humid environment i.e. in the presence of water.

It should be noted that at the 0° position, the finish machining marks were not apparent but that at 180°, the finish machining marks were still visible.

On the (non-contacting) chamfer, the non-discoloured surface had an Fe_2O_3 type of deposit. This was stated to have been formed in a dry environment, at a 'slightly elevated' temperature, probably during heat treatment.

The free-standing red area on the chamfer was analysed and also found to be an Fe_2O_3 type of deposit, again formed in a dry environment.

The remarks about carbon for the areas on the chamfer are possibly explained by the fact that the general surface will have an oxide which formed during austenitising and was then oil quenched, picking up carbon. The other area may have formed after the quenching treatment, giving a lower carbon content. Note that this is very speculative.

The results at the 0° and 180° positions in the bore, as compared to the results from the chamfer, indicate that the technique can differentiate between different oxide species.

Main conclusions and recommendations

The products in the bore of the THU inner ring at the 0° and 180° positions were an Fe(III) compound, most probably FeOOH, which were formed in a humid environment i.e. in the presence of water.

Additional comments

For clarity, the codes used by the University of Surrey will be explained here in relation to the ERC description of the products in the bore.

	ERC	University
0° in bore :	Darkened red area	SKF 01
180° in bore :	Light red area	SKF 02
Chamfer :	Free-standing red area	SKF 03
Chamer :	Non-discoloured area	SKF 04

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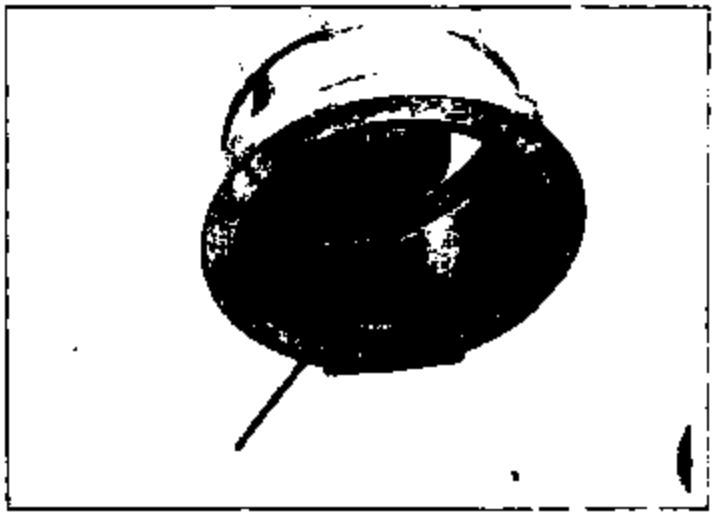
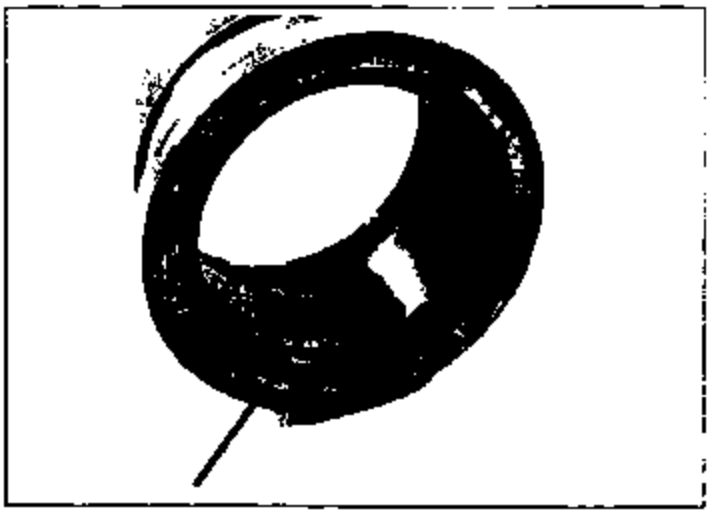
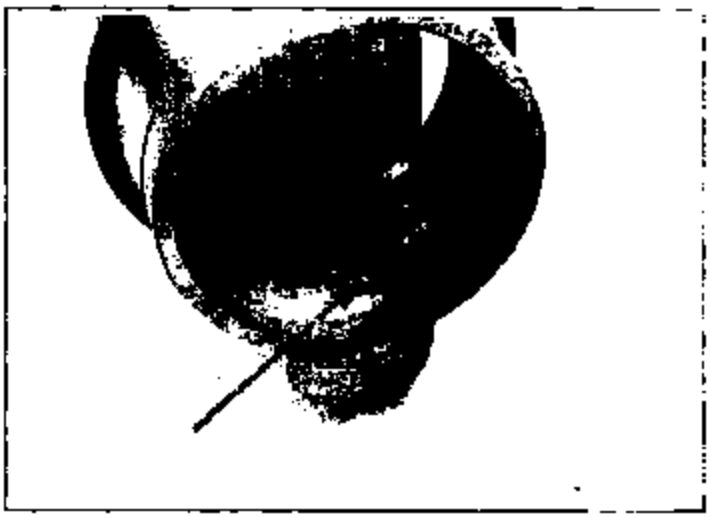
Photographs supplied to the University of Surrey



Darkened red area on bore (0°)



Light red area on bore (180°)



Free-standing red area on chamfer

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UniS

XPS Analysis of Discolouration on Bearing Inner Ring #11

J F Watts & S J Greaves

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July 2002

Prepared for:
SKF Engineering & Research Centre BV

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XPS Analysis of Discolouration on Bearing Inner Ring #11

J F Watts, S J Greaves

Executive Summary

Surface chemical analysis of "Bearing Inner Ring #11" was carried out by X-ray photoelectron spectroscopy (XPS). XPS is a surface chemical analytical technique with an analysis depth of approximately 8 nm. Samples were cut from the bore and the chamfer of "Bearing Inner Ring #11", these were identified (by the customer) as darkened red area in bore (SKF01), light red area in bore (SKF02), free-standing red area on chamfer (SKF03). In addition an analysis from an unblemished region of the chamfer (SKF04) was also required.

Analyses from specimens within the bore indicate both the darkened red and the light red discolouration (SKF's descriptions) to arise from an Fe(III) compound, most probably FeOOH, which has been formed in a humid environment.

Both analyses indicate significant surface concentrations of surface carbon contamination which is predominantly hydrocarbon in nature with the presence of some C=O organic functionalities.

The analyses from the chamfer are both of an Fe_2O_3 type of deposit. The one identified as a free-standing red area on the chamfer is a voluminous (high surface area) form whilst that from the unblemished region of the chamfer is a thin passive film of the same composition probably resulting from a heat treatment procedure at some point in the ring's thermal history.

Minor elements (Ca, Na, F, K and N) are detected in low concentrations at all analysis positions but it is not possible to relate these, either qualitatively or quantitatively, to the performance of the bearing ring in service on the information supplied.

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XPS Analysis of Discolouration on Bearing Inner Ring

J F Watts, S J Greaves

Preamble

A bearing shell identified as "Inner Bearing Ring #11" was supplied complete by the customer along with a series of digital photographs that identified regions of concern regarding the physical appearance on both the bore of the bearing and the region identified as the chamfer. The descriptions of these regions of discolouration, and those that are used in the following reports are as follows:

Darkened red area in bore
Light red area in bore
Free-standing red area on chamfer

In addition we were also instructed to carry out analysis on a region of the "chamfer" that was not discoloured, this is identified as:

Non-discoloured area on chamfer

In the attached spectra these analysis zones are given the following codes:

SKF01
SKF02
SKF03
SKF04

The bearing shell was sectioned in University of Surrey workshops to provide relatively large pieces of the bearing ring for analysis, with the regions of interest identified in the customers photographs Large specimens were used in order to avoid thermal effects that will be present near the machined surfaces, no cutting fluid was used to avoid the possibility of the modification of the surface chemistry of the regions of interest by the use of such reagents. A series of views of the sectioned bearing ring is shown in Figure 1.

XPS Analysis

The sectioned specimens were mounted for analysis on the platen of our Thermo VG Scientific Sigma Probe spectrometer. Analysis was carried out using AlKα radiation, and a survey spectrum over the region 0 – 1340 eV (binding energy) was first recorded from each region at a channel width of 0.4 eV. High resolution spectra were recorded on the basis of the elements identified in the survey spectrum These were typically C1s, O1s, N1s, F1s, Ca2p, Fe2p, Na1s, depending on the specimen. All survey spectra and high resolution spectra acquired are appended to this report. The binding energies of the principal photoelectron core levels observed are listed in Table 1.

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Carbon 1s Data

The concentrations of carbon observed on these specimens are, in three cases, at a level to be expected from samples that have been exposed to the ambient environment in a relatively uncontrolled manner, with perhaps the presence of residual carbonaceous material from previous processes. In the case of the spectra recorded from the free-standing red area on the chamfer (SKF03) this value is much lower at 15 at %. This is unusual and provides significant clues to the form of the visually identified deposit, it is of a high surface area type and has formed within a relatively recent timescale, as it has not been contaminated in the manner the other regions have experienced.

Minor Elements

Small surface concentrations of Ca, Na, F, K and N are detected on all specimens. Ca is often associated with tap water and is slightly higher on analyses recorded from the bore than the chamfer regions. F is significantly higher on analyses from the bore than the chamfer and it is not possible at this stage to speculate on the source of this element. Na is a common contaminant from physiological media and does not vary significantly between the different specimens. Likewise the N levels seem fairly consistent from one to another. K is significantly higher on the specimen SKF03 and this most likely indicates it is intimately associated with the corrosion product. In other samples the higher surface concentration of carbon attenuating the K2p signal.

Chemical State Information

Although most of the high resolution spectra contain little information of spectroscopic significance the Fe2p, O1s and C1s spectra are particularly informative.

Iron 2p Spectra

The 2p region recorded shows both the Fe2p3/2 and Fe2p1/2 components resulting from the spin orbit splitting of the Fe2p electrons. The binding energy is consistent with the Fe(III) state and this is confirmed by the presence of Fe2p3/2 satellite structure on the higher binding energy side of the valley between the Fe2p3/2 and Fe2p1/2. Thus the outer regions of the deposit (at the depth analysed by XPS, ca. 8 nm) is Fe(III) state in all cases. Fe(III) is the equilibrium phase likely to be formed in an excess of corrodant (oxygen or water), in a reduced partial pressure of oxygen Fe(II) is more likely to form.

Oxygen 1s Spectra

In the case of spectra SKF01 and SKF02, the O1s spectra [figures 8 and 16] have two well defined components at approximately 530 and 533 eV. Such observations are consistent with oxide and hydroxide components, indicating that the terminal phase is most probably FeOOH. This is the reaction product associated with the corrosion of iron in an aqueous (damp) environment. Indeed the exposure of pure iron to water vapour in clean, UHV conditions gives rise to a thin film this compound as does the exposure of mild steel to the ambient environment for short times of a few days.

The other spectra, SKF03 and SKF04 have an altogether different form of O1s line [figures 24 and 32]. In these cases the oxide component at 530 eV is dominant and the hydroxide contribution is merely observed as a broadening on the higher binding energy side. This is consistent with an oxide formed in a dry environment, possible at a slightly elevated temperature. The Fe2p and O1s data taken together indicate that the non-discoloured region (Specimen SKF04) is probably a thin (passive) film of Fe_2O_3 formed during the production process. The corrosion product (SKF03) is of similar chemical composition (Fe_2O_3) but of a more voluminous physical form.

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Carbon 1s Spectra

In all cases the spectrum is centred at a binding energy of ca. 285 eV as expected. This is the position typical of adventitious carbon and for charge referencing purposes this can be set to exactly 285.0 eV if required. All spectra have a higher binding energy component centred at approximately 286 eV which is attributed to carbon bonded to oxygen in the form C=O. In the case of the low carbon concentration (SKF03) this is associated with polar carbon adsorbed from the atmosphere but in the case of higher carbon concentrations such those observed on specimens SKF01, 02, 04, such polar contributions would be swamped by the apolar carbon. This leads to the conclusion that the source of carbon on these samples is something other than the usual adventitious material, i.e. a specific source which includes a carbonyl functionality.

Conclusions

The analysis by XPS of four regions of "Inner Bearing Ring #11" enable the following conclusions to be drawn:

- The characteristics of the analyses taken from the two regions within the bore ("darkened red area" and "light red area") are very similar.
- These two analyses (SKF01 and 02) show iron in the Fe(III) state and equivalent contributions of oxide and hydroxide which would arise from the formation of a FeOOH phase in a damp environment:

$$Fe + H_2O \rightarrow FeOOH$$

- $Fe_2O_3.2H_2O$ would have a dominant oxide component of the O1s spectrum but cannot be completely ruled out.
- The surface concentration of F is significantly higher for the SKF01 and 02 specimens than for SKF03 and 04.
- Analyses taken from the chamfer region (SKF03 and SKF04) both yield O1s spectra dominated by an oxide component, consistent with the corrosion product (SK03) and passive film (SK04) having formed in a dry environment, possible at elevated temperature.
- The corrosion product on the chamfer (SKF03) is of a high surface area and has not been exposed to gross hydrocarbon contamination (e.g. oil) since its formation.
- The surface concentration of potassium is higher in analyses taken from the chamfer than the bore.

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SKF Comment - by Aidan Kerrigan

The first and second conclusions in the report from the University of Surrey state that the species in the two positions of the bore of the inner ring (at 0° and 180°) have similar characteristics and match those that would be expected from the formation of FeOOH in a damp environment.

The third conclusion, which states '$Fe_2O_3.2H_2O$ would have a dominant oxide component of the O1s spectrum but cannot be completely ruled out', has been stated by the University of Surrey as there is a small possibility that the oxide is $Fe_2O_3.2H_2O$ rather than FeOOH. However, as is implied by the formula, $Fe_2O_3.2H_2O$ is also formed in a damp environment. Therefore, the main conclusion remains that the oxide species found in the two positions in the bore were formed in a damp environment.

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SKF01 Darkened red area in bore

C1s

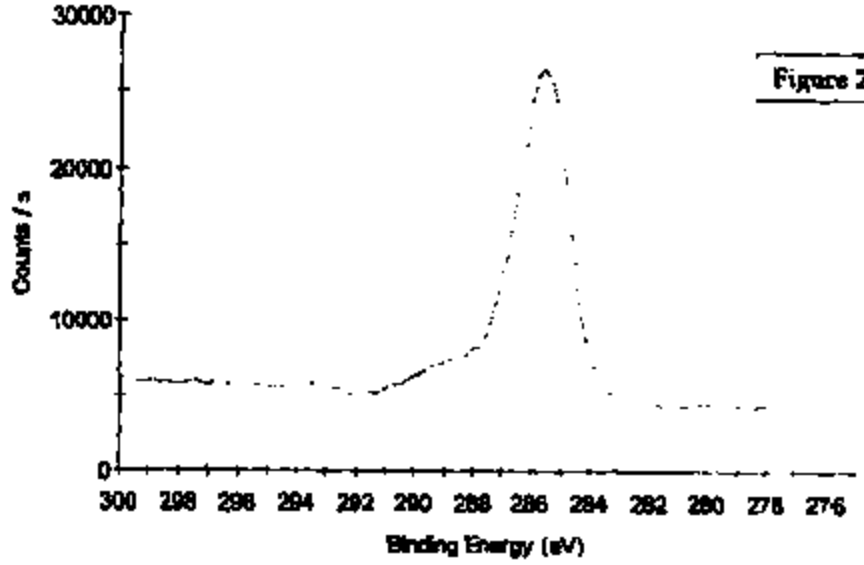

Figure 2

Ca2p

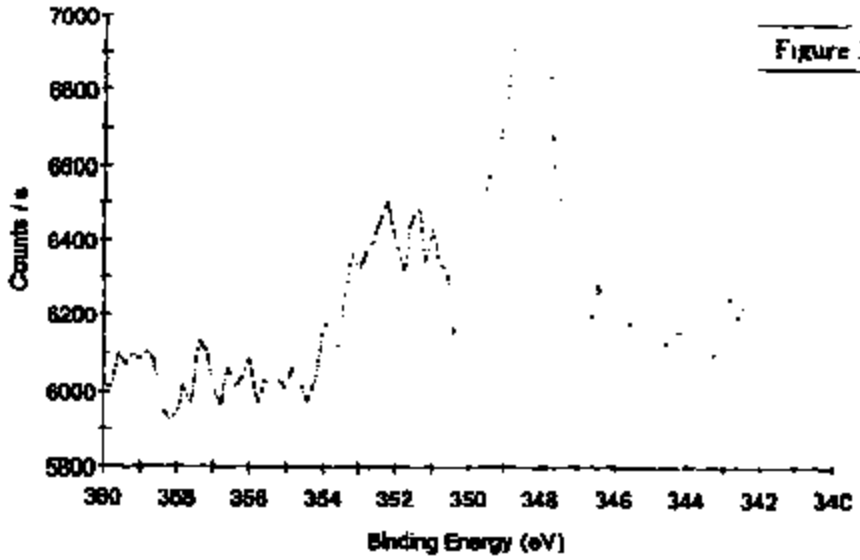

Figure 3

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F1s

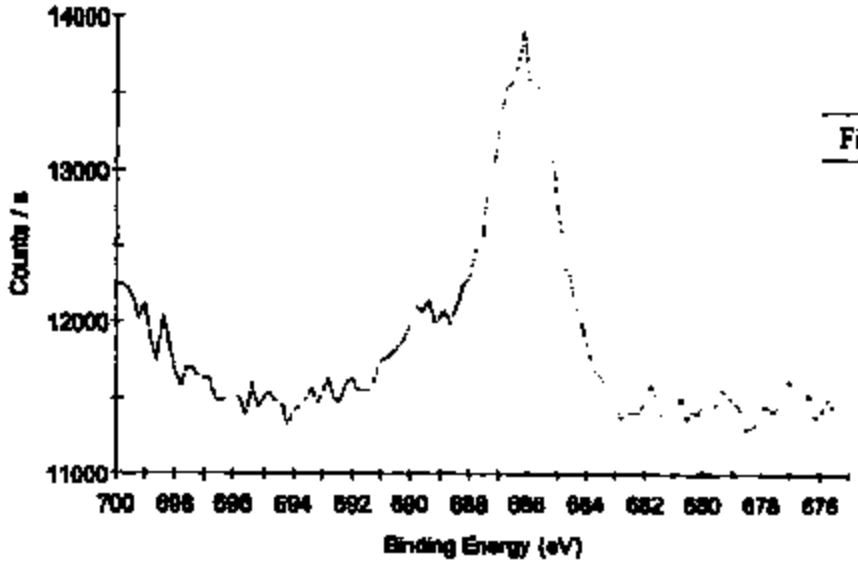

Figure 4

Fe2p

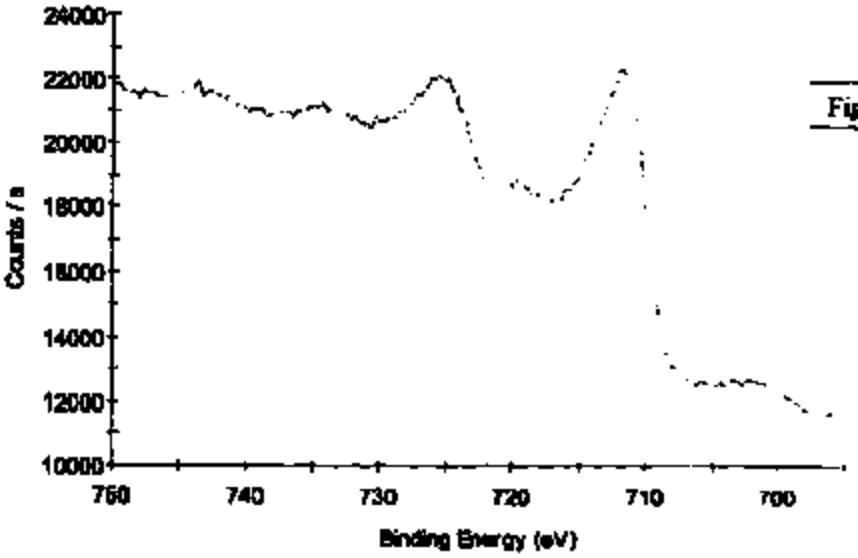

Figure 5

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N1s

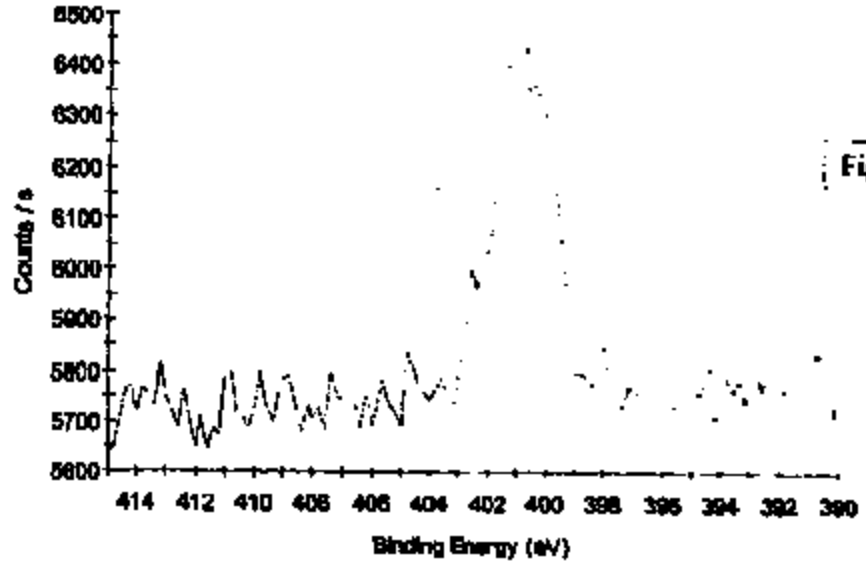

Figure 6

Na1s

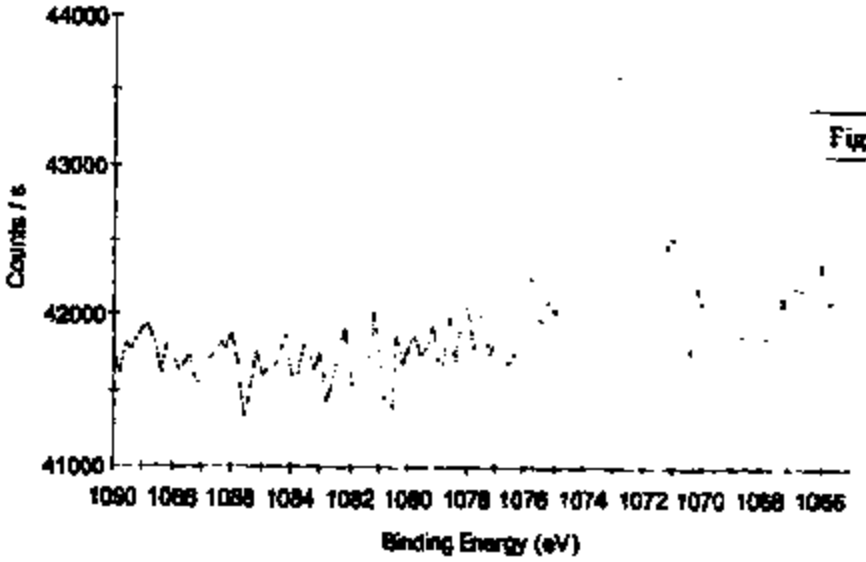

Figure 7

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O1s

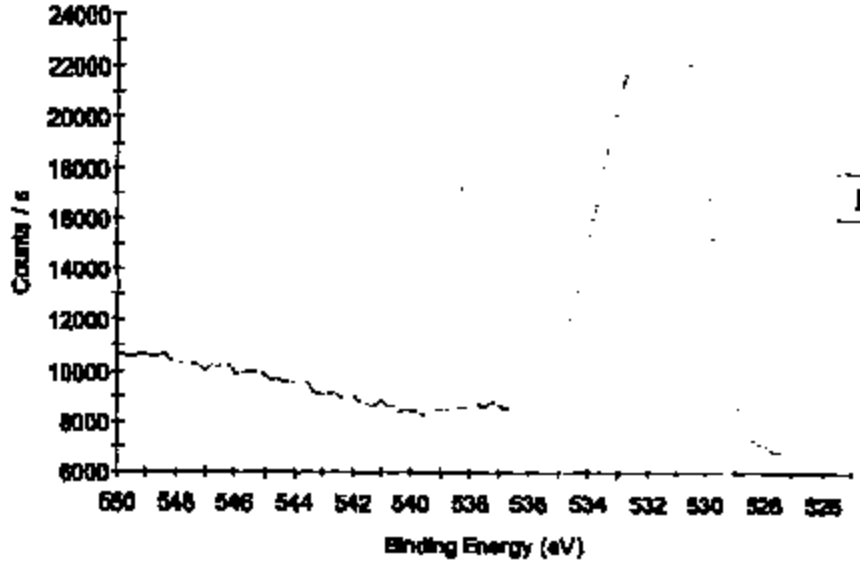

Figure 8

Survey

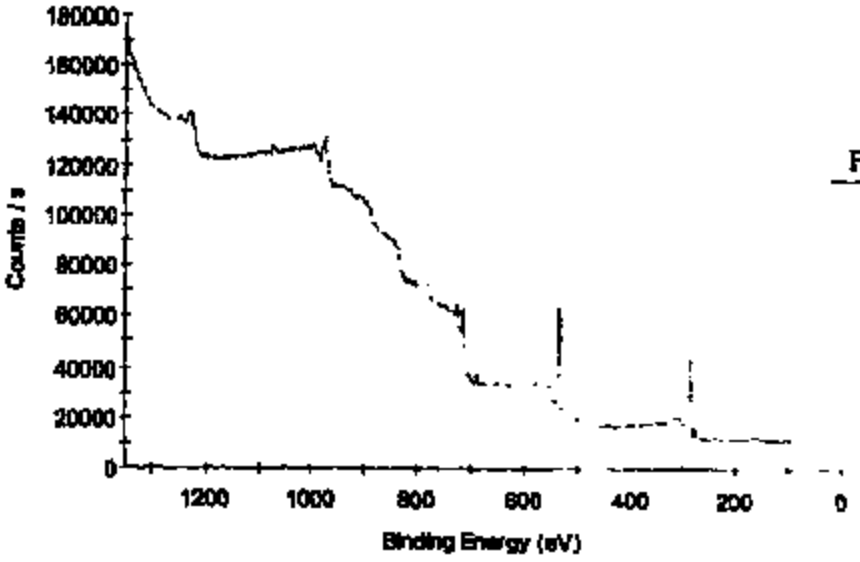

Figure 9

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SKF 02 Light red area in bore

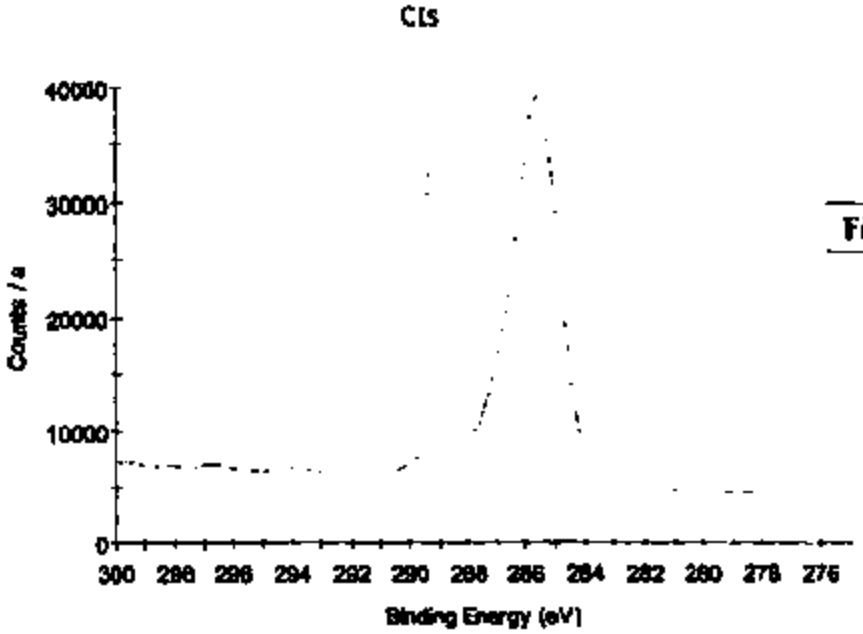

Figure 10

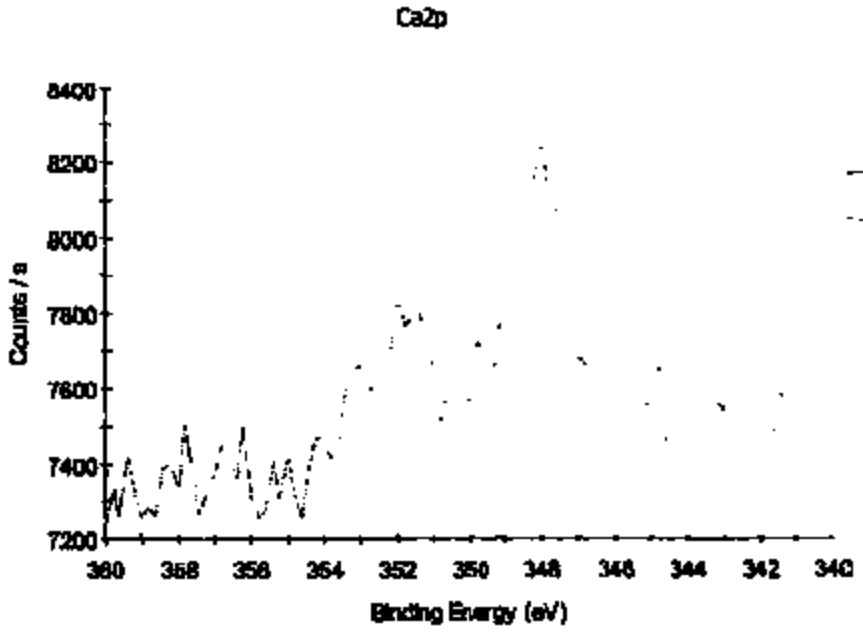

Figure 11

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F1s

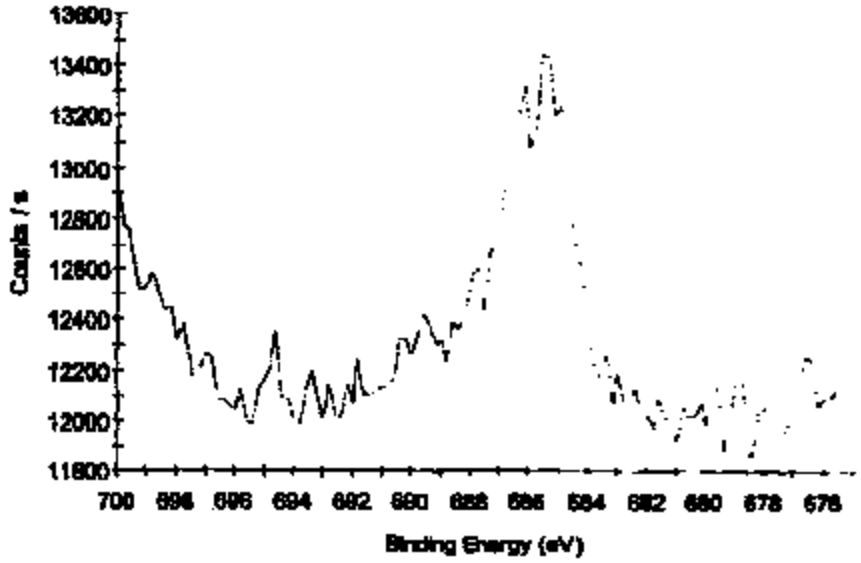

Figure 12

Fe2p

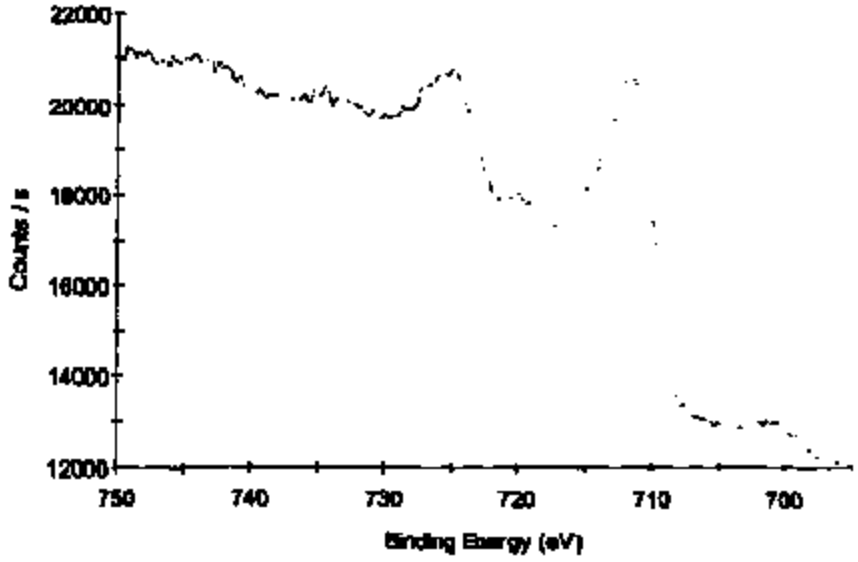

Figure 13

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N1s

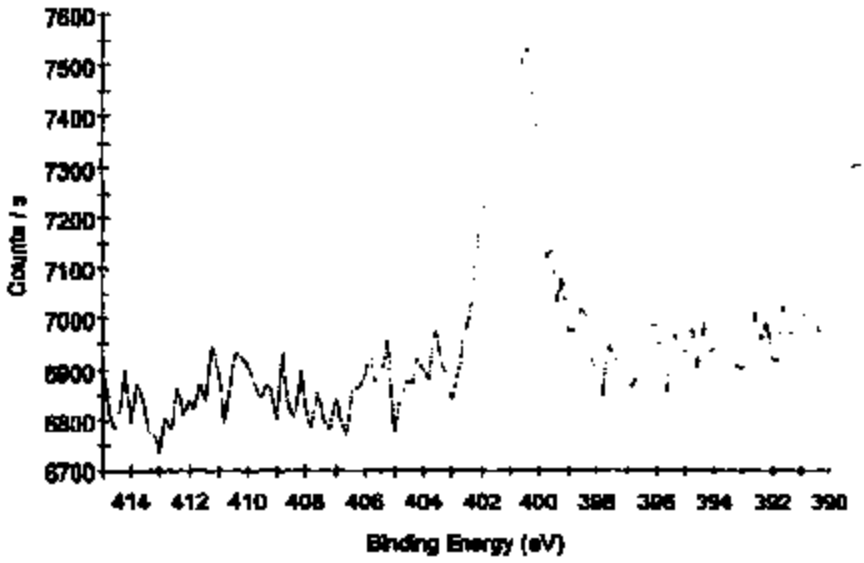

Figure 14

Na1s

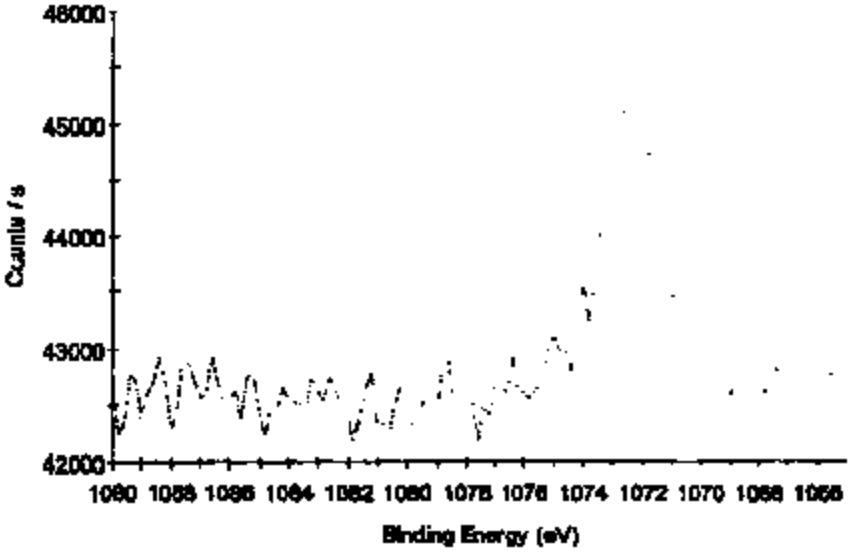

Figure 15

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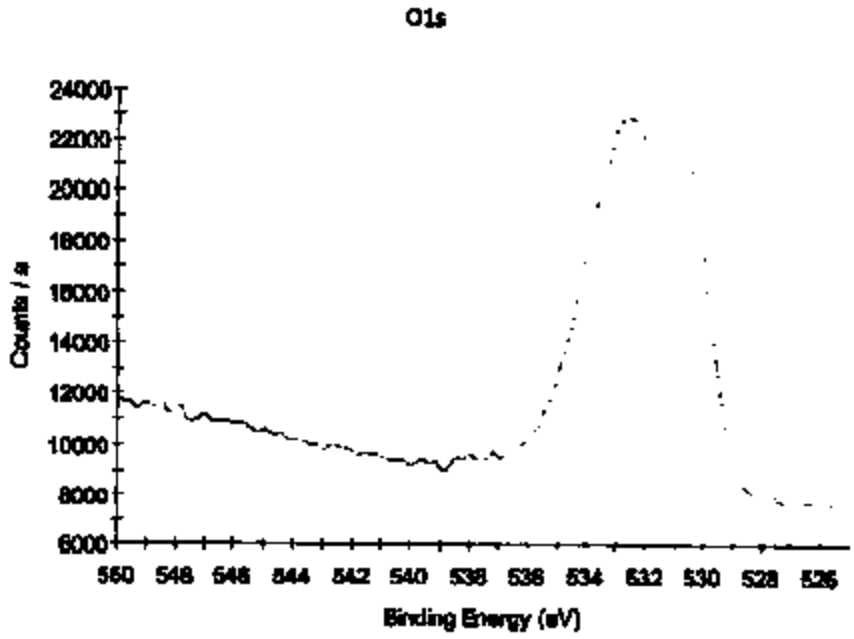

Figure 16

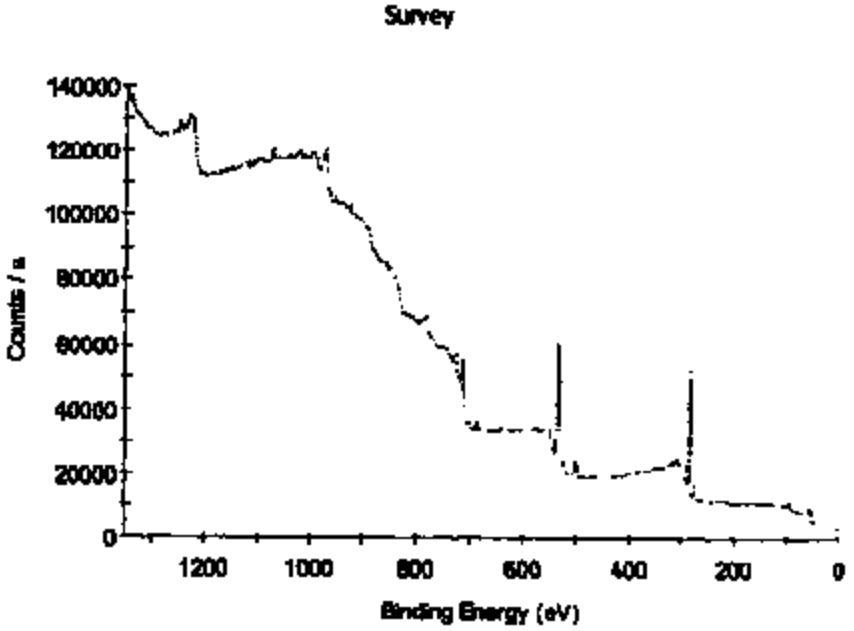

Figure 17

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SKF 03 Free-standing red area on chamfer

C1s k2p

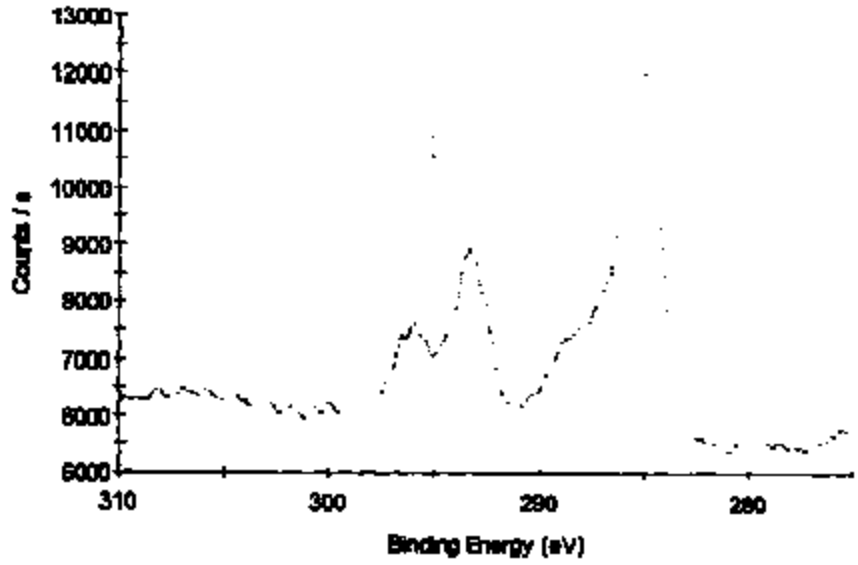

Figure 18

Ca2p

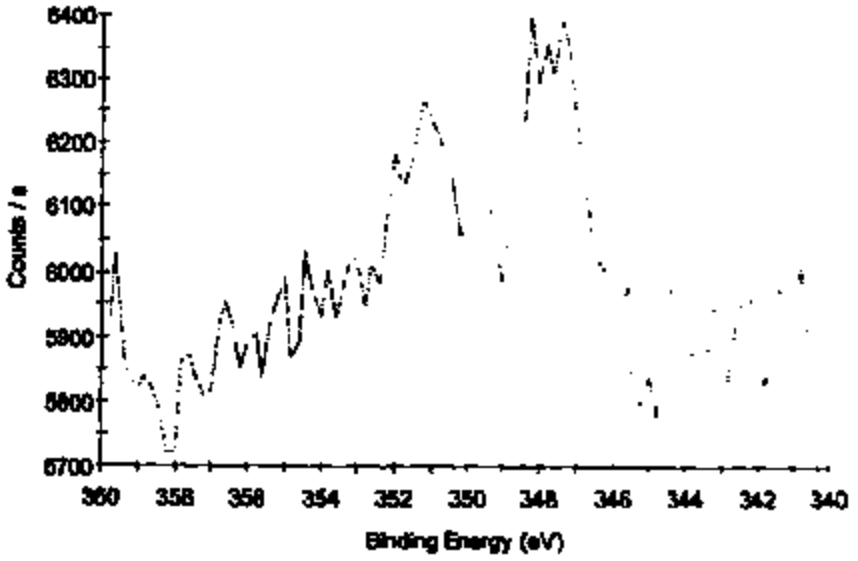

Figure 19

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F1s

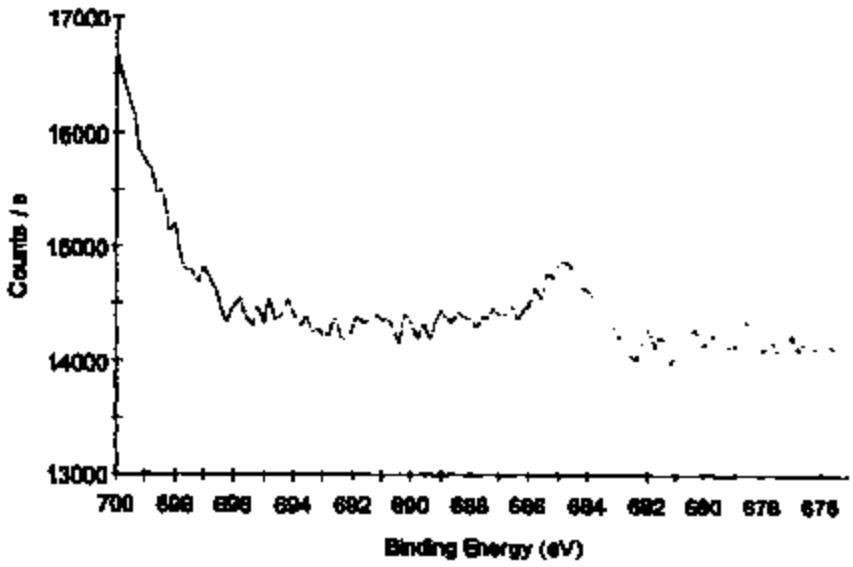

Figure 20

Fe2p

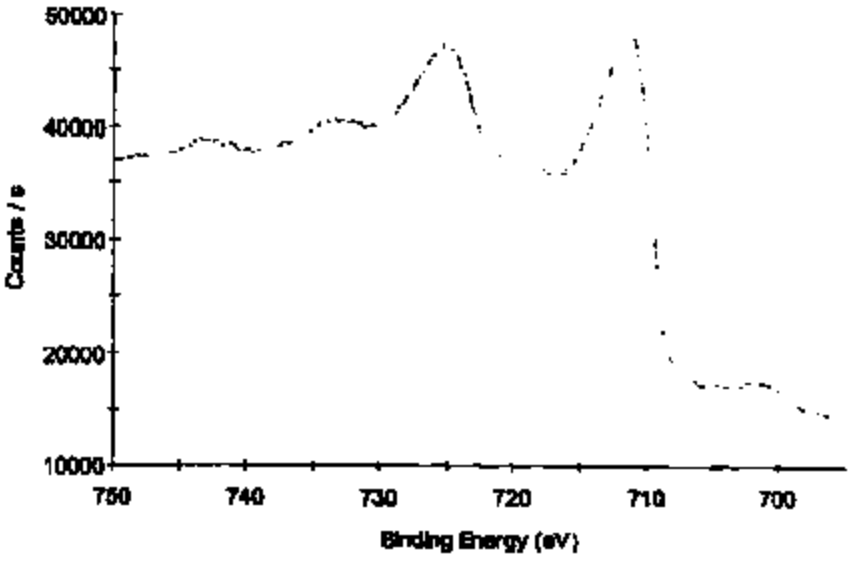

Figure 21

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N1s

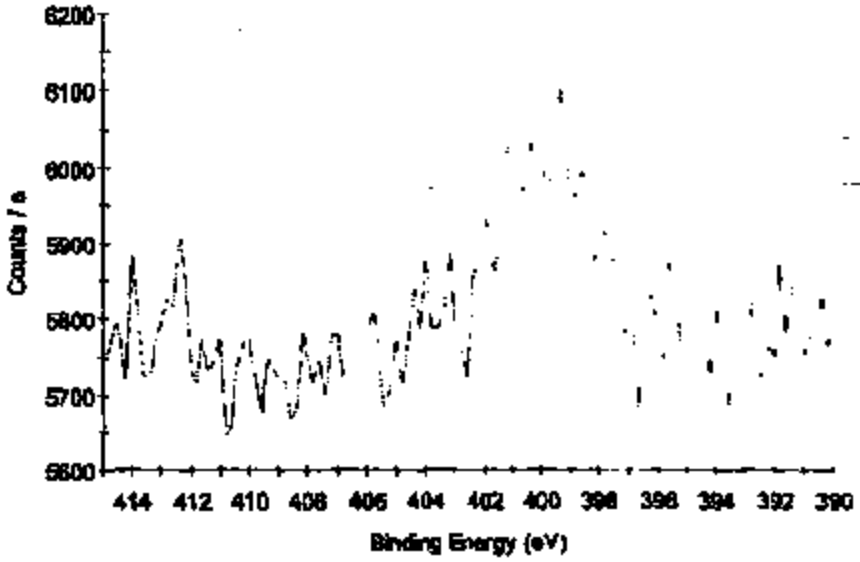

Figure 22

Na1s

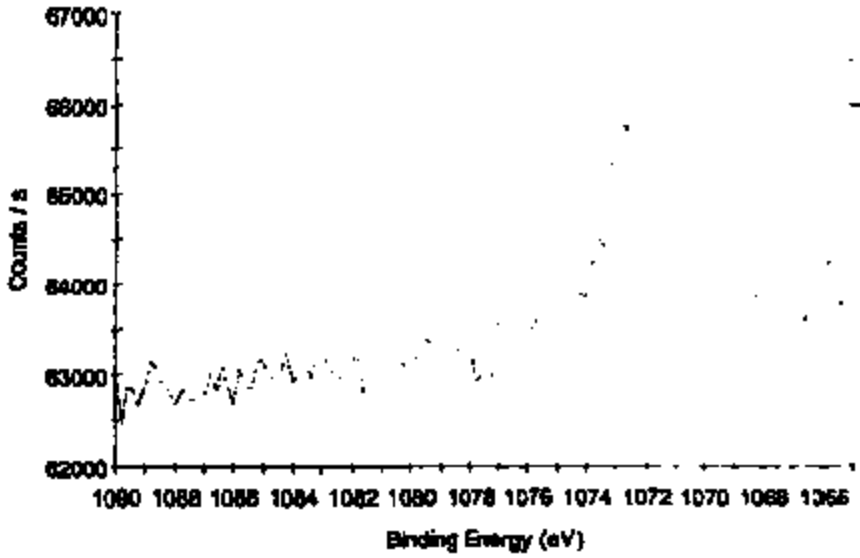

Figure 23

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O1s

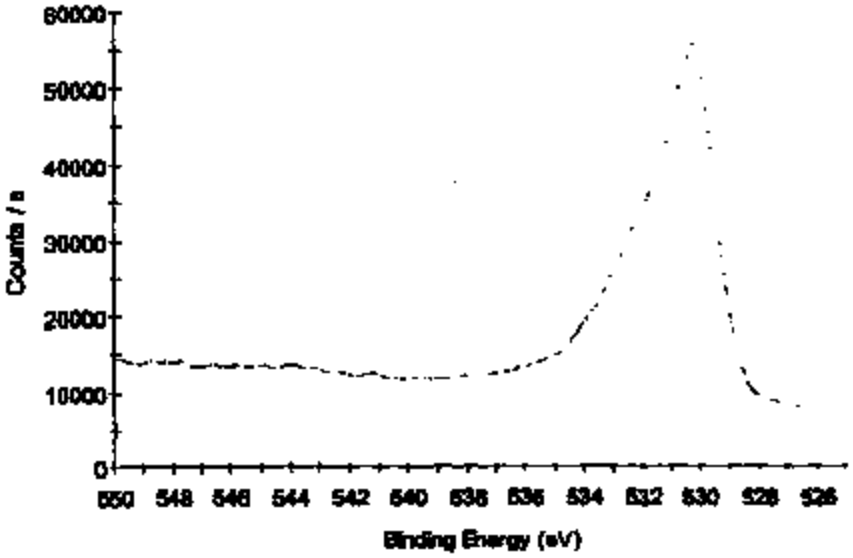

Figure 24

Survey

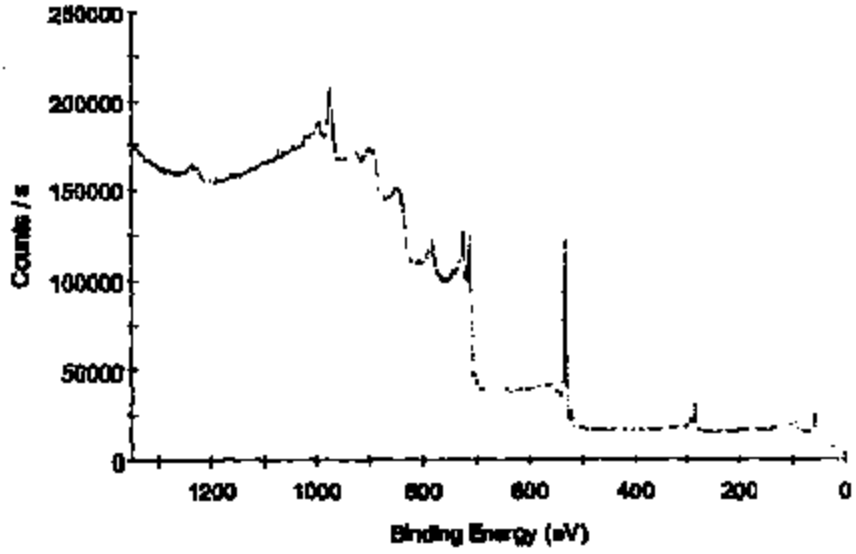

Figure 25

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SKF04 Non-discoloured area on chamfer

C1s K2p

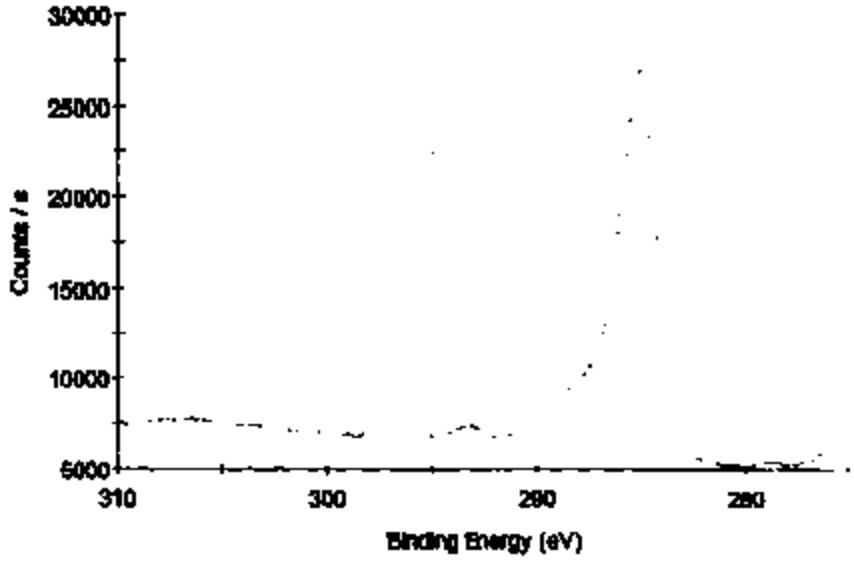

Figure 26

Ca2p

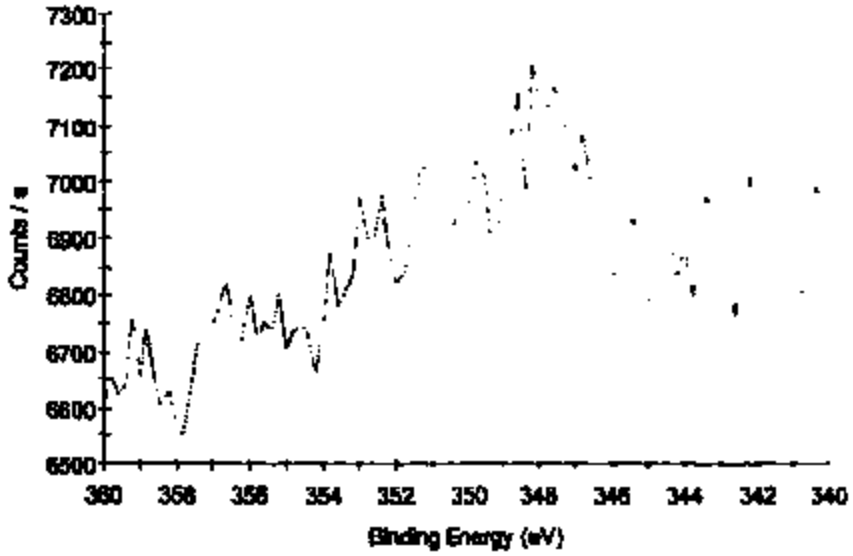

Figure 27

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F1s

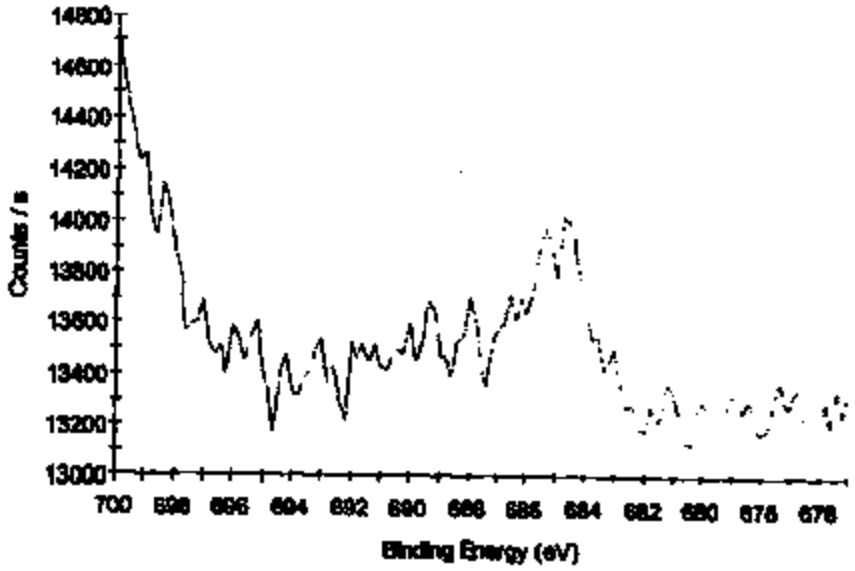

Figure 28

Fe2p

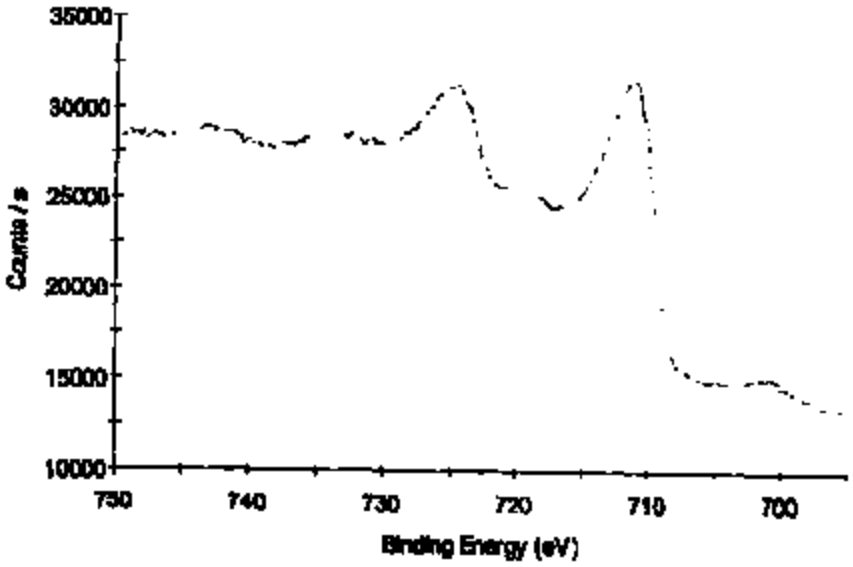

Figure 29

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N1s

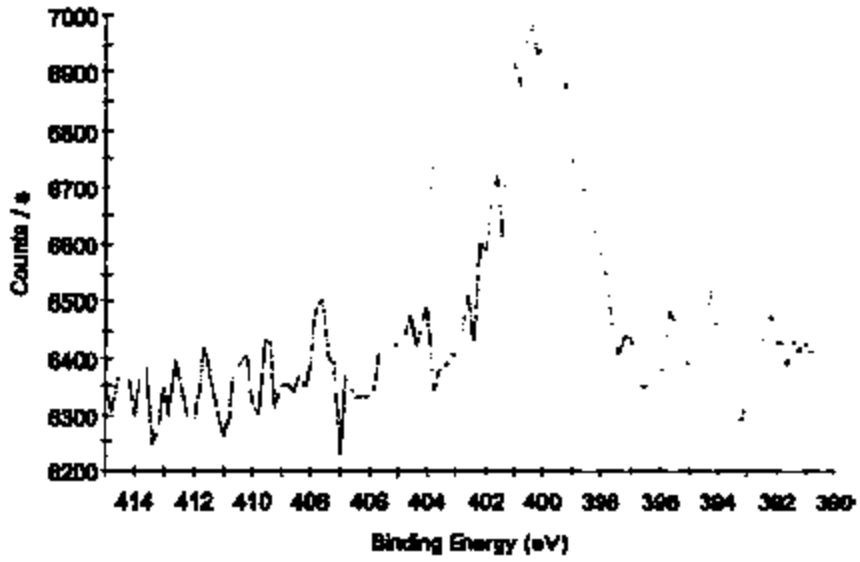

Figure 30

Na1s

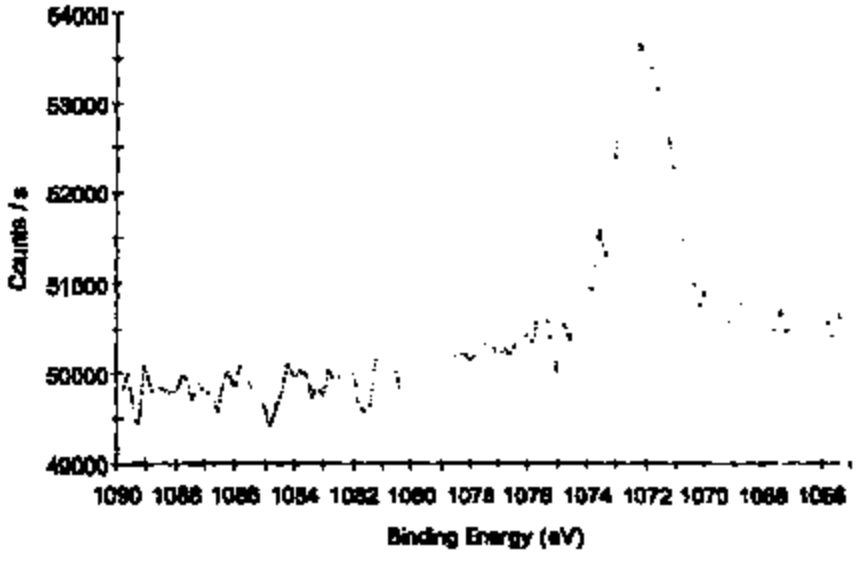

Figure 31

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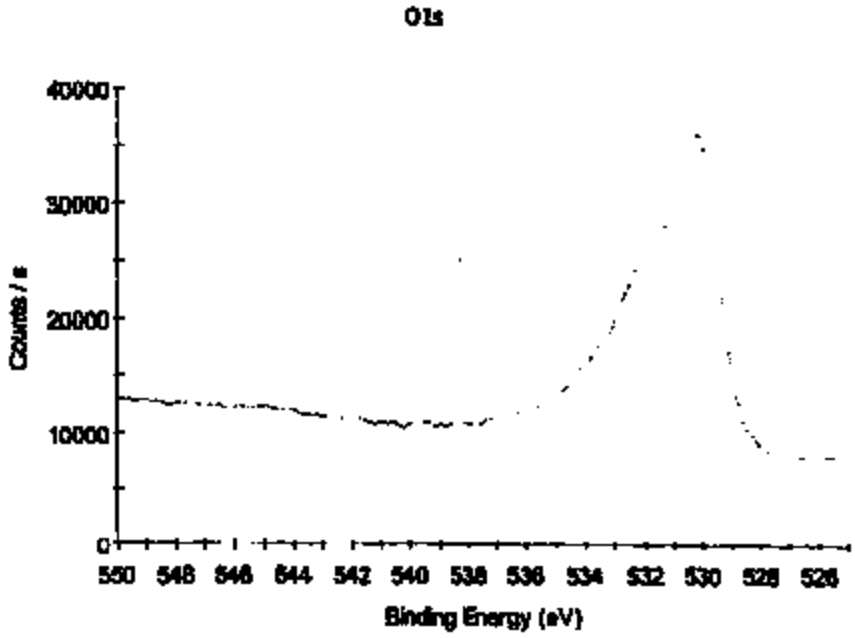

Figure 32

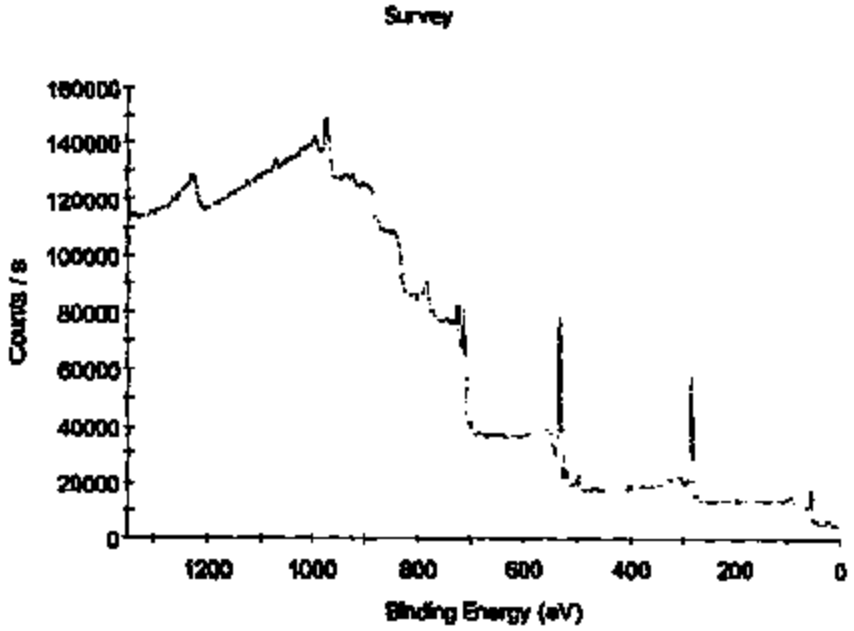

Figure 33

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NL02S690de
2002-07-10

ArvinMeritor THUs from the Field: X-Ray Analysis

Aidan Kerrigan

Materials Theory & Testing

SKF 000281

ArvinMeritor THUs from the Field: X-Ray Analysis

NL02/4904e
2002-07-10

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Key Words	THUs, grade 3, 52100, grade 55, 10S5M, through hardened, surface induction hardened, residual stress, line broadening, b/B ratio

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ArvinMeritor THUs from the Field: X-Ray Analysis

Abstract Three THUs were returned from the field after running for approximately 500,000 miles. The units had not failed. An x-ray investigation was performed on selected inner and outer ring raceways in order to determine the degree of material response to the application conditions.

Project background

Three THUs from the field were returned to SKF after running for approximately 500,000 miles. These have been investigated in RRC and reported here are the results of the x-ray investigation.

It should be noted that the THUs had not failed.

Objectives

To determine the fatigue status of the THUs after 500,000 miles in the application, using x-ray analysis.

Main results

See 'Main conclusions and recommendations'

Main conclusions and recommendations

The investigated inboard inner ring of unit 918279 did not show evidence of the accumulation of rolling contact fatigue damage to any significant extent at the centre of the raceway.

The inboard inner ring of unit 918287 showed evidence of a change in the residual stress profile in the raceway towards the edge of the overrolled track at the thinner end of the inner ring section due to running in the application. This change was in the form of the development of a compressive stress in the near surface region, which represents a material response to rolling contact fatigue. However, the line broadening parameter (b/B ratio) had a relatively high value, indicating only a limited accumulation of fatigue damage.

At the other measured positions of the inboard inner ring and all positions measured on the outboard inner ring of unit 918287, there was no evidence of significant material response to rolling contact fatigue.

The inboard raceway of the outer ring of unit 918287 gave an indication of surface fatigue, although the response was not as clear as that shown by the inboard inner ring (at the thinner end).

The outboard raceway of the outer ring of unit 918287 did not give an indication of a significant material response to rolling contact fatigue.

In summary, none of the THU components measured showed any evidence of the accumulation of sub-surface fatigue from the Hertzian stress induced by a rolling contact in the application.

Based on the residual stress profiles, there was evidence of a material response at the surface or near surface of the inboard inner ring raceway and the inboard outer ring raceway of unit 918287. In the absence of a sub-surface fatigue response, this would suggest that surface initiated fatigue would be the most likely failure mode. However, it is noted that the line broadening parameter (b/B ratio) remained at a relatively high value, indicating only a limited accumulation of fatigue damage at the surface or near surface region.

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1 Background

Four THUs were supplied to ERC for investigation. Three were returned from the field via the truck fleet operator Ryder and one unit was a new, unrun unit for baseline measurements. All units had been manufactured by SKF Aiken.

The three units from the field were marked and entered in to the ERC system as follows:

'Ryder Right Unit 918279'. The box was marked '396,184 miles' but the tag on the unit was marked '569,184 miles'. It was decided to use the mileage marked on the tag. All components of the unit were supplied, although the inner rings (IRs) were not marked as 'inboard' or 'outboard'. This unit was given the ERC code 02MR0020.

'Ryder Left Unit 317572'. This unit had covered 560,228 miles. The inboard inner ring (IR) was not supplied. This unit was given the ERC code 02MR0021.

'Ryder Left Unit 918287'. This unit had covered 591,711 miles. All components of the unit were supplied. This unit was given the ERC code 02MR0022.

The new, unrun unit was delivered complete and given the ERC code 02MR0019.

Based on the information supplied to the project team, coupled with the results of the visual inspection [Ref.1] and grease analysis [Ref.2], several investigations were performed on selected components. It should be stated that the three units returned from the field did not show any evidence of spalling fatigue on any of the raceways or cracking at the flanges.

Based on the observations of raceway damage and the position of the seal contact on the IR, it was determined which of the unmarked IRs supplied with unit 918279 was the inboard IR and which was the outboard IR.

A primary interest was to determine the material response to the rolling contact fatigue (RCF) conditions by x-ray diffraction. Prior to this, the raceway and other surfaces of the units were examined in the scanning electron microscope (SEM) [Ref.3].

2 Material Response Investigation

The investigation of material response to rolling contact fatigue (RCF) comprised of two components: determination of the residual stress profile and measurement of the change in line broadening of the diffraction lines.

Chromium (CrKα) radiation is used for the determination of the residual stress [Ref.4]. The calculated penetration depth of the radiation used was of the order of 10 µm. The residual stresses were determined by line shift analysis on the {211} martensite reflection using the $\sin^2\Psi$ method. The residual stresses are expressed in MPa.

The measured width of the {211} diffraction line in an austenite component depends on a number of factors, such as the amount of carbon in solid solution as a result of the hardening heat treatment. During RCF, the width of the {211} diffraction line can decrease, due to the accumulation of micro-plastic deformation i.e. fatigue. The measurement of the changes in the width of the {211} diffraction line is called 'line broadening', although it should be noted it is the decrease in the width (i.e. breadth) of the {211} diffraction line which is measured.

The changes in diffraction line broadening are expressed as the b/B ratio, with 'b' being the diffraction line-broadening as measured at the location of interest and 'B' being the diffraction line-broadening as measured in the unrun component (the unaffected region) at equal depth positions. For this reason, the unrun unit was measured as a baseline. For the through hardened IRs, only one baseline measurement was required. However, for the induction hardened outer ring (OR) raceways, both the inboard and outboard raceways were measured.

In order to illustrate the information which can be obtained from x-ray analysis, two examples are shown from previous investigations in figures 1 and 2.

Figure 1 shows the residual stress profile and b/B profile for the IR of a tested, but unfailed, taper roller bearing (TRB). In the unrun condition, the IR had a high compressive stress at the surface (depth = zero) which is typical and due to the hard machining operations performed after hardening. The residual stress becomes tensile at a depth of 10 µm, which would be expected in a martensitically through hardened ring. At deeper depths, the profile is basically neutral. After testing, it can be seen that a compressive residual stress of relatively high magnitude has been developed at a depth of approximately 100 µm, which was the depth of maximum shear stress (z_o). It can also be seen that the b/B profile also reduces below the surface in a similar way to the residual stress profile. Both the residual stress profile and b/B profile indicate a clear material response to the sub-surface Hertzian stress experienced by the IR due to RCF and it would be anticipated that this IR would fail by sub-surface initiated spalling.

Figure 2 shows a separate case, also for a TRB IR, but tested under different conditions. In the unrun condition, the IR has the expected residual stress profile of a martensitically through hardened bearing component. After testing, it can be seen that a compressive residual stress has developed at the surface at depths between 10 µm and 50 µm with a small dip at 75 µm. The b/B profile also shows decreasing values from a depth of 50 µm up to the surface. In this case, it is the surface or near surface region which is showing a material response to the RCF conditions and it would be anticipated that surface initiated spalling would be the failure mode. It should be noted that at 75 µm, there is a material response in that the residual stress profile shows a small dip but the b/B value at this depth is at 1.0, indicating that no significant fatigue response was evident at this depth.

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It should be noted that the quoted accuracy of a residual stress measurement is ± 50 MPa and this should be taken into account when drawing conclusions about differences between outer and race bearing components.

As a guideline, when the b/B ratio reaches a level of 0.90 or lower, this is taken as an indication of changes in the microstructure due to fatigue.

It can be seen in figures 1 and 2 that the magnitude of the changes in the residual stress and b/B ratio in these unfailed components is sufficient to clearly indicate sub-surface fatigue (figure 1) and surface, or near surface, fatigue (figure 2). Also, further decreases in the residual stress profile and b/B ratio, in the region of fatigue, would be anticipated before a fatigue failure occurred in either component.

The results of the x-ray investigations can be seen in figure 3 and figures 5 to 14. It should be noted that the depth of maximum shear stress (z_0) has been stated to be 0.133 mm if the truck is driving straight ahead and 0.206 mm for cornering with 0.15g. For the IRs, the circumferential position of the measurement was taken as the highest loaded zone, as could be observed by the marks from running.

Figure 3 shows the residual stress profile of the outer IR, which was used as a baseline for all IR measurements. The profile has a high compressive stress at the surface (depth = zero) which is typical and due to the hard machining operations performed after hardening. The residual stress becomes tensile at a depth of 10 µm, which would be expected in a martensitically through hardened ring. At deeper depths, the profile is basically neutral. Figure 3 also shows the residual stress profile of the inboard IR of unit 918279 and it should be noted that this profile was measured in the centre of the raceway. There is a compressive stress at the surface and the remainder of the profile basically follows the outer profile, with some deviation, either due to the application conditions or the accuracy of the measurement (± 50 MPa). This figure also shows the 'b/B' ratio, which is a comparison of the line broadening of the IR of unit 918279 used in the application with the outer IR. It can be seen that the b/B ratio is relatively high, never dropping below 0.95. By definition, the b/B ratio has a maximum value of 1.0 and the profile shown in figure 3 would indicate that very little fatigue damage can be observed in the centre of the inboard IR from unit 918279.

Unit 918279 had run for 569,184 miles. It was decided to investigate the longest running unit i.e. 918287 which had run for 591,711 miles. As a further refinement, it was decided to measure the profiles in three positions on the raceway, as illustrated in figure 4. For the IRs, measured in the highest loaded zone, Position 2 was the centre of the raceway (13 mm), Position 1 was at the thicker section (13 mm + 6 mm) and Position 3 was at the thinner section (13 mm - 6 mm). For the ORs, the same three positions were measured, with Position 2 at the centre of the raceway (13 mm), Position 1 at the thicker section (13 mm + 6 mm) and Position 3 at the 'thinner' section (13 mm - 6 mm). For the inboard OR raceway, the names can be used to be thicker or thinner but this is less clear for the outboard OR raceway. For the outer components, the baseline residual stress measurement was made at the centre of the raceway i.e. Position 2.

The residual stress profiles and b/B ratio of the inboard IR are shown in figures 5 and 6 with the equivalent results for the outboard IR shown in figures 7 and 8. As before, the results were compared with the profile from the outer IR. Figure 5 shows evidence of material response in the outer surface region. This was evident in Position 3 and can be seen by the generation of a compressive stress at depths to around 75 µm. The generation of compressive stresses at the near surface in Position 3 indicates some material response in this region but the high values of b/B (>0.9) in figure 6 show that there was only a limited accumulation of fatigue. At deeper depths on all three profiles, and as shown by the b/B ratio in 6, there is no evidence of a response to the sub-surface Hertzian contact stress and, hence, no indication of classic sub-surface RCF failure in this unit. Figures 7 and 8 for the outboard IR of this unit do not indicate any evidence of the accumulation of either surface or sub-surface fatigue as the profiles do not differ significantly from the outer IR and the b/B ratio remains at a high level i.e. above 0.90.

The baseline measurements for the OR raceways of new, outer unit are shown in figures 9 and 10. In figure 9, it can be seen that the inboard raceway has a high compressive stress at the surface (depth = zero) due to the hardmachining processes. At deeper depths, the residual stress is compressive, as would be expected in a surface induction hardened component, and the stress has a magnitude of 300 to 350 MPa. For the outboard raceway, the residual stress profile, figure 10, has the same characteristics as that of the inboard raceway except that the magnitude of the compressive stress in the induction hardened surface shows more variation and tends to have a lower value. This difference in residual stress is likely to stem from slight differences in the induction hardening and tempering process. This is also reflected by the line broadening measurements, which also show a slight difference. The inboard raceway had a line broadening value of approximately 7.5 while the outboard raceway had a value of approximately 8.0.

The residual stress profiles and b/B profiles for the inboard and outboard raceways of the OR of unit 918287 are shown in figures 11 to 14.

Figure 11 shows the residual stress profiles in the three positions on the inboard raceway. The magnitude of the compressive stress at the surface (depth = zero) is slightly lower than that measured on the outer unit. At the second measurement position, at a depth of 10 µm, all three profiles show a slightly higher magnitude of compressive stress as compared to the new, outer unit at the same depth. This would indicate some material response in this region but the relatively high values of b/B, in figure 12, show that there was only a limited accumulation of fatigue damage. At deeper depths, the profiles do not show any strong

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features, with compressive stresses of the order of 250 to 300 MPa. The b/B profiles for the inboard raceway are shown in figure 12 and these indicate only a limited response to RCF as the values tend to be high, lying between 0.90 and 1.0. It is noted that the lowest b/B values are at the surface.

The residual stress and b/B profiles for the outboard raceway of the OR of unit 918287 are shown in figures 13 and 14. As in the case, unlike unit it can be seen that the magnitude of compressive stress tends to be lower in the outboard raceway as compared to the inboard raceway. The residual stress profiles do not indicate a strong response to RCF, although the variation in the baseline residual stress profile makes it difficult to compare. It is noted that the b/B profiles in the three positions, figure 14 tend to have values above 0.90 i.e. only a limited accumulation of fatigue.

3 Materials Response Conclusions

The investigated inboard inner ring of unit 918279 did not show evidence of the accumulation of rolling contact fatigue damage to any significant extent at the centre of the raceway.

The inboard inner ring of unit 918287 showed evidence of a change in the residual stress profile in the raceway towards the edge of the overrolled track at the thinner end of the inner ring section due to running in the application. This change was in the form of the development of a compressive stress in the near surface region, which represents a material response to rolling contact fatigue. However, the line broadening parameter (b/B ratio) had a relatively high value, indicating only a limited accumulation of fatigue damage.

At the other measured positions of the inboard inner ring and all positions measured on the outboard inner ring of unit 918287, there was no evidence of significant material response to rolling contact fatigue.

The inboard raceway of the outer ring of unit 918287 gave an indication of surface fatigue, although the response was not as clear as that shown by the inboard inner ring (at the thinner end).

The outboard raceway of the outer ring of unit 918287 did not give an indication of a significant material response to rolling contact fatigue.

In summary, none of the THU components measured showed any evidence of the accumulation of sub-surface fatigue from the Hertzian stress induced by a rolling contact in the application.

Based on the residual stress profiles, there was evidence of a material response at the surface or near surface of the inboard inner ring raceway and the inboard outer ring raceway of unit 918287. In the absence of a sub-surface fatigue response, this would suggest that surface initiated fatigue would be the most likely failure mode. However, it is noted that the line broadening parameter (b/B ratio) remained at a relatively high value, indicating only a limited accumulation of fatigue damage at the surface or near surface region.

4 References

Ref.1 G. de Wit, ERC report NL02T903e, 'ArvinMeritor THUs from the Field: Visual Inspection'

Ref.2 A. Kerrigan, ERC report NL02M902e, 'ArvinMeritor THUs from the Field: Grease Analysis'

Ref.3 A. Kerrigan, ERC report NL02M903e, 'ArvinMeritor THUs from the Field: Scanning Electron Microscopy'

Ref.4 'Residual Stress Measurement by X-Ray Diffraction - SAE J784a', Second Edition, Society of Automotive Engineers, Inc., Two Pennsylvania Plaza, N.Y., N.Y. 10001, USA. 1971

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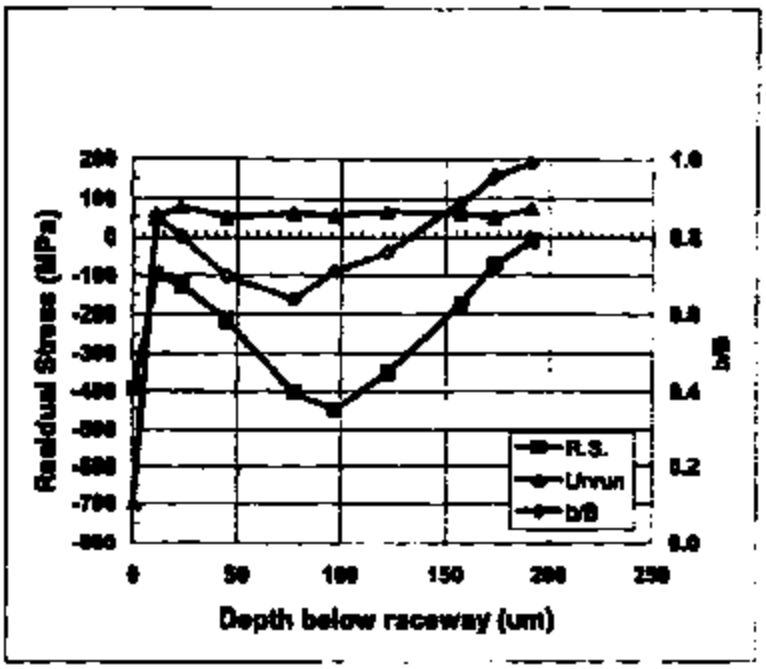

Figure 1. Example from previous investigation. "R.S." = Residual Stress of tested bearing IR

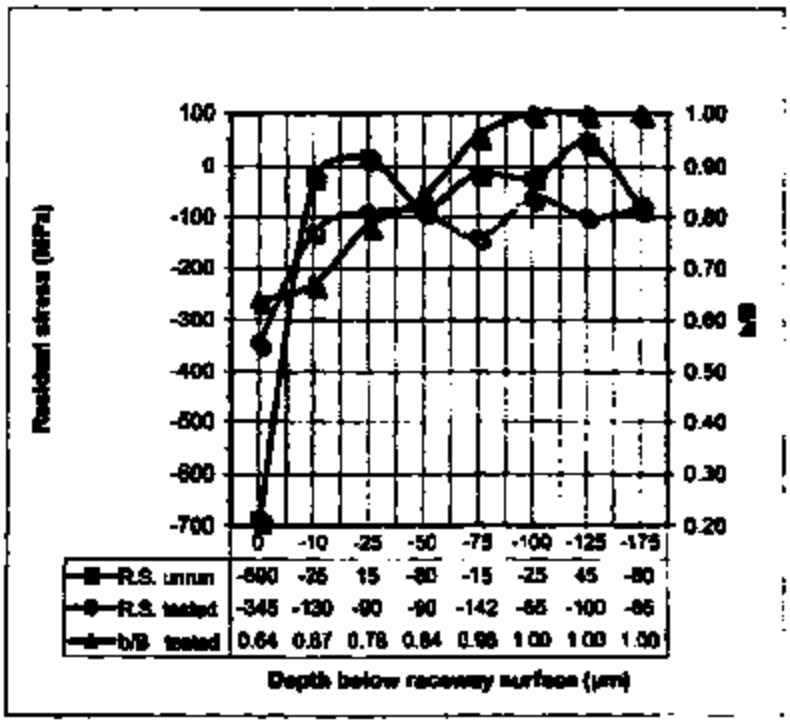

Figure 2. Example from previous investigation.

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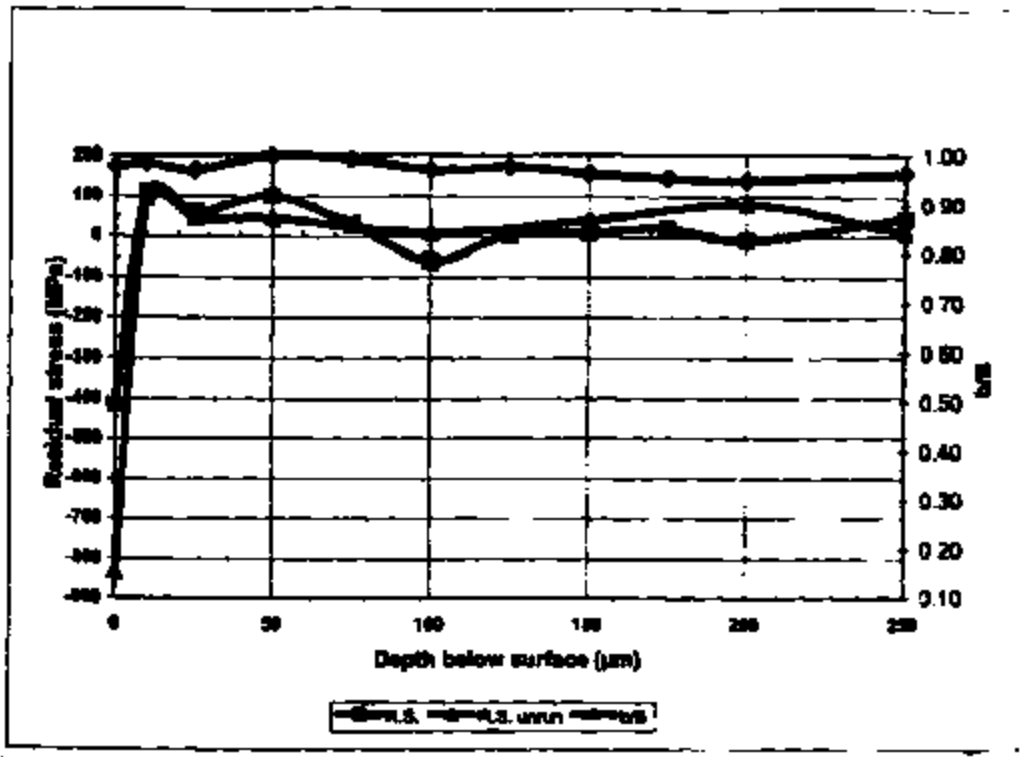

Figure 3. Inboard IR of unit 918279

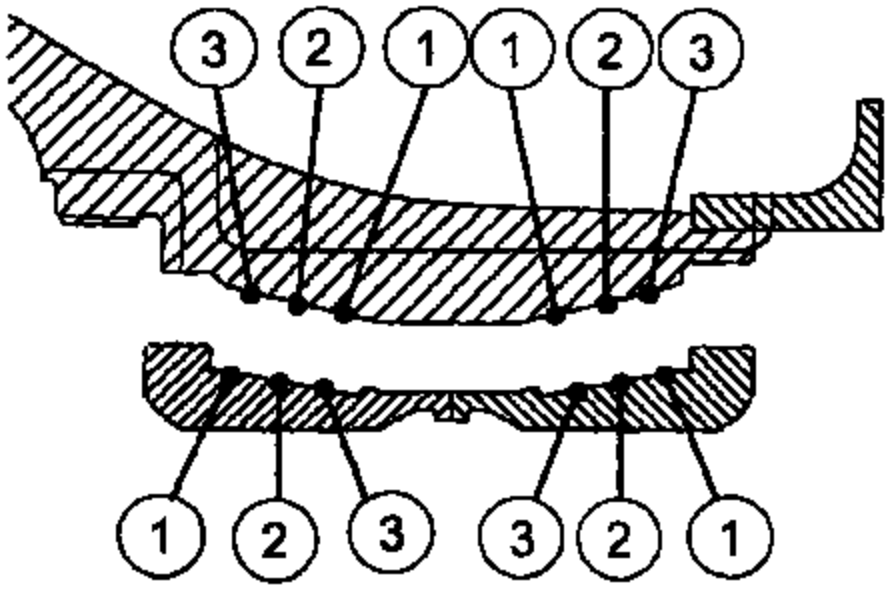

Figure 4. Indication of the measurement positions in the x-ray analysis investigation

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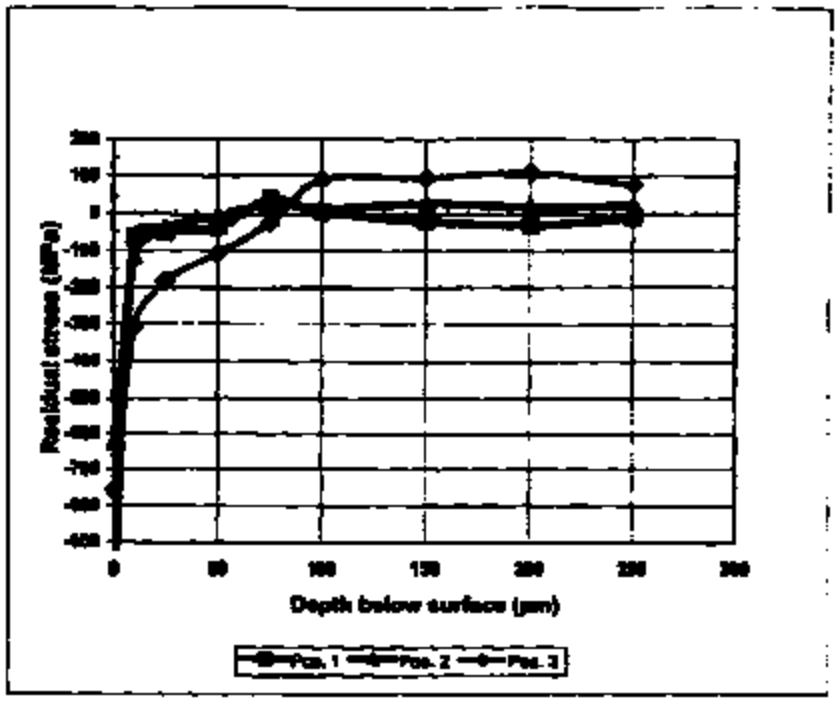

Figure 5. Inboard IR of unit 918287

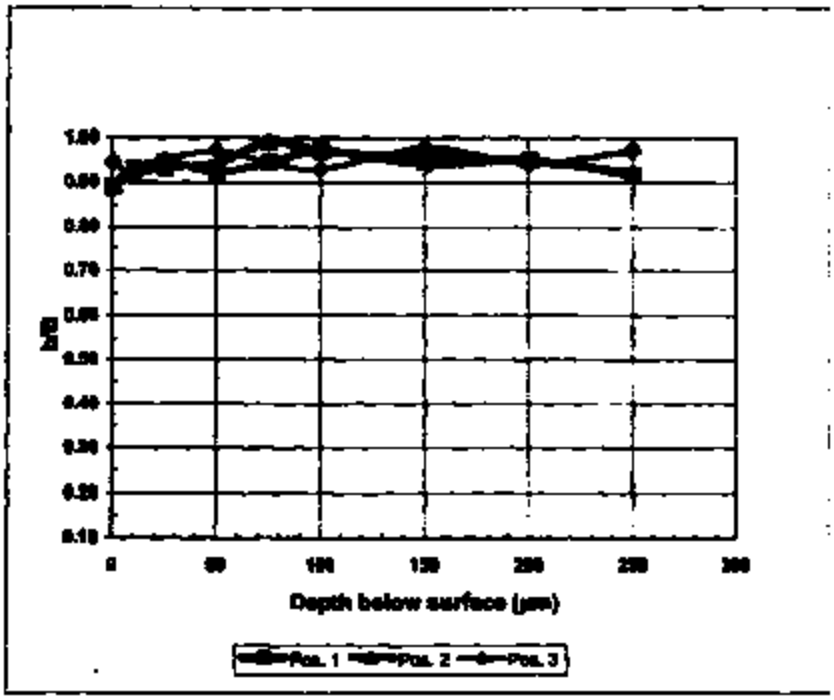

Figure 6. Inboard IR of unit 918287

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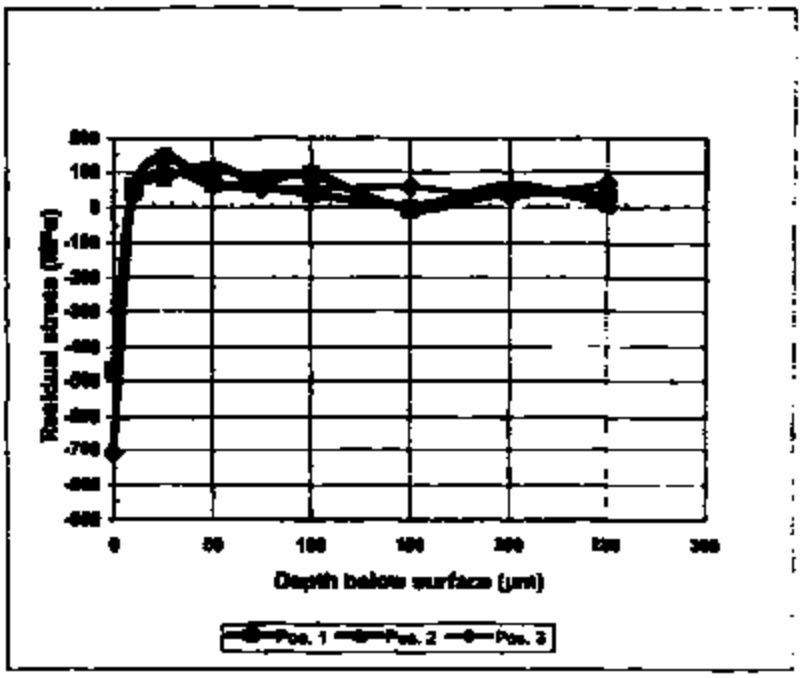

Figure 7. Outboard IR of unit 916287

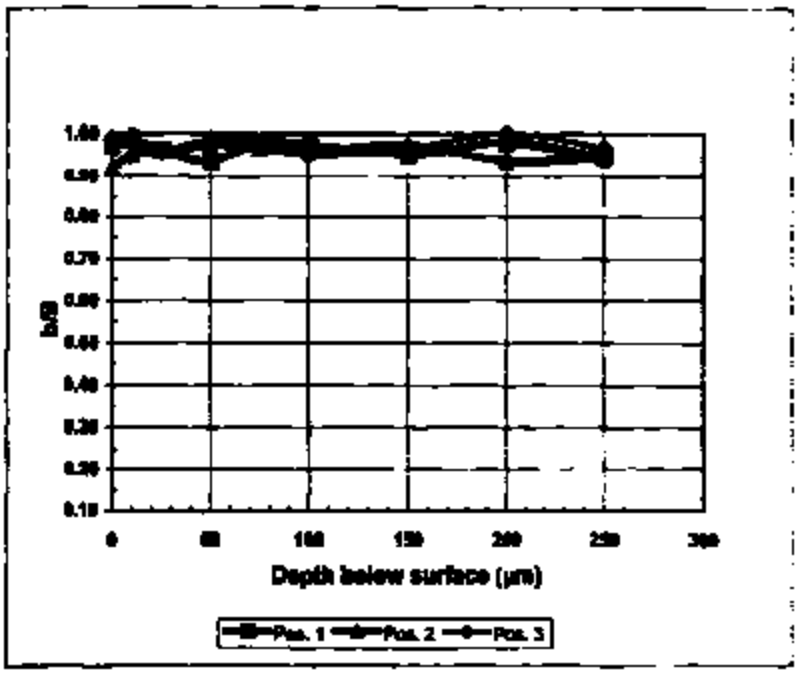

Figure 8. Outboard IR of unit 916287

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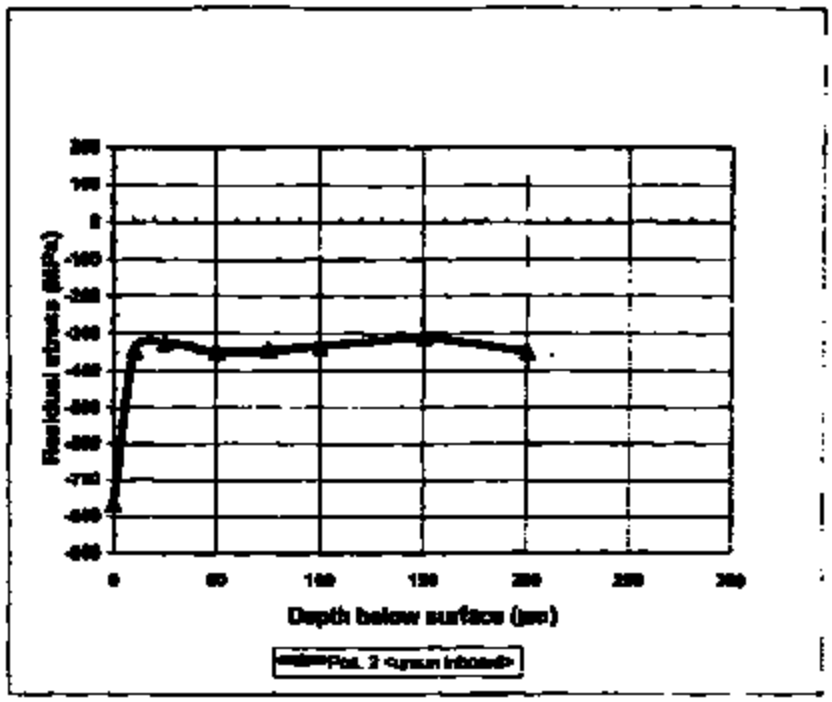

Figure 9. Inboard raceway of OR of new, unrun THU (02MR0019)

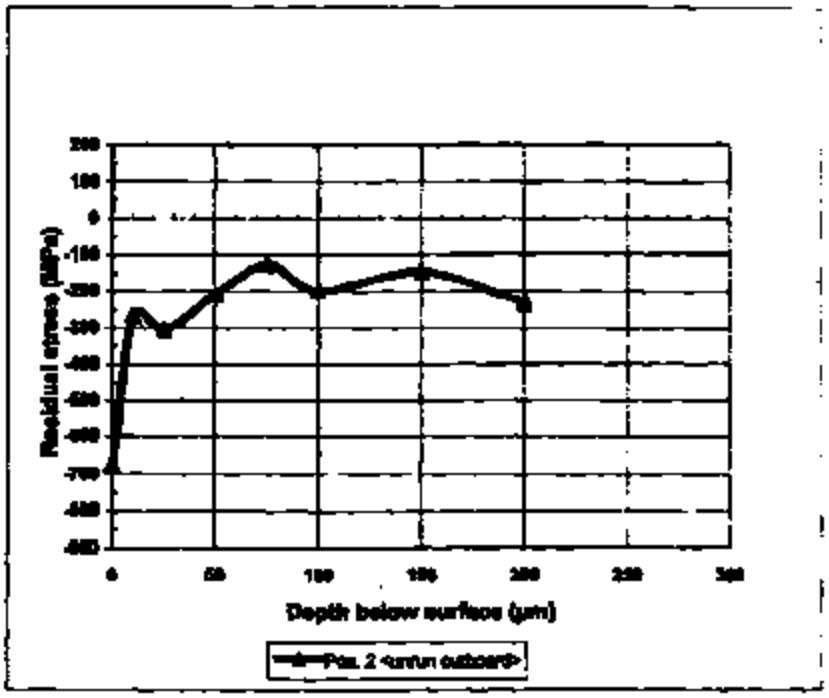

Figure 10. Outboard raceway of OR of new, unrun THU (02MR0019)

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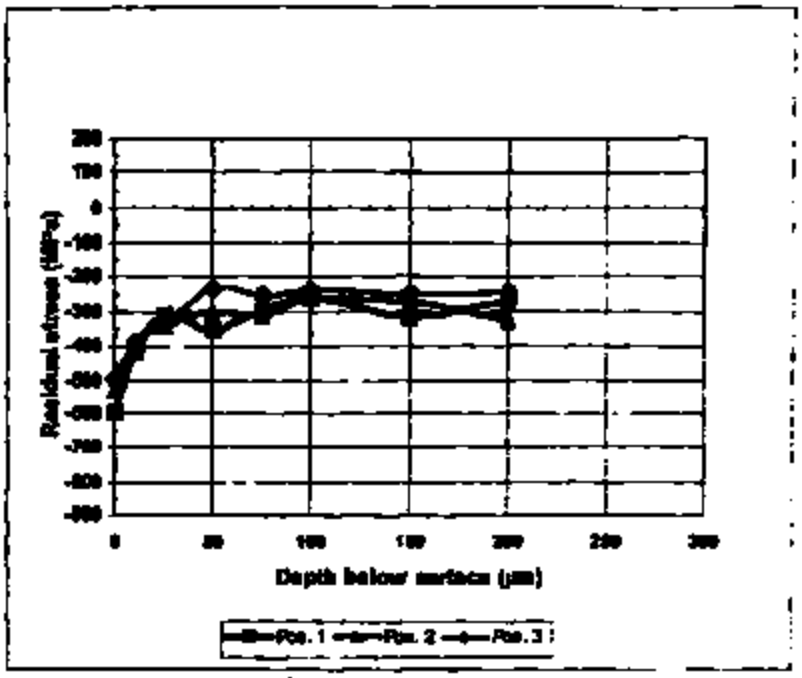

Figure 11. Inboard raceway of OR of unit 918287

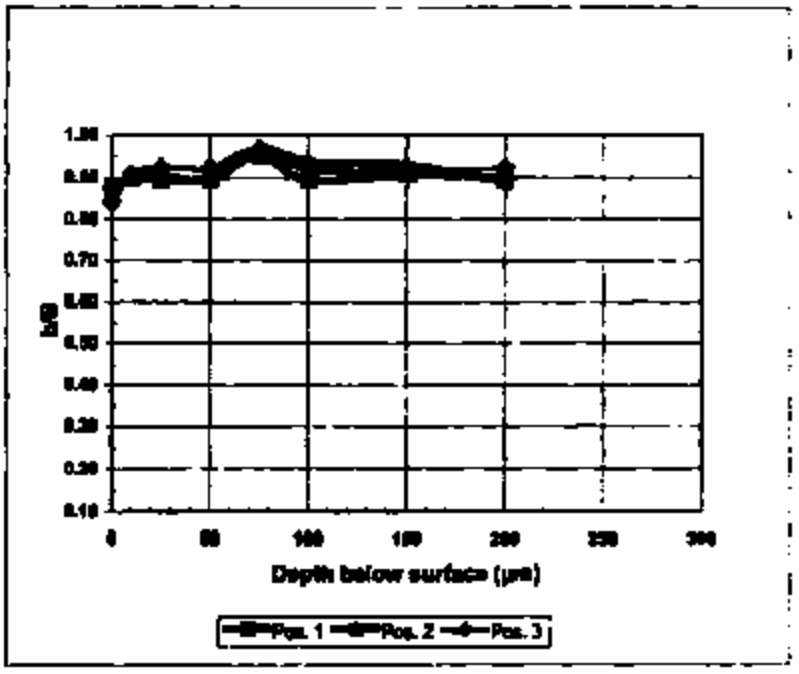

Figure 12. Inboard raceway of OR of unit 918287

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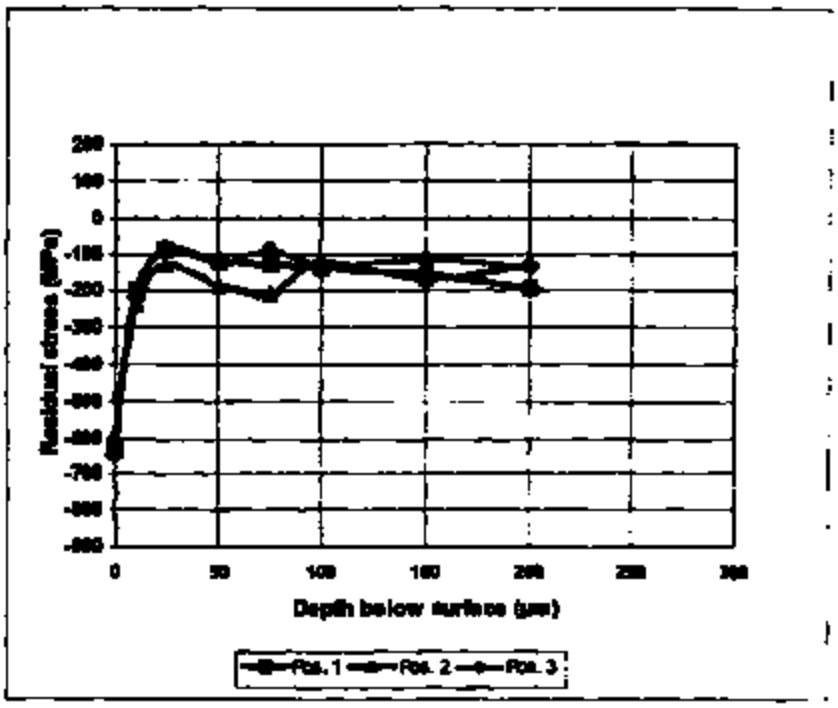

Figure 13. Outboard raceway of OR of unit 918287

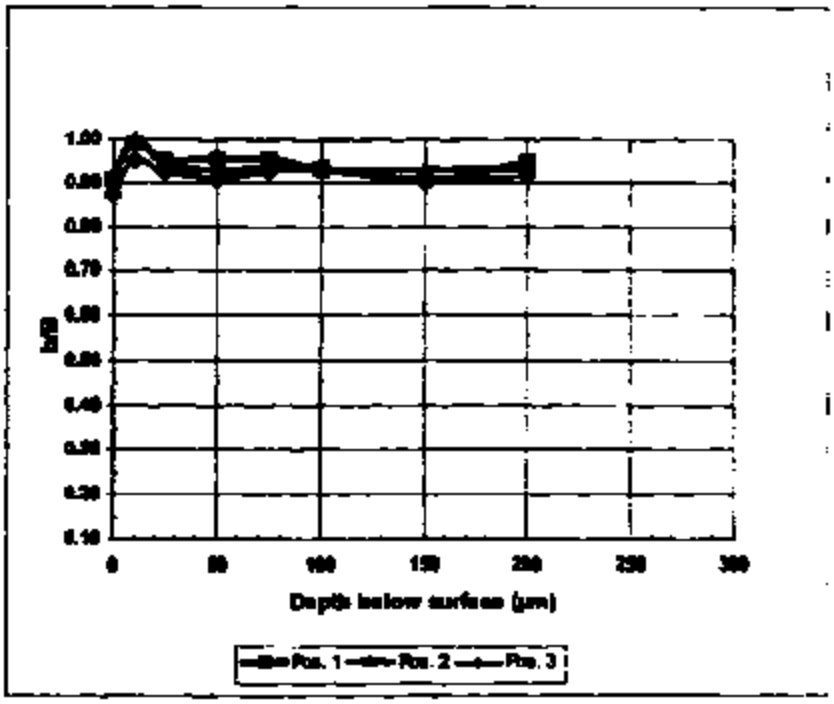

Figure 14. Outboard raceway of OR of unit 918287

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NL02M903e
2002-07-24

ArvinMeritor THUs from the Field: Scanning Electron Microscopy

Aidan Kerrigan

Materials Theory & Testing

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NL-02N803e
2002-07-24

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Key Words: THU, SEM, dent, surface distress, smearing, particles, lubrication, contaminant, raceway, flange, roller end-face

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ArvinMeritor THUs from the Field: Scanning Electron Microscopy

Abstract Three THUs from the field, which had run for approximately 500,000 miles, were supplied to ERC for investigation. In support of the initial visual inspection, the components were examined using the scanning electron microscope in order to more thoroughly characterise the condition of the THUs.

Project background

There have been incidents in the USA with THUs supplied to ArvinMeritor. As a result, three THUs, which had run for approximately 500,000 miles, were supplied to ERC for investigation.

Reported here are the observations from an investigation using the scanning electron microscope.

Objectives

To determine the condition of the THU components using the scanning electron microscope.

Main results

See 'Main conclusions and recommendations'.

Main conclusions and recommendations

The three THUs from the field have suffered damage during the ± 500,000 miles in service but were not classified as having failed. There were many similarities in the character of the damage in the three units, although it is noted that the components of units 918279 and 918287 tended to show clearer evidence of the damage than those of unit 317572.

Bearing in mind that the inboard inner ring of unit 317572 was not supplied, the following general statements can be made on the nature of the observed damage.

All raceways showed evidence of surface distress in that the finish machining marks were removed to some extent. The surface distress, in general, was not very advanced since finishing marks were still visible and there was no micropitting of the surface. One exception was the outer ring of unit 918287, which will be covered later.

Small (< 5 µm diameter) circular features were observed on all raceways but the mechanism for their formation is not clear. It is noted that on the inboard inner rings, the features were linked to localised areas of more advanced surface distress, although micropitting was not observed in these areas.

The inboard raceways had smooth dents, formed by the overrolling of deformable particles. This type of damage was not seen on the outboard raceways.

The outboard raceways, particularly the inner rings, had bands of dense fine denting and more advanced surface distress. These bands were concentrated towards the edge of the contact, nearest the thin section of the outboard inner rings or the equivalent location on the outboard outer rings and rollers. Similar bands were seen on some inboard raceways but the degree of damage was less pronounced than on the outboard raceways.

There was contact between the roller end-face and the flange, particularly for the inboard inner rings. This resulted in removal of the finishing marks, smearing and even material loss from the flange.

The flange shoulders showed evidence of contact with the seal lips, which had resulted in mild sliding damage at the position of the inside seal lip.

On the position of the external seal lip, pit-like features were observed. These pits contained dust and apparent material from the seal. There may also have been products from aqueous corrosion in some pits. It is noted that some surface corrosion was apparent outside the seal contact on the inboard inner ring of unit 918287.

The inboard outer ring raceway of unit 918287 had localised bands of advanced surface distress and associated micropitting. No other components of the units showed any evidence of micropitting.

In summary, all components examined showed evidence of surface damage on the raceways, either in the form general surface distress or localised bands of surface distress associated with fine debris. The inboard raceways had been dented by the overrolling of deformable particles and all raceways had small, micron-scale circular features.

Surface distress, whether general or localised, indicates that the lubrication film thickness is insufficient to separate the rolling contact surfaces. Surface distress is a fatigue phenomenon and, as such, is progressive and, over time, can lead to micropitting, as was seen very locally on the inboard outer ring raceway of unit 918287.

The contact between the roller end-face and the IR flange also indicates a poor lubrication film in this region.

It is recommended to investigate whether the small circular features are common to THUs and, if so, to determine their origin in order to avoid their formation.

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1 Background

Three run THUs, returned from the field, and one new stores THU were supplied to ERC for investigation. The THU identification number, corresponding ERC identification number and number of miles covered by the THUs are shown in table 1.

THU	ERC no.	Mileage
918279	02MR0020	569,184
317572	02MR0021	560,228
918287	02MR0022	591,711
New unit	02MR0019	zero

Table 1. Investigated THUs

It should be noted that for unit 918279, the box was marked 596,184 miles while the tag on the unit was marked 569,184 miles. It was decided to use the mileage marked on the tag.

The inboard and outboard inner rings (IRs) were supplied for units 918279 and 918287 while only the outboard inner ring (IR) was supplied for unit 317572.

The units were visually inspected [Ref.1], the available grease adhering to the outer rings (ORs) was analysed [Ref.2] and selected components were analysed using x-ray diffraction [Ref.3].

This report covers the examination of the THU components in the scanning electron microscope (SEM).

2 Scanning Electron Microscopy

2.1 Raceways

As was noted during the visual inspection [Ref.1], none of the raceways showed any extensive spalling. The three units from the field had run for over 500,000 miles but were not classed as having failed.

2.1.1. Inner Rings

Based on the appearance of the IR raceway, it was possible to identify the loaded zone by the darker appearance and also to identify the area of the highest load.

As a general overview, the typical appearance of the five IR raceways, in the centre of the raceway contact path in the area of the highest loaded zone is shown in figure 1.

It can be seen that the finishing marks have been removed to some extent in all of the IR raceways. This is attributed to surface distress, which is micro-scale fatigue at the surface [Ref.4]. Surface distress is indicative of metal-to-metal contact, which can occur generally over a raceway surface or locally, due to an insufficient lubrication film to separate the surfaces. The insufficient lubrication film may be due to the characteristics of the lubricant, particularly if changes occur during service, the loading conditions at the contact or the lubrication film can be broken down by the presence of indents in the raceway surfaces. These effects can be general or localised but, in either case, the fatigue of the surface is progressive and, over time, can lead to spalling on a micro-scale (microspalling).

It can be seen that the general surface distress is more advanced in the inboard IR of unit 918279 (figure 1a)) than in the outboard IR of the same unit (figure 1 b) or 1c)) in that more of the finishing marks have been removed from the inboard IR raceway. There is less apparent difference between the inboard and outboard IRs of unit 918287 and, as mentioned previously, the inboard IR of unit 317572 was not supplied. However, it is clear that the inboard IR of 918279 had the most advanced surface distress. It is noted that there was no evidence of microspalling on any of the IR raceways.

On all five IR raceways, there are circular features which are up to 5 microns in diameter. These can be most clearly seen in figures 1b), 1c) and 1e). These features are similar in character to those reported for electrical erosion damage i.e. the passage of electrical current [Ref.4]. However, the mechanism for electrical erosion is localised melting of the surface, which can be readily seen in a metallographic cross-section as the melted and re-solidified structure can be identified by the fact that it gives a 'white etching' response while the microstructure immediately below this is overtempered, giving a very dark etching response (in comparison to unaffected material). The circular features shown in figure 1 were observed on all of the raceways of all of the IRs, outer rings and rollers, although to differing extents. However, metallographic sectioning of the raceways did not reveal the local melting and overtempering of the surface, as would be expected by electrical erosion damage. Using the EDAX facility, it was determined that the circular features were not related to microstructural features such as inclusions or carbides (which have a diametrically high chromium content in grade 3). The mechanism of formation of the micro-scale circular features on the raceways is unclear, as is the potential effect on bearing performance, particularly from the photographs of the general surfaces in figure 1. However, it was noted that these circular features were more numerous in the loaded zone of the IRs and may have contributed to more advanced surface distress in very localised areas. This was observed in particular of the inboard IRs of units 918279 and 918287 and is shown in figure 2.

Relatively large smooth indents were seen on the raceways of the inboard IRs but were not observed on the outboard IR raceways. (Note that for unit 317572, only the outboard IR was supplied). Smooth indents are produced by overrolling of deformable particles, which are usually metallic and can even be hard metallic particles as these are deformable in the Hertzian contact. Examples of the smooth denting are shown in figure 3.

It was noted that circumferential bands of dense fine denting and advanced surface distress existed on the

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raceway of the outboard IR of unit 918287, and to a lesser extent on the outboard IR of unit 317572. In both cases, the bands of denting and surface distress were concentrated towards the edge of the contact, nearest the small section. This damage is shown in figure 4. This type of damage was also seen on the inboard IR raceway of unit 918287, although less pronounced than on the outboard IR raceway.

Based on the surface appearance of the IRs, it can be stated that the loaded zone tended to be across 2/3rds of the raceway width, toward the larger section i.e. towards the large flange for units 918279 and 918287. This was most apparent on the inboard IR of unit 918279, as illustrated in figure 5.

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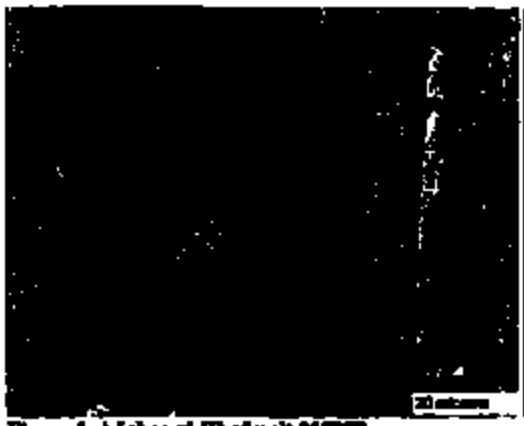

Figure 1 a) Inboard IR of unit 918279

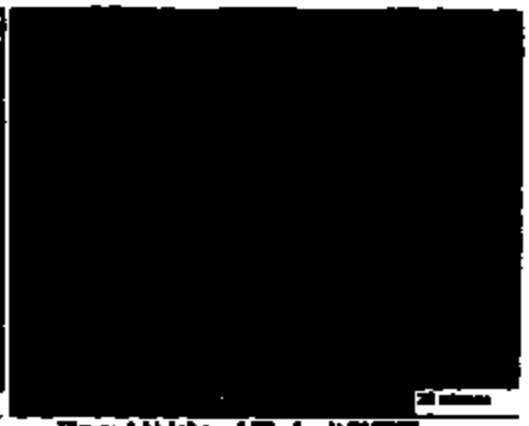

Figure 1 b) Inboard IR of unit 918287

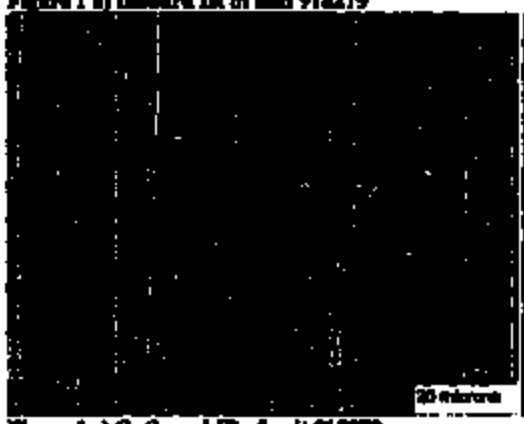

Figure 1 c) Outboard IR of unit 918279

Figure 1 d) Outboard IR of unit 918287

Figure 1 e) Outboard IR of unit 317972

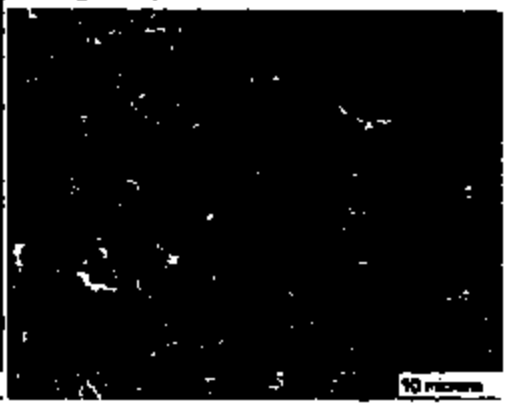

Figure 2: Surface distress associated with the circular features.

Figure 1: Typical surface appearance in the centre of the raceway of the IRs.

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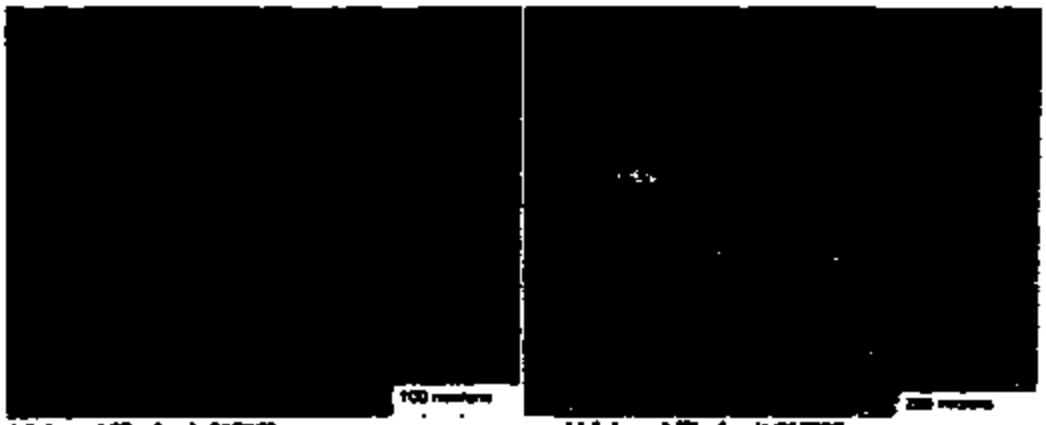

a) Inboard IR of unit 918279 b) Inboard IR of unit 918287

Figure 3: Typical examples of denting by deformable particles

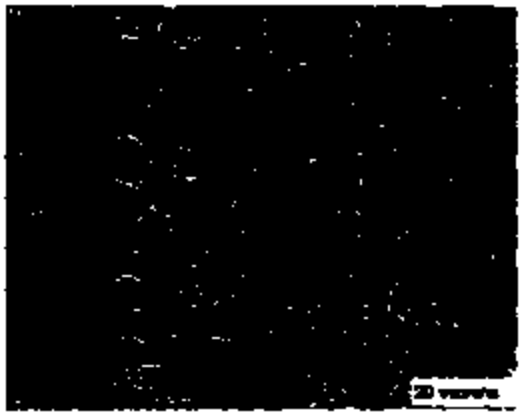

Figure 4: Band of advanced surface distress and fine dense denting on the surface

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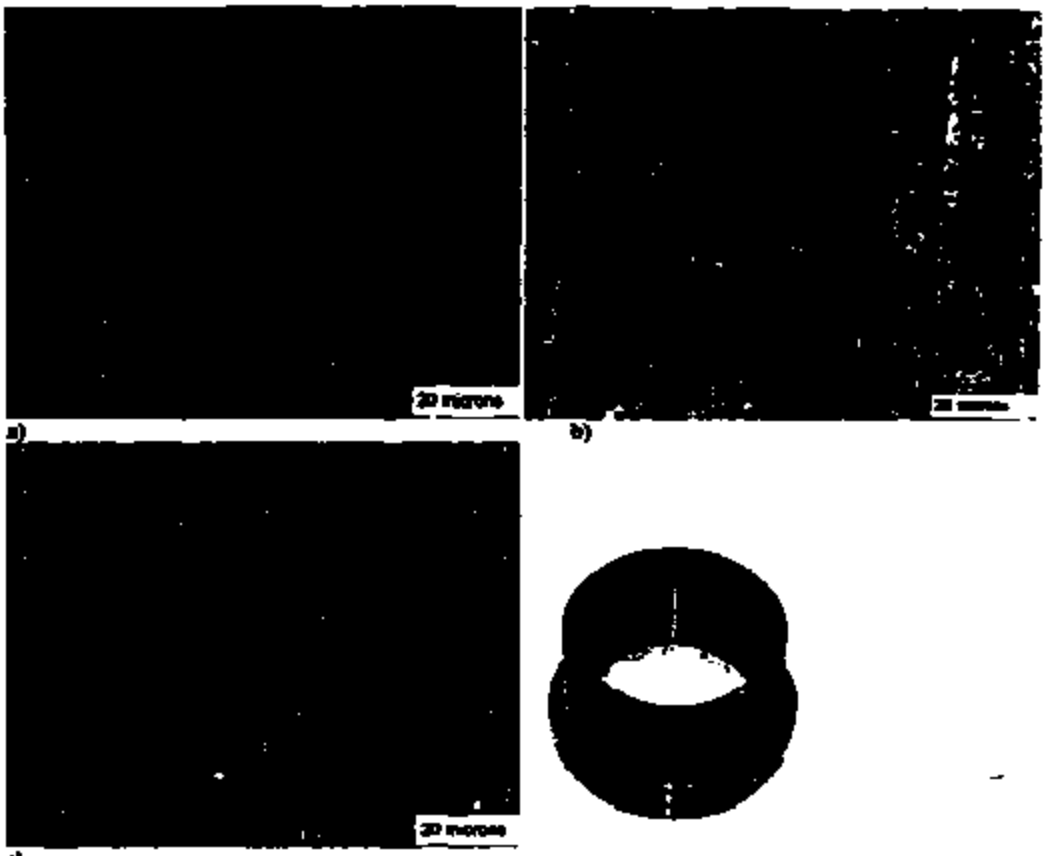

Figure 5: Surface appearance of the running track of the inboard IR of unit 918279 a) in the loaded zone at the flanged side, b) in the loaded zone in the centre of the raceway and c) in the loaded zone at the thin section end

The raceway surface of the outboard IR of unit 317572 did not reveal such a load distribution but indicated a uniform load across the width of the raceway.

2.1.2 Outer Rings

The outer ring (OR) raceways also showed surface distress in that the finish machining marks had been removed to some extent, as illustrated in figure 6.

Relatively large smooth indents were seen on the inboard OR raceways of units 918287 and 918279 but were not observed on the outboard OR raceways, as with the IRs. The OR raceways of unit 317572 did not have any evidence of overrolling of deformable particles.

For the inboard and outboard raceways of the OR of unit 918287, bands of dense fine denting and advanced surface distress (as illustrated in figure 4 were seen but were less clear than these seen in the IR but were in the corresponding location. In addition, bands of more advanced surface distress with surface initiated microspalling were seen in this raceway, as shown in figure 7. This microspalling was not observed in any of the other OR raceways.

2.1.3 Rollers

As with the IRs and ORs, the rollers from the inboard side of units 918279 and 918287 tended to show relatively large, smooth indents from the overrolling of deformable particles and an example can be seen in figure 8. The rollers from the outboard raceways of these units, as with the outboard IR and OR raceways, did not have such smooth indents. The rollers from unit 317572 did not show evidence of the overrolling of deformable particles.

The outboard rollers showed the same bands of dense fine indentations and more advanced surface distress, as illustrated in figure 4. There was some evidence of this type of banding on the inboard rollers but, as with the IR and OR raceways, the banding was less pronounced than on the outboard raceways.

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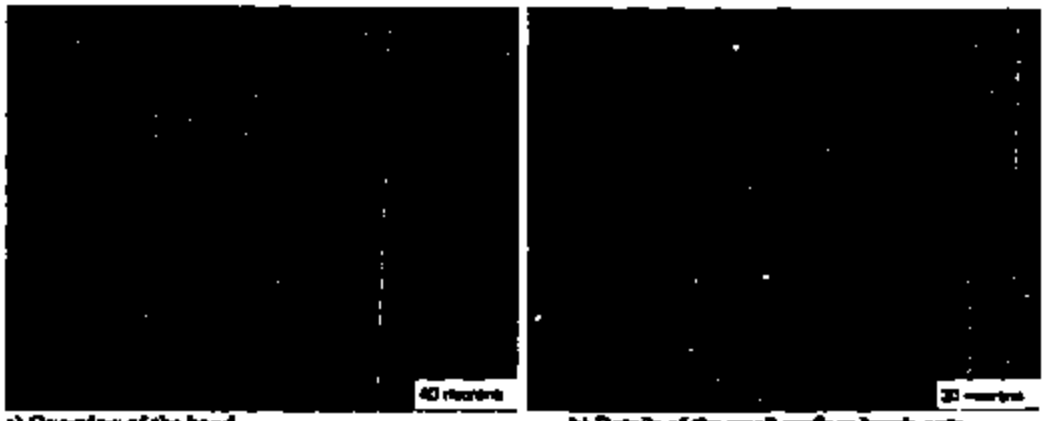
a) Inboard OR raceway of unit 918279 b) Inboard OR raceway of unit 918287

c) Outboard OR raceway of unit 918279 d) Outboard OR raceway of unit 918287

Figure 6: Typical surface appearance of the centre of the OR raceway of various units



a) Overview of the band b) Details of the small surface break-outs

Figure 7: Band of advanced surface distress on the inboard raceway of the OR of unit 918287.

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Roller from inboard raceway of unit 918279

Figure 8: Typical example of denting by deformable particles

a) Typical surface appearance of the flange of the inboard IR of unit 918279

b) Details of the smearing shown in a)

Figure 9: Surface appearance of the flange of the inboard IR of unit 918279.

Figure 10: Edge surface appearance of the flange of the outboard IR of unit 918287

Figure 11: Edge surface appearance of the flange of the inboard IR of unit 918287

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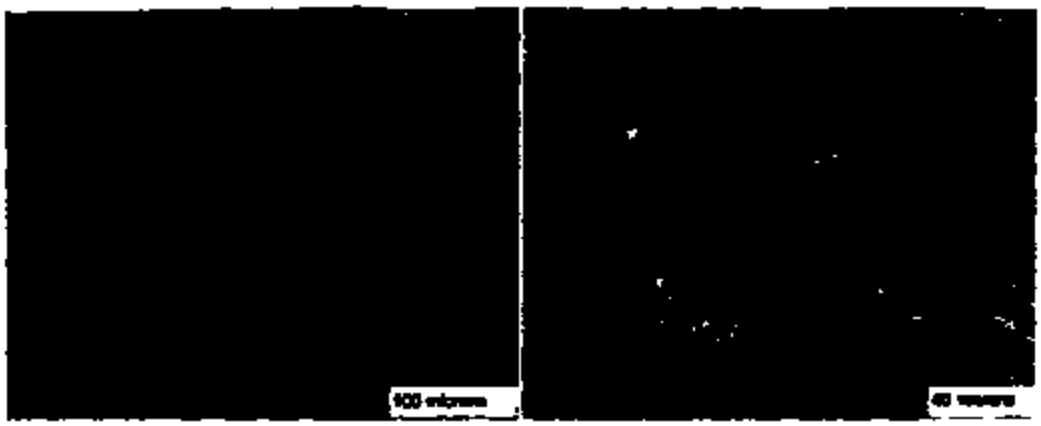

a) Large smearing mark in the flange of the inboard IR of unit 918287

b) Typical surface appearance of the flange of the inboard IR of unit 918287

Figure 12: Surface appearance of the flange of the inboard IR of unit 918287.

Figure 13: Surface aspect in the sliding band of the inside seal lip onto the inner ring shoulder of the

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2.2 Other Surfaces

2.2.1 Flange and roller end-faces

The units 918279 and 918287 both showed evidence of roller end-face contact on the flange at the larger section, particularly on the inboard IRs. This is illustrated in figure 9 for unit 918279, where the original finish machining marks (which would have been oriented vertically) have been totally removed and there is apparent smearing of the surface. This would suggest a rather poor or very thin film conditions, especially for the flange contact.

For unit 918287, the damage on the flange on the inboard IR was more exaggerated. It was noted that the contact with the roller end-face was over the whole flange surface. The finish machining marks were totally removed, due to surface distress, and micro-plastic deformation was apparent at the edges of the flange. This is illustrated by comparing the edge of the flange of the less damaged outboard IR in figure 10 with that of the inboard IR of unit 918287 in figure 11.

In some areas, larger areas of smearing were seen and also areas where material had been removed from the flange surface, as shown in figure 12.

2.2.2 Flange shoulders

This area corresponds to the contact of the seal lips. It was noted that the inboard IRs tended to show more evidence of the removal of the finishing marks in this area, due to the seal contact, than the outboard IRs. There were three sliding bands on the inboard IR shoulders, corresponding to the seal lips. The inside seal lip sliding band showed a smoothed surface, as can be seen in figure 13. This level of sliding damage is considered to be mild.

On the external sliding band, there were various pit-like features.

Some pits contained silica particles (i.e. dust), but most of the pits contained elements such as carbon, oxygen, sodium, sulphur, chlorine, potassium and calcium. These elements can be related to rubber material of the seal itself, components of the grease and possibly also aqueous corrosion deposits. It is noted that some surface corrosion outside the seal contact and outside the bearing could be seen for the inboard IR of unit 918287.

3 Conclusions

The three TFRUs from the field have suffered damage during the ± 500,000 miles in service but were not classified as having failed. There were many similarities in the character of the damage in the three units, although it is noted that the components of units 918279 and 918287 tended to show clearer evidence of the damage than those of unit 317572.

Bearing in mind that the inboard inner ring of unit 317572 was not supplied, the following general statements can be made on the nature of the observed damage.

All raceways showed evidence of surface distress in that the finish machining marks were removed to some extent. The surface distress, in general, was not very advanced since finishing marks were still visible and there was no micropitting of the surface. One exception was the outer ring of unit 918287, which will be covered later.

Small (< 5 µm diameter) circular features were observed on all raceways but the mechanism for their formation is not clear. It is noted that on the inboard inner rings, the features were linked to localised areas of more advanced surface distress, although micropitting was not observed in these areas.

The inboard raceways had smooth dents, formed by the overrolling of deformable particles. This type of damage was not seen on the outboard raceways.

The outboard raceways, particularly the inner rings, had bands of dense fine denting and more advanced surface distress. These bands were concentrated towards the edge of the contact, nearest the thin section of the outboard inner rings or the equivalent location on the outboard outer rings and rollers. Similar bands were seen on some inboard raceways but the degree of damage was less pronounced than on the outboard raceways.

There was contact between the roller end-face and the flange, particularly for the inboard inner rings. This resulted in removal of the finishing marks, smearing and even material loss from the flange.

The flange shoulders showed evidence of contact with the seal lips, which had resulted in mild sliding damage at the position of the inside seal lip.

On the position of the external seal lip, pit-like features were observed. These pits contained dust and apparent material from the seal. There may also have been products from aqueous corrosion in some pits. It is noted that some surface corrosion was apparent outside the seal contact on the inboard inner ring of unit 918287.

The inboard outer ring raceway of unit 918287 had localised bands of advanced surface distress and associated micropitting. No other components of the units showed any evidence of micropitting.

In summary, all components examined showed evidence of surface damage on the raceways, either in the form general surface distress or localised bands of surface distress associated with fine indents. The inboard raceways had been dented by the overrolling of deformable particles and all raceways had small, micron-scale circular features.

Surface distress, whether general or localised, indicates that the lubrication film thickness is insufficient to separate the rolling contact surfaces. Surface distress is a fatigue phenomena and, as such, is progressive and, over time, can lead to micropitting, as was seen very locally on the inboard outer ring raceway of unit 918287.

The contact between the roller end-face and the IR flange also indicates a poor lubrication film in this region.

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SKF 000305

It is recommended to investigate whether the small circular features are common to THUs and, if so, to determine their origin in order to avoid their formation.

4 References

Ref.1 G. de Wit, ERC report NL02T903e, 'Monitor THUs from the Field: Visual Inspection'

Ref.2 A. Kerrigan, ERC report NL02M902e, 'Monitor THUs from the Field: Grease Analysis'

Ref. 3 A. Kerrigan, ERC report NL02M904e, 'Monitor THUs from the Field: X-Ray Analysis'

Ref.4 T. E. Tallian, 'Failure Atlas for Hertz Contact Machine Elements', ISBNO-7918-0008-3

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SKF 000306

NL02E902e
2002-07-24

ArvinMeritor THUs from the Field: Grease Analysis

Aidan Kerrigan

Materials Theory & Testing

EXTERNAL CUSTOMER
Interim Report on Project No. N02 184

ArvinMeritor THUs from the Field: Grease Analysis

NL02N802a
2002-07-24

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Key Words	THU, grease, FTIR, analysis, GWZ, MT33, GEJ, base oil, thickener, water

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ArvinMeritor THUs from the Field: Grease Analysis

Abstract Samples of grease from three THUs from the field were analyzed using FT-IR. The main conclusion was that all three samples contained a proportion of water.

Project background

There have been incidents with THUs in the field in the USA. Three units were sent to ERC, via SKF Schweinfurt, for investigation, including grease analysis.

Objectives

To analyse the grease using Fourier Transform Infra Red (FT-IR) analysis.

Main results

See 'Main conclusions and recommendations'

Main conclusions and recommendations

The grease from the three THUs returned from the field was not SKF GWZ but is likely to be grease GEJ i.e. Shell Calithia EP2.

In general, the grease from the three THUs returned from the field was in good condition in that there was no evidence of thickener degradation or base oil oxidation. However, it should be noted that the grease samples were taken from the outer ring at a position between the two raceways. The samples, therefore, may not reflect the condition of grease overrolled in the contact zone.

The samples from the three THUs returned from the field gave a clear indication that the grease contained water. The estimated water content in the samples was:

THU no. 317572: ± 1% water

THU no. 918287: ± 1% water

THU no. 918279: ± 1.5% water

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NL02M906e
2002-08-01

ArvinMeritor THUs from the Field: Final Report

Aidan Kerrigan

Materials Theory & Testing

ArvinMeritor THUs from the Field: Final Report

NL02M005e
2002-08-01

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Key Words	THU, visual inspection, grease analysis, surface analysis, SEM, x-ray, fretting, corrosion, fatigue, water

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ArvinMeritor THUs from the Field: Final Report

Abstract This report summarises the various investigations which have been performed to assess the degree and nature of the damage on three THUs returned from the field after approximately 500,000 miles in service.

Main conclusions and recommendations

Investigation of the material response to rolling contact fatigue showed only a limited accumulation of fatigue damage, using the line broadening parameter (b/B ratio), at the depth of maximum Hertzian stress for the inner and outer rings investigated. Based on this, it is unlikely that classical sub-surface initiated fatigue will be the 'life limiting' failure mode in these THUs.

The material response results also indicate that the material and heat treatment combinations for these major components were suitable for the bearing loads experienced in service, from the point of view of classical, sub-surface initiated failure.

In unit 918287, the inboard inner ring and inboard outer ring showed some material response at the surface or near surface in that a compressive stress was generated in this region. Despite this change, the line broadening parameter (b/B ratio) remained at a relatively high level, indicating only a limited accumulation of fatigue damage at the surface.

Despite the above statement, the visual and SEM investigations showed a number of types of surface damage which had been accumulated during running in service. The raceways, in general, showed evidence of surface distress, although this had not totally removed the finish machining marks. Denting, due to overrolling of particles, was also observed in the raceways. This was present as generally distributed denting on the inboard raceways due to overrolling of deformable particles and also as more localised denting and more advanced surface distress in the form of bands at the edges of the contact, mainly on the outboard raceways but also visible on some inboard raceways. It is noted that one inboard outer ring raceway had suffered localised micropitting on one band of advanced surface distress.

The surface damage indicates a lubrication regime which is not optimum, either in terms of film thickness or in terms of cleanliness with respect to contaminant particles.

The grease from all three units was found to contain water, in a proportion of ± 1% to 1.5%. Although the effect is difficult to quantify, in terms of lubrication properties in the application conditions, it is strongly suspected that the water contamination of the grease contributed to the surface distress damage by adversely affecting the lubrication film.

From the observations of the visual inspection and SEM, combined with the x-ray results of material response, it is most likely that surface initiated fatigue will be the "life limiting" failure mode in the three THUs investigated.

Surface fatigue is progressive, first noted as surface distress which increases in severity until micro-spalling of the surface occurs. Micro-spalling can occur locally (e.g. related to bands of advanced surface distress) or can occur generally on a raceway surface and, again, this is a progressive failure mode which can lead to larger scale spalling.

It is noted that the surface damage on the three THUs from the field was on a micro-scale, in terms of denting and surface distress, with only one raceway showing evidence of localised micropitting.

The bores of the inner rings, particularly the inboard inner rings, showed evidence of corrosion. In the position of the highest load, this would be classed as fretting corrosion, due to the darkened appearance of the surface and the removal of the finishing marks. An investigation of one inner ring from the field showed that the corrosion products in the bore at different positions had similar characteristics and that they had been formed in a damp environment, i.e. in the presence of water.

Despite the damage observed in the three THUs, they were still not classified as having failed. The level of damage seen in these three THUs was certainly not advanced and does not indicate the likely specific 'life limiting' failure mechanism in more detail, other than being surface initiated.

It is recommended to further investigate the condition of the grease in units from the field. The grease sample should be taken at the time of dismounting the THU in order to eliminate doubts about the pick-up of moisture between dismounting and investigation. Note that the grease should ideally come from the raceway position to determine the extent of thickener degradation and base oil oxidation in grease that has been overrolled. Included in the grease analysis could be particle analysis, in order to indicate, if possible, the source(s) of indents on the THU raceways.

It is recommended to determine whether the small circular features are a common occurrence in THUs. If so, their nature and origin should be determined as a means of indicating how their formation can be avoided.

The results of these ERC investigations should be combined with those of SKF Schweinfurt and finite element modelling to determine the likelihood of water ingress into the THU and the possibility for migration of a damp environment.

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1 Background

Three run THUs, returned from the field, and one new unrun THU were supplied to ERC for investigation. The THU identification number, corresponding ERC identification number and number of miles covered by the THUs are shown in table 1.

THU	ERC no.	Mileage
918279	02MR0020	569,184
317572	02MR0021	560,228
918287	02MR0022	591,711
New unit	02MR0019	zero

Table 1. Investigated THUs

It should be noted that for unit 918279, the box was marked 596,184 miles while the tag on the unit was marked 569,184 miles. It was decided to use the mileage marked on the tag.

The inboard inner ring (IR) of unit 317572 was not supplied. All components of the other THUs were supplied.

In addition to the investigations on these three THUs from the field, further examples of returned THUs were examined in SKF Schweinfurt and the observations are included in this report.

2 Summary of Investigations

2.1 Visual Inspection [Ref. 1]

The three THUs delivered to ERC had not failed and could still have been used in the field. These THUs were in the ideal condition for a determination of the applied running conditions. These showed to have been tough for the bearings in term of the lubrication conditions, most likely caused by water ingress.

Additional unfailed THUs were visually inspected at SKF Schweinfurt and these showed a very similar appearance as the three THUs supplied to ERC.

Failed THUs were also visually inspected at SKF Schweinfurt and these showed the logical result of what would happen to the unfailed bearings if they had been used longer.

Some of the conclusions are only indicative as they were based purely on the visual inspection of the THUs. Bearing this in mind the following route causes for failure is suggested as the most likely:

1. The application conditions for the THUs were not ideal.

1.a. Loose fit on the shaft, resulting in fretting corrosion in the bore of the inner rings.

1.b. High bending forces on the knuckle and/or shaft, resulting in fretting corrosion on both side-faces of the inner rings.

1.c. Poor surface finishing of the knuckle surface in contact with the inner ring (in-board) had an accelerating effect on the formation of fretting corrosion.

The recommended investigations are ongoing and are required for the confirmation of the following.

2. Water entered in to the THU in the bore/shaft position.

2.a. Resulting in found moisture corrosion.

2.b. Water entered also in to the grease, resulting in poor lubrication conditions, i.e. thin film.

3. The surface initiated spalling, as observed in eight THUs in Schweinfurt, was caused by poor lubrication resulting in adhesive wear, smearing and surface distress.

4. Modelling of the loading conditions could explain if these might have contributed to a (temporary) negative effect, e.g. during braking, on the lubrication conditions and therefore have had an accelerating effect on the failure process.

2.2 Bore Corrosion Product Analysis [Ref. 2]

An individual inner ring was supplied by SKF Schweinfurt for an analysis of the corrosion products in the bore. In the bore, at the highest loaded position (nominated as 0°), there was a darkened red area, which would normally be classed as fretting corrosion. However, there was also a light red area at the 180° position, which was regarded as unusual. In general, the chamfer was not discoloured but there was a free-standing red area on the chamfer i.e. in a non-contacting location. These four areas were subjected to analysis at the University of Surrey, UK, using x-ray photoelectron spectroscopy (XPS). This technique is used to determine the chemical species by measurement of the chemical bonding energies.

According to the results and interpretation from the University of Surrey, the products in the bore of the THU inner ring at the 0° and 180° positions had similar characteristics and were an Fe(III) compound, most probably FeOOH, which is formed in a humid environment i.e. in the presence of water.

It should be noted that at the 0° position, the finish machining marks were not apparent but that at 180°, the finish machining marks were still visible.

On the (non-contacting) chamfer, the non-discoloured surface had an Fe_2O_3 type of deposit. This was stated to have been formed in a dry environment, at a "slightly elevated" temperature, probably during heat treatment.

The free-standing red area on the chamfer was analysed and also found to be an Fe_2O_3 type of deposit, again formed in a dry environment.

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unit 918287, there was no evidence of significant material response to rolling contact fatigue.

The inboard raceway of the outer ring of unit 918287 gave an indication of surface fatigue, although the response was not as clear as that shown by the inboard inner ring (at the thinner end).

The outboard raceway of the outer ring of unit 918287 did not give an indication of a significant material response to rolling contact fatigue.

In summary, none of the THU components measured showed any evidence of the accumulation of sub-surface fatigue from the Hertzian stress induced by a rolling contact in the application.

Based on the residual stress profiles, there was evidence of a material response at the surface or near surface of the inboard inner ring raceway and the inboard outer ring raceway of unit 918287. In the absence of a sub-surface fatigue response, this would suggest that surface initiated fatigue would be the most likely failure mode. However, it is noted that the line broadening parameter (b/B ratio) remained at a relatively high value, indicating only a limited accumulation of fatigue damage at the surface or near surface region.

3 Discussion

The residual stress profiles and line broadening (b/B) profiles measured on the THU components show that there was only a limited material response to rolling contact fatigue (RCF) in the sub-surface region i.e. at the depth of maximum Hertzian stress. This observation was valid for the inboard inner ring of unit 918279, the inboard and outboard inner rings of unit 918287 and the inboard and outboard raceways of the outer ring of unit 918287. This means that the through hardened grade 3 inner rings and surface induction hardened grade 55 outer rings did not show any clear indication of the development of sub-surface fatigue after ≈500,000 miles in service. This, in turn, would indicate that the material and heat treatment combinations for these major components were suitable for the bearing loads experienced in service, from the point of view of classical, sub-surface initiated failure.

Note:
Grade 3 is an SKF steel designation and is equivalent to ASTM A295-98 52100. Grade 55 is also an SKF steel designation and is equivalent to ISO 683-17:1999 steel type B40.

The residual stress profiles of the inboard inner ring (at the thin section) and the inboard outer ring raceway (at the three measured positions) of unit 918287 showed a material response at the surface and near surface region. This was apparent due to the development of a compressive stress of a higher magnitude than existed in the equivalent component from a new unrun THU. Despite this, the line broadening parameter (b/B) had relatively high values (≥ 0.90), indicating only a limited accumulation of fatigue at the surface and near surface region. (The b/B ratio has a maximum value of 1.0 and decreases with increasing accumulation of fatigue).

Surface fatigue can be due to one or a number of contributing factors such as particle contaminated lubrication or metal-to-metal contact, which in turn indicates a lubrication regime which is not optimum.

The SEM investigation clearly showed smooth indentations on the raceways of components on the inboard side of the THUs. Smooth indents are formed due to the overrolling of deformable particles and these particles are typically metallic. It should be noted that metallic particles are deformable in a Hertzian contact even if the particles are hard. The smooth indents seen on the inboard raceways were not seen on the outboard raceways.

The outboard raceways, however, did have bands of dense fine denting and associated surface damage. These bands were concentrated towards the edge of the contact, nearest the thin section of the outboard inner ring (or the equivalent position on the rollers and the outer ring although less clear on these components). The surface distress associated with the bands was more advanced than generally seen on either the inboard or outboard raceways. Bands of dents, at the edge of the contact, were also seen on the inboard raceways but to a much lesser extent than on the outboard raceways.

Both inboard and outboard raceways, therefore, show evidence of indentation by overrolling of particles. In the outboard raceways, the indenting was on a small scale and specifically at the edge of the contact, and associated with more advanced surface distress. For the inboard raceways, the indenting was in the form of general overrolling of deformable particles with some evidence of annular bands of dents at the edge of the contact.

The raceway surfaces, in general, showed evidence of moderate surface distress in that the finishing marks were removed to some extent, although the deeper finishing marks were still present. The existence of surface distress indicates some metal-to-metal contact between the ring raceways and those of the rollers. This can be caused by localised lubrication film breakdown, such as at the presence of indentations, or be the result of a lubrication film which, in general, is not sufficient to separate the surfaces.

Surface distress is a fatigue phenomenon and, as such, is progressive and, over time, can lead to macrospalling, as was seen very locally on the inboard outer ring raceway of unit 918287.

In unit 918279, the inboard inner ring had slightly more advanced surface distress as compared to the outboard inner ring although this difference between inboard and outboard inner ring raceways was less apparent in the unit 918287. (The inboard inner ring of unit 317572 was not supplied).

The overrolled tracks of the inboard inner rings of unit 918279 and 918287 showed that the loading tended to be towards the thicker flanged section, such that the roller sub-

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face contacted the flange. This contact resulted in the removal of the finish machining marks on the flange by surface distress, smearing of the flange surface and even material loss. This would also suggest rather poor or very thin film conditions at the roller end-face contact with the flange.

Because of the evidence of general surface distress on the raceways and at the roller end-face contact with the flange, the condition of the grease was investigated. The FT-IR analysis showed that the GRI (Shell) Calithin EP 2) grease in the three units from the field all contained a proportion of water, of the order of 1%. Note that the grease samples were taken from a position between the outer ring raceways (i.e. inside the THU.

It is generally accepted that water contamination of grease is detrimental for bearing performance, either due to adversely affecting the lubrication properties of the grease or even causing standstill corrosion. In the case of the three THUs returned from the field, there was no evidence of standstill corrosion on the raceways. However, the water in the grease may have contributed to the development of the general surface distress observed on the raceways and the surface distress and smearing seen at the contact between the roller end-face.

It is acknowledged that the FT-IR analysis also indicated that, despite the presence of water, there was no evidence of grease thickener degradation or base oil oxidation. However, it is noted that the samples were taken from a position between the two raceways of the outer ring and, as such, may not reflect the condition of the grease overrolled in the contact.

The results of the XPS analysis indicated that the darkened red product at the highest loaded position of an inner ring bore (0°) and the light red product in the bore (located at approximately 180°) were both FeOOH, which is formed in a damp environment.

At the 0° position, the finishing marks were not visible and this damage, in combination with the darkened red area, would be classified as fretting corrosion. At the 180° position, the finishing marks were still visible, despite the light red deposit at that location.

It is noted that the THU has a loose fit on the inner ring. According to information received [Ref.6], the maximum specified spindle diameter is 64.976 mm while the smallest specified inner ring bore is 64.985 mm, giving a difference of minimum 9 µm. This would suggest that a space exists for a humid atmosphere to form between the inner ring and the spindle.

The investigations performed cannot draw definitive conclusions regarding a link between the damp environment between the spindle and the inner ring bore and the presence of water in the grease. It is noted that finite element modelling of the dynamics of the THU may indicate possibilities for a physical link between the grease inside the unit and the environment between the spindle and the inner ring bore.

(It is noted that an investigation in SKF Schweinfurt [Ref.4] has found evidence of corrosion pits on the outer ring of a unit returned from the field and concludes that water entered the unit from the outboard side. The type of damage seen in this unit was not observed in the three units supplied to ERC for investigation).

In the three units supplied to ERC, there was evidence of corrosion on other surfaces of the unit to that the clamping ring showed clear evidence of red rust (moisture corrosion) on a non-contacting surface. In the SEM investigation, small pit-like features were seen on the flange shoulders which may have contained the products from aqueous corrosion. It is noted that some pits also contained dust particles and may also have contained material from the seal.

The small circular features observed on the raceways in the SEM have a similar appearance to electrical erosion damage but do not exhibit the 'melted' microstructures typically associated with this form of damage. Using the SEM EDAX facility, it was possible to determine that these features were not carbides, which in grade 3 have a measurably higher chromium content than the matrix. This the fact that the size of the small circular features tended to be larger than the carbides in grade 3, which are typically less than 1 µm in diameter. The EDAX investigation also showed that the small circular features were not related to inclusions.

The mechanism of formation of the micro-scale circular features on the raceways is unclear, as is the potential effect on bearing performance. As with dents, it can be speculated that the small circular features contribute to a localised breakdown of the lubrication film and, hence, promote metal-to-metal contact and surface fatigue.

4 Conclusions and Recommendations

Investigation of the material response to rolling contact fatigue showed only a limited accumulation of fatigue damage, using the line broadening parameter (b/B ratio), at the depth of maximum Hertzian stress for the inner and outer rings investigated. Based on this, it is unlikely that classical sub-surface initiated fatigue will be the 'life limiting' failure mode in these THUs.

The material response results also indicate that the material and heat treatment combinations for these major components were suitable for the bearing loads experienced in service, from the point of view of classical, sub-surface initiated failure.

In unit 918287, the inboard inner ring and inboard outer ring showed some material response at the surface or near surface in that a compressive stress was generated in the region. Despite this change, the line broadening parameter (b/B ratio) remained at a relatively high level, indicating only a limited accumulation of fatigue damage at the surface.

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Despite the above statement, the visual and SEM investigations showed a number of types of surface damage which had been accumulated during running in service. The raceways, in general, showed evidence of surface distress, although this had not totally removed the finish machining marks. Denting, due to overrolling of particles, was also observed in the raceways. This was present as generally distributed denting on the inboard raceways due to overrolling of deformable particles and also as more localised denting and more advanced surface distress in the form of bands at the edges of the contact, mainly on the outboard raceways but also visible on some inboard raceways. It is noted that one inboard outer ring raceway had suffered localised microspalling on one band of advanced surface distress.

The surface damage indicates a lubrication regime which is not optimum, either in terms of film thickness or in terms of cleanliness with respect to contaminant particles.

The grease from all three units was found to contain water, in a proportion of ≈ 1% to 1.5%. Although the effect is difficult to quantify, in terms of lubrication properties in the application conditions, it is strongly suspected that the water contamination of the grease contributed to the surface distress damage by adversely affecting the lubrication film.

From the observations of the visual inspection and SEM, combined with the x-ray results of material response, it is most likely that surface initiated fatigue will be the 'life limiting' failure mode in the three THUs investigated.

Surface fatigue is progressive, first noted as surface distress which increases in severity until micro-spalling of the surface occurs. Micro-spalling can occur locally (e.g. related to bands of advanced surface distress) or can occur generally on a raceway surface and, again, this is a progressive failure mode which can lead to larger scale spalling.

It is noted that the surface damage on the three THUs from the field was on a micro-scale, in terms of denting and surface distress, with only one raceway showing evidence of localised microspalling.

The bores of the inner rings, particularly the inboard inner rings, showed evidence of corrosion. In the position of the highest load, this would be classed as fretting corrosion, due to the darkened appearance of the surface and the removal of the finishing marks. An investigation of one inner ring from the field showed that the corrosion products in the bore at different positions had similar characteristics and that they had been formed in a damp environment i.e. in the presence of water.

Despite the damage observed in the three THUs, they were still not classified as having failed. The level of damage seen in these three THUs was certainly not advanced and does not indicate the likely specific 'life limiting' failure mechanism in more detail, other than being surface initiated.

It is recommended to further investigate the condition of the grease in units from the field. The grease sample should be taken at the time of dismounting the THU in order to eliminate doubts about the pick-up of moisture between dismounting and investigation. Note that the grease should ideally come from the raceway position to determine the extent of thickener degradation and base oil oxidation in grease that has been overrolled. Included in the grease analysis could be particle analysis, in order to indicate, if possible, the source(s) of indents on the THU raceways.

It is recommended to determine whether the small circular features are a common occurrence in THUs. If so, their nature and origin should be determined as a means of indicating how their formation can be avoided.

The results of these ERC investigations should be combined with those of SKF Schweinfurt and finite element modelling to determine the likelihood of water ingress into the THU and the possibility for migration of a damp environment.

5 References

Ref.1 G. de Wit, ERC report NL02T903e, 'Meritor THUs from the Field: Visual Inspection'

Ref.2 A. Kerrigan, ERC report supplement NL02T903e, 'ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis'

Ref.3 A. Kerrigan, ERC report NL02M902e, 'ArvinMeritor THUs from the Field: Grease Analysis'

Ref.4 A. Kerrigan, ERC report NL02M903e, 'ArvinMeritor THUs from the Field: Scanning Electron Microscopy'

Ref.5 A. Kerrigan, ERC report NL02M904e, 'ArvinMeritor THUs from the Field: X-Ray Analysis'

Ref.6 A. Müller, internal SKF memo dated 2002-07-18

Ref.7 SKF Schweinfurt report Nr. 186/02, issued 2002-07-11.

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NL02M905
2002-06-09

ArvinMeritor THUs from the Field: Metallurgical Investigation

Aidan Kerrigan

Materials Theory & Testing

SKF 000322

CONFIDENTIAL REPORT
Interim Report on Project No. N02 184

ArvinMeritor THUs from the Field: Metallurgical Investigation

NL02M905
2002-08-09

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	Title	Report No.
Related ERC reports	Meritor THUs from the Field: Visual Inspection	NL02T903e
	ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis (Report Supplement)	NL02T903e
	ArvinMeritor THUs from the Field: Grease Analysis and Testing	NL02M902
	ArvinMeritor THUs from the Field: Scanning Electron Microscopy	NL02M903e
	ArvinMeritor THUs from the Field: X-Ray Analysis	NL02M904e

Key Words	THUs, grade 3, 52100, grade 55, 1055M, through harden, surface induction, hardness, profile, retained austenite, microstructure

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Meritor THUs from the Field: Metallurgical Investigation

Abstract The metallurgical quality of the components of THUs has been investigated. The results have shown that there are quality issues, mainly surrounding parts which are either purchased from other manufacturers or which are subcontract heat treated.

Project background

There have been incidents with THUs in the USA. Three units from the field were supplied to ERC along with a new, unrun unit. These have been subjected to various investigations and reported here is the assessment of the metallurgical quality of the components of the THUs.

Objective

To assess the metallurgical quality of the components of THUs.

Main results

See 'Main conclusions and recommendations'.

Main conclusions and recommendations

The outer rings (ORs), in terms of composition and surface induction hardening, are of good metallurgical quality. There were slight deviations from the specifications but these were very minor and certainly not detrimental to bearing performance.

Some of the inner rings (IRs) examined had been over-austenitised during the hardening operation, leading to relatively high retained austenite contents (± 20% by volume). With the given application conditions, this is unlikely to be detrimental to the THU in terms of dimensional stability. It can only be speculated as to the effect on the rolling contact fatigue performance but the x-ray analysis investigation performed did not indicate the accumulation of sub-surface fatigue damage after ± 500,000 miles in service.

It is recommended to review the procedures and process specifications used in the hardening of the inner rings in order ensure that the product characteristics consistently meet the product specifications.

The carburised rollers examined did not meet the product specifications in terms of surface hardness. Again, it is recommended to review the procedures and process specifications used in the heat treatment process to ensure that the product specifications are met consistently. It is noted that reports from the field do not indicate any issues regarding roller performance in this application.

There were no specific quality issues with the studs examined. The stress cracking sensitivity test did reveal some features, but their origin and influence on the performance of the studs is unknown. Given that problems with the studs have been reported from the field, it is recommended to review the manufacturing route from steelmaking to finishing of the studs.

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4 Conclusions and Recommendations

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5 References

Ref. 1 G. de Wit, ERC report NL02T903e, 'Meritor THUs from the Field: Visual Inspection'

Ref. 2 A. Kerrigan, ERC report NL02M902, 'ArvinMeritor THUs from the Field: Grease Analysis and Testing'

Ref. 3 A. Kerrigan, ERC report NL01M017, 'ROLF Testing of Induction Hardened HBU Steel Variants'

Ref. 4 A. Kerrigan, ERC report NL02M904e, 'ArvinMeritor THUs from the Field: X-Ray Analysis'

Ref. 5 A. Kerrigan, ERC report NL02M903e, 'ArvinMeritor THUs from the Field: Scanning Electron Microscopy'

Ref. 6 Untersuchungsbefund Nr. 186/02, 2002-07-11

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NL02M902
2002-08-01

ArvinMeritor THUs from the Field: Grease Analysis and Testing

Aidan Kerrigan

Materials Theory & Testing

CONFIDENTIAL REPORT
Interim Report on Project No. N02 184

ArvinMeritor THUs from the Field: Grease Analysis and Testing

NL02N902
2002-08-05

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	ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis (Report Supplement)	NL02T903a
	ArvinMeritor THUs from the Field: Scanning Electron Microscopy	NL02N903a
	ArvinMeritor THUs from the Field: X-Ray Analysis	NL02N904a
	ArvinMeritor THUs from the Field: Metallurgical Investigation	NL02N905
	ArvinMeritor THUs from the Field: Final Report	NL02N906a

Key Words	THU, grease, FTIR, analysis, GWZ, MT33, GEJ, base oil, thickener, water

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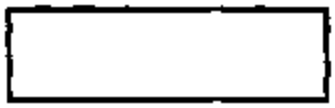
AIR LEAK TEST

Additional Investigations



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Test Results page 3
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Tabellen und Bilder

Key words: Truck Hub Unit, Air Leak Test,

Test Description

Additional air leak tests as described in ST02T205 have been performed on an original ArvinMeritor wheel end assembly using the O-ring, which is in use in the series assembly since April 2000. For comparison, the same test was performed on a European trailer axle wheel end assembly (see picture 1) without additional sealing.

Test Results

Neither of the two wheel end assemblies showed any air leak along the spindle and knuckle axle face

Conclusion

This test proves the effectiveness of the O-ring, which was introduced by ArvinMeritor to be assembled onto the front wheel spindle. It also proves that European wheel ends do not exhibit the potential leak path along the knuckle axle face and the spindle due to their different manufacturing process (see picture 1).

AIRLEAK TEST ON FF98X KNUCKLE

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Tabellen und Bilder

Key words: ArvinMeritor, Truck Hub Unit, water ingress, leak path, air leak test

THU,

Background

ArvinMeritor is claiming an unacceptable level of progressive bearing damages on their FF98X non-driven front steer axles. The discussed SKF product is a so called "full flanged" Truck Hub Unit.

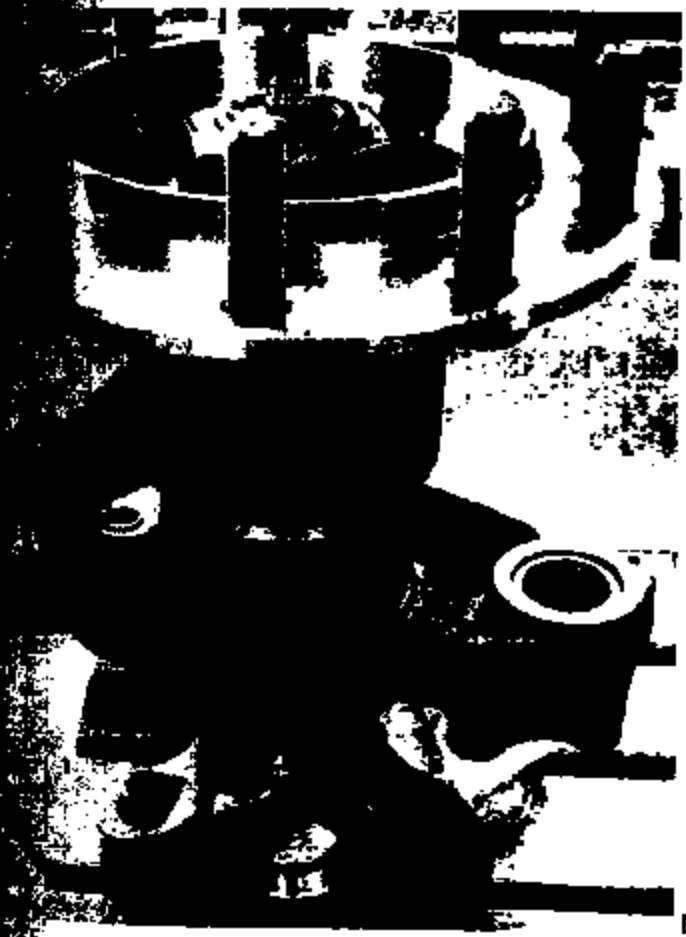
During a visual inspection of returned field parts (see report ST 02 T 206), it was found out that the vast majority of parts shows damage related to water ingress into the bearing. In contradiction to earlier inspections, a leak path along the inboard inner ring side face and the spindle was concluded to be a main contributor to the presence of water in the bearing.

...s of the Test

...e potential leak paths for water entering the bearing cavity.

Description

...SKF Truck Hub Unit BTF-0065 was installed onto a new ArvinMeritor FF98X knuckle. ...ring was clamped with a torque of 600 ft-lbs applied to the inner locking nut. A coupling for ...ed air was installed into a hub cap and the hub cap was then installed with a torque of 110 ... picture 1).



Picture 1: Air leak test set up

pressurized air (0.5 bar) was lead into the hub cap cavity. A leak detection spray was applied onto the inboard side and the hub cap of the installed unit. The test was repeated also with a used hub

Results

The formation of foam indicates the presence of leak paths along the spindle and the inner ring side face as well as along the hub cap thread (see pictures 2 to 4).

Picture 2: Foaming leak detection spray at unit side face

Picture 3: Foaming leak detection spray on new hub cap

Picture 4: Foaming leak detection spray on used hub cap

It is to be noted that this test is a static test only. It is assumed that dynamic effects caused by driving and braking of the vehicle are enforcing the observed leakages.

Conclusion

The foam formation of the leak detection spray on both the unit side face and the hub cap indicates two potential leak paths for water entering the bearing. One is along the inner ring side face and the spindle, the other is through the hub cap thread.

ASSEMBLY TEST

Non Rotation of THU Outer Ring

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st02t207 1835520kB Achim Müller

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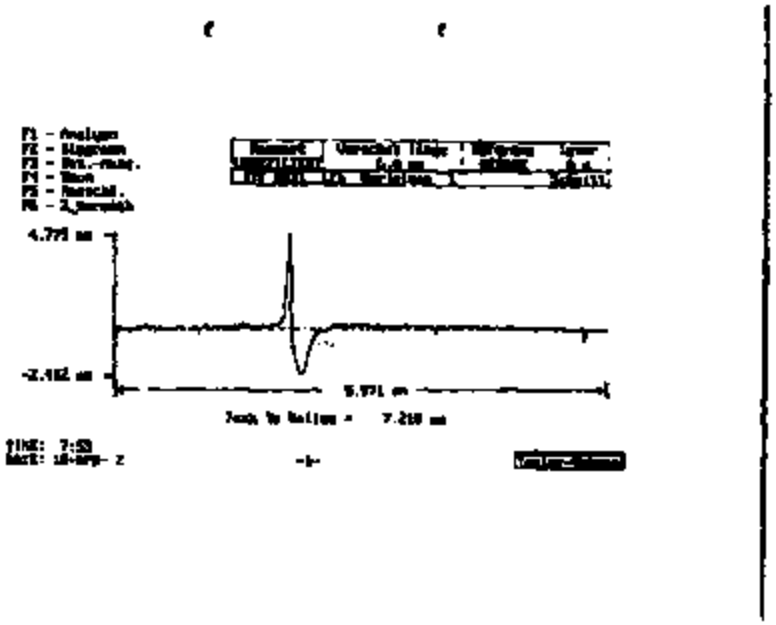
Conclusion page 4

Tabellen und Bilder

Key words: Truck Hub Unit, Assembly Test,

The extension of the indentation in picture 2 was determined to be 0.35 mm in circumferential direction and approximately 7.2 µm from peak to valley (picture 3).



Picture 3: Raceway surface and indentation

Conclusion

This test proves that non rotation of the THU outer ring during clamping can cause considerable damage of the bearing. This kind of damage is considered to be detrimental to the bearing performance

Raceway Qualification Test with Pre-Damaged THU2 BTF-0065

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Test Description page 3
Test Results page 3
Conclusion page 4

Tabellen and Bilder

Key words: Truck Hub Unit, Raceway Qualification Test, Damage

Test Description

A THU has been pre-damaged due to non rotation during assembly (see report ST02T207) That bearing was then put on a THU test rig and run under "Raceway Qualification Test" conditions.

These test conditions are chosen such, that heavy but realistic corner loads, which may occur under normal operation, are simulated. The dominant loading condition (85% of the test time) simulates + 2.25 g cornering load. Road recordings ("Service Condition Recordings...", NL93T035, G.-J. Schoters) are proposing that this condition occurs with a percentage of less than 0.3% under linehaul service. It is assumed that during city delivery, a similar cornering condition is present for less than 2% of the total service life of a vehicle.

Based on this information it is a safe assumption that every hour of test time, the test rig operates at 500 rpm, simulates approximately 2650 miles of operation under city delivery condition, while it represents more than 8300 miles under linehaul conditions.

Test Results

The reported bearing was operating for 395 hours when a vibration level, which was twice as high as the base level of the already damaged bearing was measured. These 395 hours would be already equivalent to approximately 1,000,000 miles of city delivery condition. Upon inspection small damages on the inboard outer ring raceways were detected (see picture 1).

Picture 1: circumferential operation traces and scratches on run, predamaged THU outer ring raceway

During a Design Verification Test, these scratches would have been evaluated as bearing damage, and the test would have been terminated.

Since the target of this test was to demonstrate the feasibility of a 50,000 miles inspection interval, it has been decided to continue the test instead of investigating the observed damage in detail.

Upon restarting of the test, the bearing was overloaded by mistake. The overload was such that a axial load equivalent to approximately 1 g was acting on the THU. The bearing was immediately heavily damaged on the raceways and outer ring guiding flanges (see picture 2). Nevertheless the test was continued with this, now excessively, damaged bearing.

Picture 2 THU zone after overload

The bearing is operating since then for 32.5 hours under the earlier described test condition. The test time would translate into approximately 86,000 miles of field operation under city delivery conditions.

During the test, inboard and outboard inner ring temperatures were recorded (see table 1). After test termination, the axial endplay of the Truck Hub Unit was determined to be 0.315 mm.

Test Time [h]	Inboard inner ring temp. [°C]	Outboard inner ring temp. [°C]
6	130	not recorded
11.6	150	130
18.7	165	133
25	180	140
28.4	180	140
32.5	190	150

Table 1: Inner ring temperatures

Conclusion

From the above result it is concluded, that a damage caused by a wrong assembly method (i.e. no rotation during clamping) will not immediately affect the bearing performance. It is, however, to be expected that such damage will reduce the potential service life of a Truck Hub Unit.

The heavy bearing damage caused by mistake would have been noticed during a "Basic Inspection" of the wheel end. The wheel would have been considered as running rough and noisy. Continuing the test for another 12.5 hours (equivalent to 86,000 miles under city delivery condition) shows that the chosen 50,000 miles interval between two "Basic Inspections" is sufficient to detect bearing damages prior to a safety critical condition of the wheel end.

Raceway Qualification Test
on BTF-0065
with "Water Contaminated Grease"

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Conclusion page 6

Tabellen und Bilder

Key words: Truck Hub Unit, water contamination, raceway qualification,

1. Objective

To demonstrate the performance of a THU with water ingress under Raceway Qualification Test Conditions

2. Test Bearings

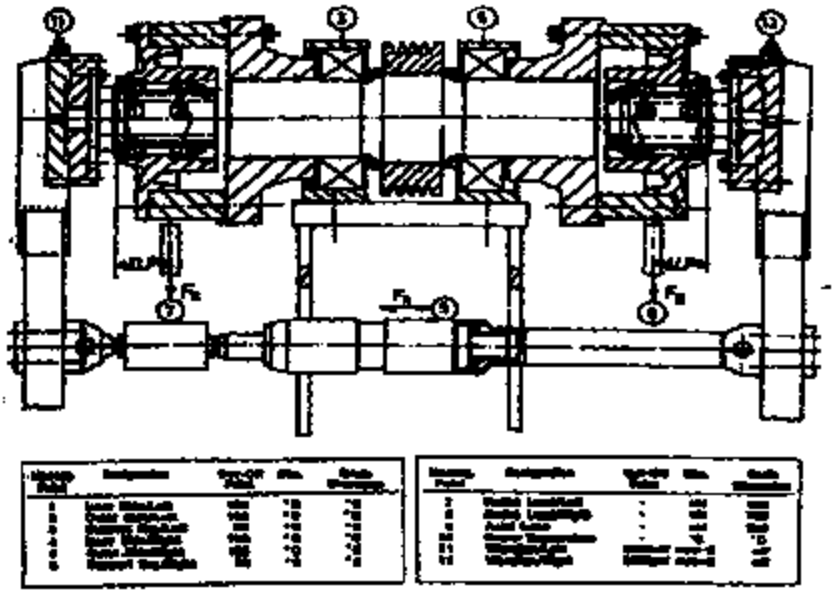
Test Bearing: BTF-0065 manufactured by Aiken USA

Customer: ArvinMeritor

Application: 13200 lbs Front Steer Axle

3. Test Rig

The test was performed on SKF Truck Hub Unit test rig THU4 in Schweinfurt, Germany. A principle sketch of the test rig is shown below.



Picture 1: Principle sketch of the THU test rig

Two bearing units are running at the same time. Radial and lateral load are applied with hydraulic cylinders as under road running conditions.

Radial load is applied independently to each unit, lateral load is applied via a toggle rod to both units at the same time. The lateral load, applied at a loading radius equivalent to the tire radius, creates a moment load on the unit.

The spindles are equipped with thermocouples to measure the bearing temperature. Also the rig support bearing temperature and vibration level for alert stop are measured.

Rotational speed and loads are electronically controlled and monitored.

A picture of the THU test rig is shown below in picture 2.

Picture 2: Truck Hub Unit test rig

4. Test Description

This test is designed to evaluate the raceway fatigue life of the tested THU under severe but realistic conditions. The conditions have been chosen to accelerate the test while ensuring a realistic failure mode. The test does not determine the L_{10} life of the test THU since not enough bearings are tested for such an evaluation.

5. Test conditions

5.1 Test Target

Two units will be tested until failure or max $2*L_{10}$. In this case L_{10}= 208 hours. L_{10} is calculated using SKF computer program BEACON assuming the load cycle below.

5.2 Load Conditions

Time [sec.]	Acceleration (g)	F_{rad} (kN)	F_{ax} (kN)
102	0.25	40.4	10.1
3	0	29.4	0
12	-0.25	18.5	-4.6
3	0	29.4	0

5.3 Assembly Conditions

Load line from vehicle inside (LLP):	62.5mm
Wheel radius:	533mm
Clamp force of the inner rings:	80 kN

Speed:	500 mm
Cooling:	air cooling equivalent 100km/h
Temperature measuring points:	measured in the spindles under the raceways with thermocouples

5.4 Remarks

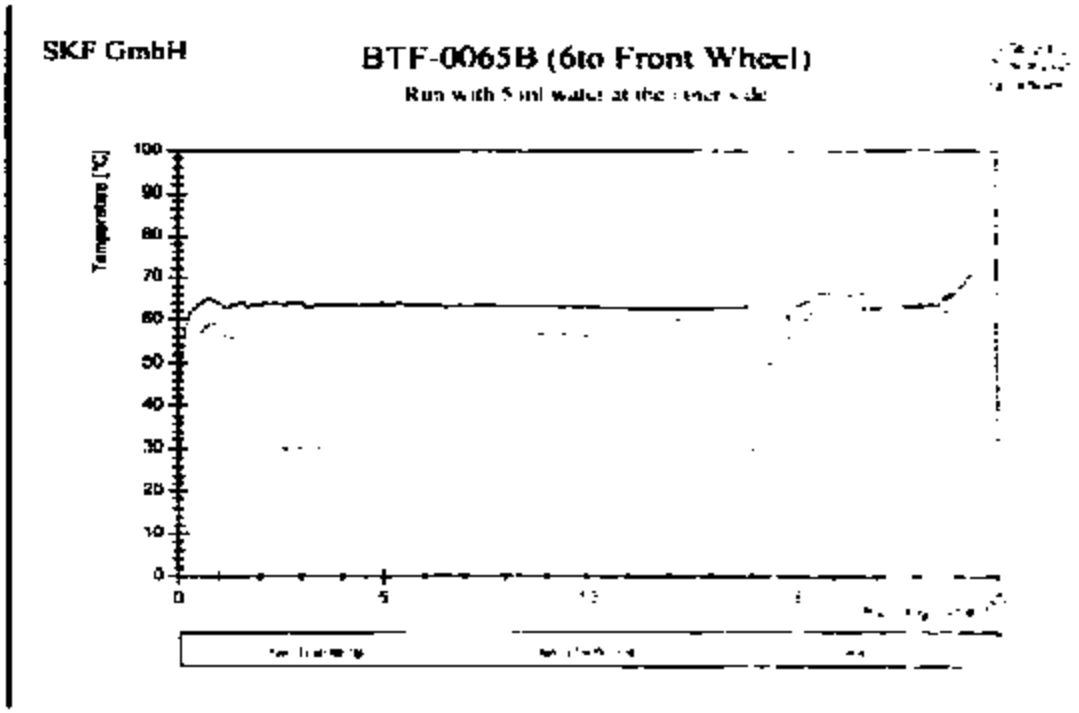
Both bearings were lubricated with 61 grams of grease in which 1.5% of water (0.9 gram) were dispersed. One bearing was equipped with an R-SAFE type seal, the other with a garter seal. After 37.5 hours of operation, the rig was stopped and a grease sample was taken from the bearing with the R-SAFE seal. The amount of water in the grease dropped to 0.3%, i.e. water is evaporating during operation.

The missing amount of grease was substituted and 5 grams of water were injected to the inboard inner ring retaining flange.

The earlier mentioned test cycle was run for 14 hours continuously, followed by a standstill period of 10 hours.

6. Test Results

After the addition of the aforementioned 5 grams of water, the test bearing completed 14 hours of operation and the following standstill period. Upon restart of the operation, it was noticed that the bearing temperature increased steadily, indicating a bearing damage (see picture 3).

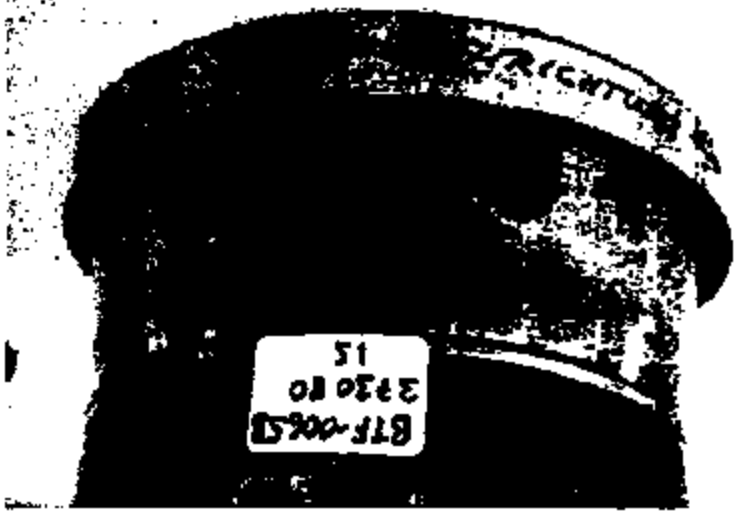


Picture 3: Temperature recording indicating bearing damage after standstill period

The bearing was run for additional 4.5 hours until it was decided to terminate the test.

7. Bearing conditions after the test

After disassembly and cleaning of the bearing, the inboard inner ring of the unit shows several shallow spalls (see picture 4). The appearance of the roller raceways is shiny.



Picture 4: Spalled inboard inner ring raceway (the arrow indicates the sense of rotation)

Grease samples were taken from both units. It was determined that the bearing with the garter seal showed only traces of water. The amount of water in the spalled unit was reduced to approximately 1.5 grams only

8. Conclusions

The damage of the spalled unit has the same appearance as damages of bearings returned from the field (see ST02T206). This confirms that even relatively small amounts of water, entering a Truck Hub Unit will cause major damage in a short time.

It could furthermore be demonstrated that water, which entered the bearing, eventually evaporates during operation. This can explain the presence of salt and other minerals in bearings returned from the field, without obvious water content in the lubricant.

WHEEL STUD REPLACEMENT TEST

On THU2 BTF-0065

SKF GmbH
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Tel.: +49 (9721) 56-0

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Requested by		
Project		
Reported by Achim Müller/ATT-PK	Supervised by	Approved by A. Stubenrauch / ATT
Copies to		
Michael D. Lewis	ADNA	SKF NATC
Achim Müller	ATT-PK	SKF Schweinfurt
Archiv	MWI	SKF Schweinfurt

st02t211 347648kB

Achim Müller

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Test Description page 3
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Conclusion page 4

Tabellen und Bilder

Key words: Truck Hub Unit, Stud Replacement Test,

Purpose

Purpose of this investigation was to prove that replacing wheel studs of a Truck Hub Unit (THU) by using inappropriate tools (e.g. a hammer) will cause damage on ring and roller raceways of the bearing.

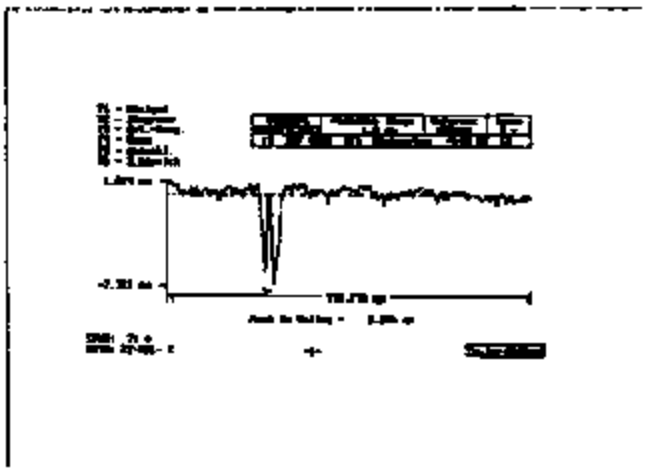
Test Description

A THU (BTF-0065) was assembled onto a test spindle. This spindle was then horizontally attached to a table. Two bolts were "pressed" out by a single hammer (weight 2.5 kg, 5.5 lbs) stroke. After that, two new studs were installed by approximately 10 strokes each.

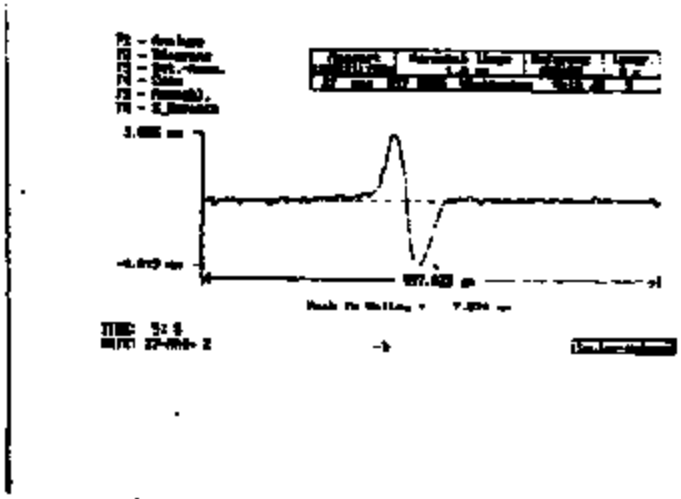
This test was repeated with three different units.

Test Results

Upon disassembly of the unit, several indentations were found on ring and roller raceways. The typical shapes of such indentations are given in picture 1 (inner ring raceway) and 2 (roller raceway)



Picture 1: Indentation on inner ring raceway after wheel stud replacement



Picture 2: Indentation on roller raceway after wheel stud replacement

Conclusion

This test proves that replacing wheel studs of a THU by using inappropriate tools can cause considerable damage of the bearing. This kind of damage is considered to be detrimental to the bearing performance.

STATIC WATER SPLASH TEST ON ARVINMERITOR KNUCKLE

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Achim Müller	ATT-PK	SKF Schweinfurt
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Tabellen und Bilder

Key words: Truck Hub Unit, Water Splash Test, ArvinMeritor, Knuckle

Purpose of the Test

The purpose of this static test was to prove if water may enter the joint between a Truck Hub Unit's outer ring and the knuckle side face of ArvinMeritor's front steer axle.

Test Description

A Truck Hub Unit BTF-0065 was assembled onto a new knuckle of an ArvinMeritor front steer axle. A torque of 450 Nm (590 ft-lbs) was applied to the inner lock nut. The specified minimum clamp torque is 680 Nm (680 Nm). The outer lock nut was clamped to specification.

The knuckle is then installed horizontally to a rig. To achieve some temperature variation, the Truck Hub Unit was set into rotation by means of a driving belt. Simple tab water was then sprayed onto the joint between knuckle and outer ring side face (see picture 1).

Picture 1: Static Water Splash Test set up

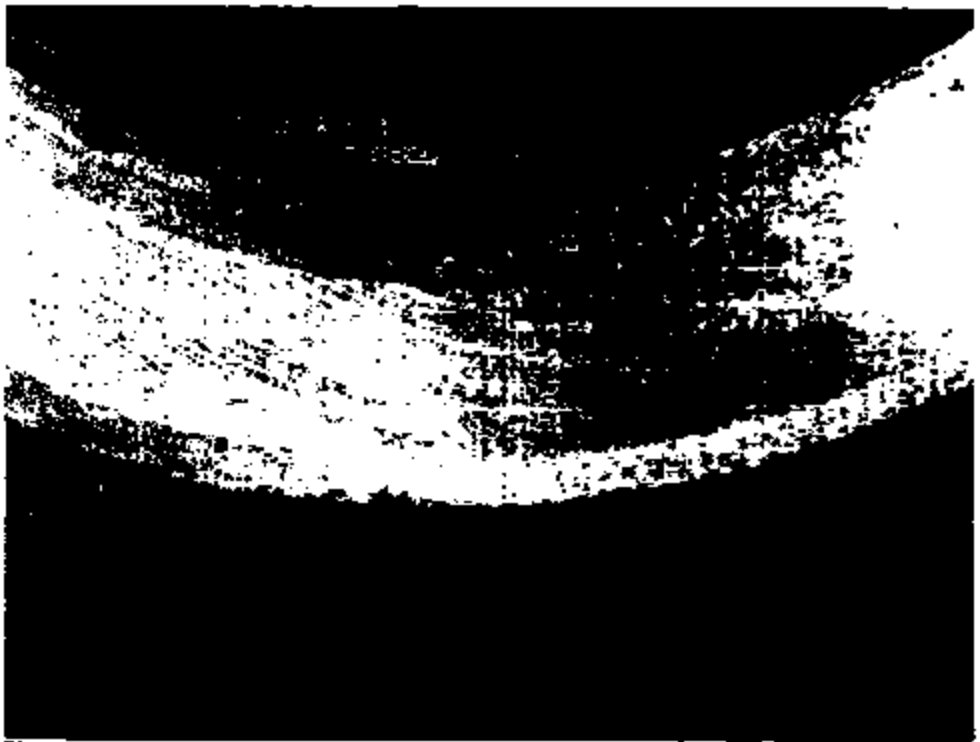
The rotational speed of the unit was set to be 800 rpm during "dry" periods, while it was 300 rpm during wet periods with water splash. The duration of each time period was set to be 30 minutes.

Test Results

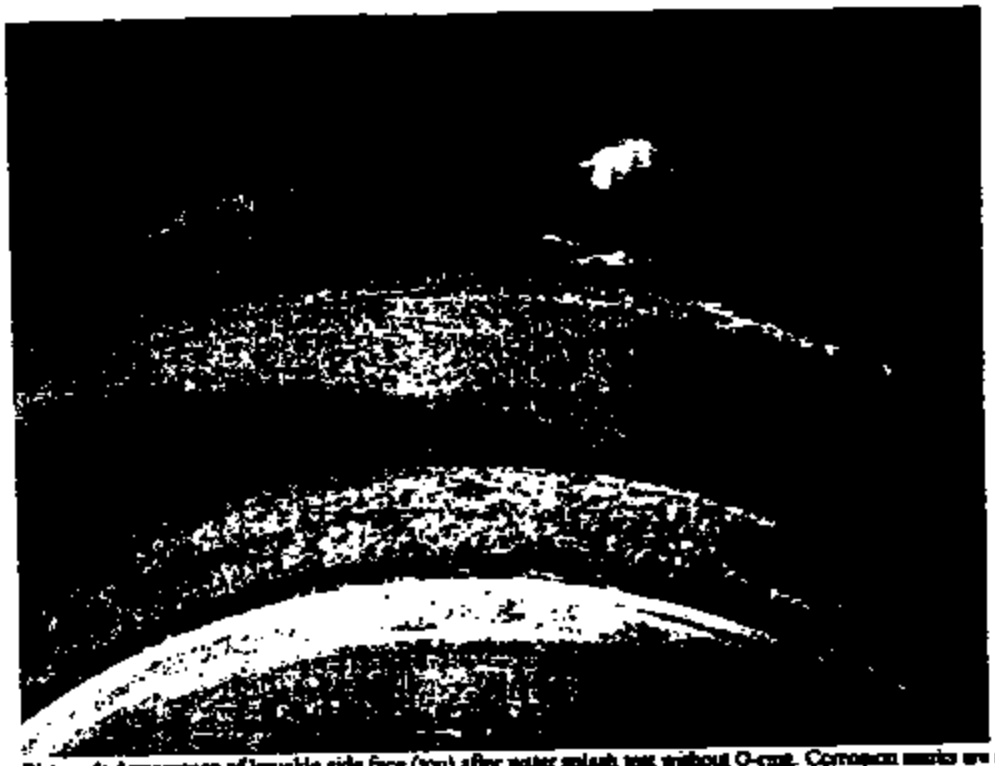
Two different assemblies were tested: one with an O-ring in the joint, a second without this seal. The first test was run for 16 "water splash cycles", the second for 13. Temperatures at the outer ring (inboard side) were determined to be around 25°C during water splash, and around 60°C without.

The following pictorial depicts the appearance of the knuckle side face after each test and the bearing side face and bore after the test without the O-ring.

Picture 2: Appearance of the knuckle side face (top) after water splash test with O-ring. Water ingress along the milling traces is visible.



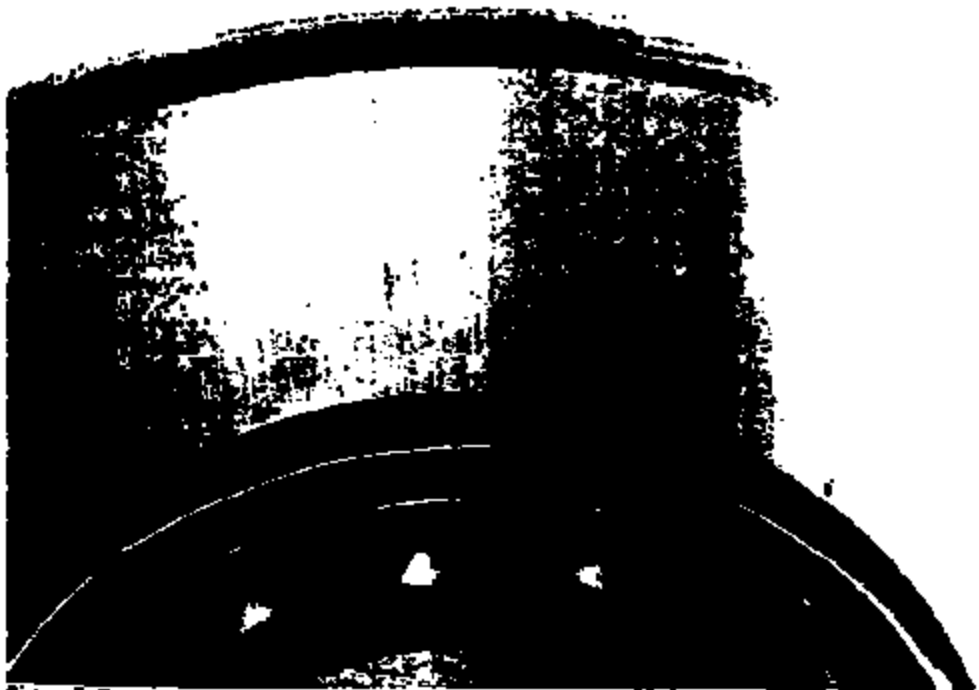
Picture 3: Appearance of the knuckle side face (bottom) after water splash test with O-ring. Water is collected in the cavity between spindle, O-ring and bearing side face.



Picture 4: Appearance of knuckle side face (top) after water splash test without O-ring. Corrosion marks are more visible on the spindle

Picture 5: Appearance of knuckle side face (bottom) after water splash test without O-ring. Virtually all staining marks are indicating water intrusion.

Picture 6 Bearing side face (bottom) after water splash test without O-ring. The complete chamfer exhibits corrosion marks.



Picture 7 Bearing bore after water splash test without O-ring. Corrosion marks are distributed around the complete circumference.

Conclusion

This test proves the potential water leak path between the knuckle and inner ring side faces and along the stub axle. It is to be assessed that the risk of water intrusion is increasing, when dynamic loading conditions like cornering and or braking are applied.
The test also proves the performance of a sealed (O-ring) joint.

VISUAL INSPECTION OF RETURNED THU INNER RINGS

Origin: Ryder, Big Springs

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Requested by Requester

Project Project Titel

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Summary **page 5**

Tabellen und Bilder

Key words: ArvinMeritor, Truck Hub Unit, Ryder, Visual Inspection

Purpose of the Inspection

To verify findings of earlier visual inspections performed by ADNA personal. In total 13 inboard inner rings, roller complements and seals of Truck Hub Units BTF-0032 were returned. These bearings have been identified earlier to be spalled, thus not reaching the expected service life of a million miles. It had been determined that the spalls are caused by lubricant film break down due to water ingress through the inboard seal.

Findings of Visual Inspection

Hereunder are listed the findings and conclusions of the visual inspection performed in the Schweinfurt test laboratory. To identify individual bearings, the findings are summarized under the respective claim number and mileage.

E1753364 308,528 miles

Two shallow spalls in roller distance over 3/4 of the inner ring raceway length. The seal main lip wear is 1.6 mm wide. No signs of corrosion on seal counterface. Corrosion is found in the clip ring groove.

Shallow raceway spalls are indicating surface distress. Such a damage is typically caused by either vibrations or lubricant film break down. The most common reason for lubricant film break down is the presence of water in the bearing. The presence of rust in the bearing bore and the appearance of the seal are indicating a leak path along the axle.

Ryder 3617 393,580 miles

Ring and roller raceways as well as the guiding flange are in good condition. The seal main lip wear is 1.1 mm wide. The seal counterface is partially corroded. No corrosion is found in the clip ring groove.

The bearing has not failed yet. The heavily worn seal indicates a reduced sealing function, allowing water and other contamination entering the bearing.

E1755459 438,586 miles

The guiding flange is heavily worn over about 90° of the circumference ("hot runner"). Ring and roller raceways are in good condition. The seal main lip wear is 0.6 mm wide. Corrosion is found in the clip ring groove. No evidence of water in the bearing. Fretting corrosion in the bearing bore is indicating two load zones.

Seizing on guiding flange surfaces is considered to be an unusual occurance. It may be caused by either heavy axial loading, extremely high preload (clamp load), lubricant film break down or misaligned running parts (perpendicularity of spindle and shoulder). Due to the good overall appearance of the bearing components, lubricant film break down is an unlikely root cause for the damage. Two load zones typically show up when the bearing is disassembled and put back onto the spindle.

Ryder 33623 615,339 miles

Ring and roller raceways as well as the guiding flange are in good condition. The seal main lip wear is 1.4 mm wide. The seal counterface appears to be in good condition. The clip ring groove is not corroded. No evidence of water ingress is found. However, there are traces of over rolled particles.

The source of those particles could not be clarified. The findings on this bearing do not lead to a conclusion.

Ryder 33628 482,615 miles

One shallow spall over about 130° of the ring raceway. The areas close to the spall appear shiny. The seal main lip wear is 2.8 mm wide. The seal counterface is not corroded. Rust can be found in the clip ring groove. The ring and the seal are damaged by disassembly tools.

Shallow spalls and/or shiny, mirrorlike, raceways are indicating a lubricant film break down. Both, the shiny raceway surface and the heavily worn seal, are indicating water ingress into the bearing. There is, however, also evidence of a leak path along the spindle.

E1755533 463,206 miles

One shallow spall over about 160° of the ring raceway. In addition, the guiding flange is heavily worn over about 90°. The seal main lip wear is 2.7 mm wide, the main lip is torn away over about 90° of the circumference. Rust can be found in the clip ring groove.

Shallow spalls are typical for lubrication problems. The heavy seal wear indicates contamination ingress into the bearing, there is also evidence of a leak path along the spindle.

E1752375 273,721 miles

The ring raceway is spalled over about 90° of its circumference. The roller raceways are shiny. A 2 cm long particle (*chip?*) is found in the guiding flange undercut. The seal main lip wear is 1.6 mm wide. The seal counter face appears in good condition, however, the trace of the dust lip shows some corrosion. Rust is found in the clip ring groove.

Shiny raceways are evidence of lubricant film break down. Both corrosion traces, on the seal counterface and the bearing bore, indicating potential leak paths.

E1756339 680,347 miles

The ring raceway is spalled over about 90° of its circumference. The seal main lip wear is 3.8 mm wide. The seal counterface is heavily corroded. Rust is present in the clip ring groove. The roller raceways are shiny. The seal main lip exhibits several voids, up to five mm long, on the bearing side.

The spall appears to be caused by lubricant film break down due to water entering the bearing. The voids in the seal lip may be explained by roller skewing as a consequence of the spall.

CWA86569 385,087 miles

The ring raceway is spalled, while the roller raceways are shiny. The seal main lip wear is 1.3 mm wide. The seal counter face is in good condition. Rust can be found in the clip ring groove.

Shallow spalls and shiny raceways are indicating a lubricant film breakdown due to water ingress. A leak path along the spindle appears to be possible.

CWA87833 mileage ?

Ring and roller raceways are in good condition. The guiding flange is seized. The seal main lip wear is 3.0 mm wide. The seal counter face appears to be in good condition. The seal spring is missing. Only little rust can be seen in the bearing bore.

The reason for this damage is not determined. The seal is heavily worn. However, since the mileage of the bearing is not known, a conclusion about the seal performance is hardly possible.

E1744715 268,745 miles

The appearance of the raceways and the guiding flange is good. Traces of over rolled particles are to be seen. The seal main lip wear is 0.9 mm wide. The seal counterface is in good condition. Rust can be found in the clip ring groove. The dust lip of the seal has a five mm long cut.

The source of these particles could not be clarified. The findings on this bearing do not lead to a conclusion.

E1752418 192,639 miles

The raceways are shiny, while the guiding flange is seized. The seal main lip wear is 3.5 mm wide. The seal counterface is heavily corroded. The bearing bore is also heavily corroded. Multiple dark lines on the ring raceway in roller distance are indicating contact corrosion between rollers and ring raceway.

The overall appearance of the bearing components leads to the conclusion that the bearing was submerged in water. Free water was present in the bearing, causing a lubricant film break down. Since multiple lines of contact corrosion can be seen, it can be assumed that the bearing was operating for a while after the submersion happened.

81727705 1,165,585 km

The ring raceway is polished. Reaction layers on the roller raceways are indicating elevated operation temperatures. The seal main lip wear is 3.6 mm wide. The seal counterface is corroded.

The appearance of the bearing is typical for a lubricant film break down. The heavy seal wear supports the assumption that water passed the seal lip.

Summary

A total of 13 returned bearing cones and seals have been inspected. All of those bearings had been classified by ADNA as being damaged after inboard seal leakages.

The findings reported above do not fully support this earlier assessment.

It may be confirmed that the vast majority of the bearing damages are due to lubricant film break down caused by water intrusion into the bearing. It is, however, not verified in all cases that water entered the bearings through the seal. There is also a potential leak path along the spindle.

This conclusion is supported by the presence of rust in the inner ring's clip ring groove and the good overall appearance of the seal lips and their counterfaces in about half of the inspected bearings.

A total of five bearings out of 13 are concluded not to have seal leaks. One bearing damage is not conclusive since the service mileage is not known. The remaining seven bearings show evidence of seal leakage. It has to be pointed out, that in almost all cases, water was present in the bearing bore. Therefore it is not to be determined whether some of these seven cases may also be linked to water intrusion along the spindle.

SKF 000384

Printed for: MICHAEL LEWIS
04/03/2002, 08:24:26 PM, 1

David M Simms
04/03/2002 05:34 PM

To: William J Farrell/ELG/SKF@SKF
cc: Robert J Bondy/DET/SKF@SKF, Michael D Lewis/DET/SKF@SKF, Daniel L Riedl/ELG/SKF@SKF, Bruce Westel/AMER/SKF@SKF, Richard W Frett/ELG/SKF@SKF
Subject: REVISED E-Mail on Visual Analysis of R-Safe Seals from Inventory

Bill,

We received 97 new and unused SV BTFB 446329 CD [CR#539233] R-Safe seals from Aikan inventory on Tuesday morning. Each has been carefully disassembled and then visually analyzed for lip and/or surface defects which may lead to water ingression. Based upon what what seen on each seal, a 'go - no go' decision was then made for each. The items looked for were sufficient grease-pack (100% good), whether or not the axial lip was fully formed (12 seals were found without a fully formed axial lip tip); surface defects (deep creases, deep knit lines, inclusions, cuts, or a peppled surface texture) on or across either the axial lip or the primary sealing lip (found on 53 seals); flow lines on or across either lip (heavy or light - 100% of seals); the metal to mold fit (not connected to good / bad but possibly connected to process issues); quality of trim (additional knife - assumed to be by hand - trimmed causing or not causing lip damage (lip cuts were seen on 8 seals of 64 seals determined to be hand trimmed while trim stringers were seen on 5 additional seals which would have allowed primary lip ingression); blobs of Bore-Tite on either lip from handling (seen on 30 seals); and whether there was a good or bad bond between the sirvene and the metal (areas of bad bond was found on 12 seals). The overall rating of good seal / bad seal was then based on a cumulative addition of those observations and their severity. Numerous seals had a plethora of various blemishes / defects on them.

Overall, of the 97 seals looked at, 50 seals (51.5%) were determined to be acceptable for use (no visually obvious surface lip defects or damage which would allow water ingression being evident) and the remaining 47 seals (48.5%) were determined to be not acceptable for use based on the high probability they would allow water to ingress into the hub unit bearings. The 12 seals without the fully formed axial excluder lip (12.4%) would allow immediate water ingression.

The types and degree of blemishes/defects on these 47 unused seals closely match what was seen on the 4 field failures of CR 539233 submitted previously and analyzed (detailed analysis report still needs to be written and distributed - the results of the analysis has been discussed verbally with those concerned). The blemishes/defects seen on the four field failures included the not fully formed axial lip edge which would allow immediate water ingression. Deep knit lines and creases, pebbled surface texture, and spotty bond were also found on lips of these four seals although with obvious signs of wear due to field use mileage.

Broken down by cavity, the numbers are:
Cavity #1 - 4 good, 7 bad
Cavity #2 - 5 good, 3 bad
Cavity #2A - 4 good, 7 bad
Cavity #3 - 7 good, 4 bad
Cavity #4 - 10 good, 1 bad
Cavity #5 - 4 good, 7 bad
Cavity #6 - 5 good, 6 bad
Cavity #8 - 5 good, 6 bad
Cavity #9 - 5 good, 6 bad

From this quick visual study, it would appear that cavity #4 generates good seals for reasons unknown to

ma. No surface blemishes were found on the axial lip or primary lip surfaces and flow lines (which seem to be inherent with FKM materials) are light.

A .XLS spreadsheet will be done with all observations for each seal noted and distributed to those listed above at a later date along with the detailed field failure analysis. If you should have any questions or need to discuss these findings, please let me know.

Dave

BTF-0005 Query 03 Apr 2002 [illegible]

Wednesday, April 03, 2002

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fritw	08212174	10/12/00	Ryder	D1104480	10/19/01	02/26/01		109318	Rec'd diseam, pulled and flattened clip ring noses, IB IR RW shallow spalls - shiny	IB SEAL LEAK - INGRESS
Navistar	0329003	01/05/01	WalMart	0382006A	01/14/02	06/22/01	Worn - Left	57513	Endplay 0.000", smooth quiet rotation, IB row corrosion	IB SEAL LEAK - INGRESS
Fritw		01/12/01	Star Transp	NFFD0001F052		03/19/01	Found bearings dry		OB seepage nil, IB dry, endplay 0.000", noisy, OB row VG, IB IR RW fine spalls, grease no water or debris,	INNER RING SPALL
Fritw	0332952	02/27/01	Mike Hoisington	E1750131	01/14/02	07/25/01	Noise	60934	Endplay 0.000", noisy, OB row G, IB row corrosion	IB SEAL LEAK - INGRESS
Fritw	0334502	03/01/01	Prime	E1752589	01/15/02	06/22/01	Noise	91672	Endplay 0.000", noisy, OB row G, IB row shallow spalls IR RW shiny	IB SEAL LEAK - INGRESS
Fritw	0334568	03/09/01		E1669300	07/28/01	06/28/01	Loose	2325	Cage melted, seal lip burned away, grease has low water content	LOW GREASE WEIGHT
Navistar	0321457	11/21/01	Ruan leasing	44366A	12/28/01	02/23/01	Worn - left	99353	Endplay 0.000", noisy, IB IR RW shallow spalls - shiny	IB SEAL LEAK - INGRESS

SKF 000387

Bruce Weeks 04/11/2002 10:30 AM

To: dale.bell@arvinmeritor.com
cc: Michael D Lewis/DET/SKF@SKF, Robert J Sondy/DET/SKF@SKF
Subject: INFO: Mileages on R-Safe Failure Analysis Parts

Dear Dale,

On Wednesday 10 Apr, you requested mileages on the R-Safe returned parts that SKF has reviewed. I have added them below to a copy of the original information.

1. R-safe failure analysis
   6 units returned to date

Ser No.	Manf Date	Seal Lot	Mileage
0312174	10/17/00	3	109,318
0329003	01/05/01.	3,4	57,813
0332982	02/27/01.	4,5	80,894
0334602	03/09/01.	5,6	91,572
0321457	11/13/00.	3	69,363
0348940	07/24/01	??	21,083

Also attached below is the electronic copy of the Pareto I gave you in hard copy on Wednesday as well.

1Q2002 Interim Report 09 APr 2002

Regards,

Bruce

David M Simms
03/20/2002 04:55 PM

To: Michael D Lewis/DET/SKF@SKF
cc: William J Farrell/ELG/SKF@SKF
Subject: Re: Visual Analysis of R-Seals seals

Mike,
Answers to your queries are below (should be in blue). With any seal problems I am conservative by nature so my responses should be taken with that view in mind.

As of this morning, we received additional seals from other cavities than those originally looked at. Two seals were pulled from the box and looked at. One was from cavity #6 and was immediately noted to have a section of the axial lip missing at the tip. Enough is missing that there would be a gap existing at that point, a definite ingression point for water. The second seal was from cavity #8 and had a smaller deformity of the same type. This could be due to air entrapment in the mold, excessive mold solutioning, or possibly a low prep weight, though the latter is not too likely. The primary sealing lips had the same imperfections as the previous two cavities though to a lighter degree. The rest of the seals will be examined tomorrow.

Per request, the amount of grease pack on these two seals was measured and the grease weights were 0.8 grams and 0.9 grams respectfully.

Michael D Lewis

Michael D Lewis
03/18/2002 06:38 PM

To: David M Simms/ELG/SKF@SKF, Christopher Jones/AMER/SKF@SKF
cc: William J Farrell/ELG/SKF@SKF, Bruce Weeks/AMER/SKF@SKF
Subject: Visual Analysis of R-Seals seals

Dave,

Thanks for the detail and analysis.

There are several basic questions regarding these seals. They are:

Are these parts OK to use for current production ? We are building more everyday. If there is a significant risk for performance problems, we need to make changes now. The seal surfaces indicate molding process problems on the finished product ranging from light to heavy. The seals with moderate to deep creases (knit lines) and flow lines will most likely be the ones resulting in early field failures. The seals with light flow lines and creases should probably lose those characteristics as the seal lip wears in. The danger here is that any water ingression (with accompanying salts and silicates) past any of the seal lips will most likely not be detected until irreparable damage to the bearings has occurred. With even the light characteristics, the question becomes, will the seal lip bed in (wearing past the surface blemishes and into sub-surface rubber) before being exposed to a large enough amount of water for ingression to occur. My personal opinion is that a 'significant risk' factor for performance problems is fairly high. Based on the surface imperfections seen on these seals to date, I don't believe the seals will last as long as the 750,000 miles / 7 years anticipated .

Are the parts in the field OK (assuming they are in same condition as these) ? Parts currently running in the field should be okay for the majority of units out there. A point to remember is that the seal lip is a wear component and parts with light or shallow flow lines and creases (knit lines) should lose those characteristics over a fairly short period of time due to bedding in of the lip. This process typically occurs within the first 20 hours of rotational operation. The majority of the seals looked at had these types of process blemishes (light flow lines and creases - not the moderate or heavy).

How do we make them better ? and how soon ? and how much will it cost ? Not being a process engineer, I can't really answer this with any specifics. Typically, adjustments to the mold process parameters (and strict adherence to them once they are adjusted and set for a particular batch of polymer mix) should eliminate these problems or at the very least reduce them to a level of insignificance. A process engineer with FKM processing experience would probably have specific corrective actions to recommend.

I think these are the questions Allen (and I) need to have answered. Please answer as best you can

Thanks and best regards,

Mike

---------- Forwarded by Michael D Lewis/DET/SKF on 03/18/2002 08:30 PM ----------

David M Simms
03/11/2002 02:49 PM

To: Michael D Lewis/DET/SKF@SKF
cc: Darrell D Elkins/ELG/SKF@SKF, William J Ferrell/ELG/SKF@SKF, Dave J Heil/AMER/SKF@SKF, John R Tipps/KOP/SKF@SKF, Dave Zimmerman/KOP/SKF@SKF
Subject: Visual Analysis of R-Seals seals

Mike,

We received 30 seals that were randomly selected, 15 off cavity #6 and 15 off cavity #2A. Following is the result of the visual analysis performed. I also had three process engineers and the metals group look at these parts. Unless noted otherwise, each observation applies to parts off both cavities. Dave Zimmerman is attempting to get parts off some of the other cavities for comparative purposes.

Comments / observations:

Sealing Element:
- the axial lip surface of all seals looked at have a mottled appearance (areas with a pebbled appearance)

- spot areas of un-bonded rubber to metal were found around the circumference at the pierced ID

- the metal component pierced ID has no sign of the typical shear marks due to the punch press. The surface appears to have been machined. If so, is this being done to obtain a tighter registry in the mold?

- areas along the pierced ID of the metal (0.048" thick) have rubber flow up ~0.015" of the wall surface whereas the flow should be pinched off at the top surface of the metal to achieve as much bonding surface area as possible.

- the flash extension on the seal lip appears to be both a pick trim and a knife trim depending upon the individual seal. Is knife trimming only done on seals with excessively long or ragged extensions left from the pick trim? The seals with the apparent knife trim appear to be erratically ("messy") trimmed.

- spots of BoreTite were seen on the surface of the axial excluder lip, around the area of the primary sealing lip, and even spotted inside the spring groove (on one seal)

- seals off cavity #8 indicate there is a large tool line at the primary contact point

- knit/flow lines can be seen running across the axial lip surface and around the contact point of the primary lip. This varies in degree of severity. Two seals had a deep, wide knit line running from the edge of the axial lip onto the face and back up again. This would be definite points for water ingression.

- seal lip appears offset to metal pierced ID / OD due to tight registry in mold. As mold closes, the metal is shifting to one side a bit. This is evident by a ~120° arc of missing bond tab on some of the seals. The molded ends of the tab are feathered in.

- the BoreTite is a dull, matte green and tacky to the touch. It appears to have been applied more than once or with a thicker coating than is normally used (CR uses a 0.001" to 0.003" coating thickness). The CR BoreTite is a glossy green and dry to the touch.

Possible contributing causative factors:

- a low cavity pressure in cavities #8 and #2A

- oversolutioning of the mold cavities resulting in a "dirty mold" condition

- pitting of the chrome plating on the mold cavities or even the possibility of oxidation on surfaces

- the rubber stirvene mix could also be a contributing factor in some of the observations made with a particular batch being susceptible to scorching [especially if the mold temperature was too high - this could occur across the entire mold deck or just on a couple of cavities].

- any combination of the above

Seal Sleeve:

Sleeves are of stainless steel (non-magnetic) but can be easily scratched with a steel rule. Print call-out is for AISI 304 stainless steel. Sleeve wear surfaces (flange and wall) appear to have been tumbled (common deburring method) but with large media (stones). CR typically uses smaller stones which takes more time in process but leaves a smoother finish. The sleeve flange surface (axial lip contact area) appears to be pebbled with peaks and valleys. [See attached photo 1] The sleeve wall surface (primary lip contact surface) appears to have arcs of a series of valleys around the circumference. A few spots were noted to be somewhat crescent in shape. [See attached photo 2] These areas have what could be referred to as an "accordion-like" surface appearance. The cause of this effect is unknown by visual inspection.

Photo01RSafesleeve.bn

Photo02RSafesleeve.bn

Dave Simms

SKF SERIAL #	SUPPLY PROGRAM/ AGREEMENT	VIN#	CLASS	FLEET	IN SERVICE DATE	FAILURE DATE	CLAIM DATE	MILES	R/L OR BOTH	END PLAY	SKF / FS LAB COMMENTS	ANT FD
1998 Bi [illegible]	YES		01208						2 of 27		Complete failure; worn spindle under IR; grease worn in slip ring; low clamp load	
26200-0128412	YES	3HBGAAVR4WL[illegible]	05208	Celadon Carriage	10/2/98			259,000			Axial hub brg worse than rad; low clamp load	
12400-0128160	YES	1FUPCZYB0YDW[illegible]	70751I	KULM	09/1/98			341,849			Cannot successfully determine failure origin; to lit engineer; OEM; Hub flange up	
	YES	2HSFTANWRYC[illegible]	0208481A	Mesa Logos	09/30/98	11/27/01		289,298K			Hub burnt up; SR rollers returned; IR inner cone fractured into 5 pieces; O supplier statement; two cag fractured into several pieces; OR inner cone not fractured - absorb very little damage from rollers	
26200-0128711	YES		0201497A	Norton Warranty Repairing							Unbalanced complaint	
	YES		0207480A					81,608	1 of 27		Hub burnt up; unbalanced complaint	
80127284	YES	3HSFBAXR1YC[illegible]	0207397 / 0202484	Monson Unit 710	09/1/97	04/1 1/01		480,347			Hub "fell off" when vehicle was jacked up. hub was involved in Troy dismantled for shorter overtime on inner race and three (3) rollers on outer races between the cones; debris in the hub cap towards A; outer seal bore - this debris was accepted by SKF - results of analysis not available at this time; corrosion in outer bearing in bore at outer spacing; Hub off as trunk was jacked up	
42000-0140000	YES	3HSCNAER1YL[illegible]	1010034A	Westchester Freight	10/10/00	09/04/01		178,000			Hub was returned with OR big cone in place & IR cool in place, IR big cone & cag ring missing, bore ring broken off, OR cups starting to rust, all grease dry & stiff, can only imagine what IR big looks like	
07300-0204000	YES		1108004A					93,024			Warehouse, unbalanced complaint, IR Jay failed, entire hub returned, mailed shims, inspect IR AP end	
12400-0137001	YES		0204440								Unbalanced complaint	
26100-0200000	YES		00001								Studs burnt, bearings were hot, unbalanced complaint	
70000-0139070	YES		0209A					31,300			Bending hub, hub cap on	
05400-0210000	YES YES	1FUYSDYB4VP[illegible] 2HSFTANWRYC[illegible]	A0102444 CA0227 B	Monson Unit 201	09/1/97	10/12/01 03/29/00		360,720 287,120	R		Pen hub burned up, unbalanced complaint Hub separation from wheels, failed hub assembly, spindle wash under inner cones, grease worn in slip ring, indication of washer motion between inner cones, hub off	
[illegible]	YES	4VBFAAR8[illegible]	0203-000	Monson Unit 316	03/2001	03/2001		488,000				

SKF 000312

(2/17)

(2)

	SKF SERIAL #	SKEELY PROCESSING INCIDENT#	VIN #	CLAIM #	PLANT	SKF ARRIVAL DATE	FAILURE DATE	CLAIM DATE	$$$.$$	RTL ON BOTH	SKF PLAY	SKF / FE LAB COMMENTS	AMT PD
A		YES	2HSCAAMR2YC010386	KFM88941	Metro International Trucks	09/14/00	01/14/02		133,710			OB raw rusty wallbolt corrosion in OB flow; IB raw coarse; slips in Fe @ slip ring bores, bearing bore scrape both IR flow; spindle head chamfer off & pulled out of rotation; corrosion in bearing appears to be post-failure (no shudder); grease lost	
?	No info	YES		No info								Rivet dimension bad, no rollers or cages, IB race failed dyn	
A		YES		NO SKF# 0128511	Mid-Mich				66,087			Locked up, unplanned disassy @	
A/P	SKF# 4207888	YES		SKF#0000A 719	Pilot Inc							Bearings locked up; IRs fractured; IB pl cracked	
P		YES		Unit 1491	Interstate		10/15/01					Fire	
L	SM140788 05 1/01	YES	1R1VCDYB8WA852886	Log 302893	Ryder Truck Rental, Oklahoma City, Ok	12/18/97	12/18/01		491,194			TS rollers from OB; TS bpl rollers from IB returned; both inner cones fractured of opposite; not all pieces of IB inner cone ring returned; cannot determine if inner cones were cracked causing loss of clamp load, eb inner cone did not crack, from up	
A	0120872	YES		Log 3026	Fleet Pride							Received disassembled, badly damaged, no rollers-cages-grease or seals, cannot determine origin of failure due to loss of components	$3,191.16
A		YES	1R1VB0M27YP468247	Unit 2186	Interstate	09/29/99	11/29/01					Fire	
P	SKF# 884814	YES		Unit 279	Interstate								
L	134917 M903988	YES	WC448488	WC448488	Ryder TMS/Pitt Ohio	04/19/99	03/13/02		143,499			Axial play of RETURNED KNUCKLE RIGHT SIDE, BOTH CONES & CLIP RING, NO ROLLERS RETURNED, CIRCULAR WITNESS MARK ON CONE FACES, GROOVES ON SPINDLE FROM CONES ROTATING, LOW CLAMP LOAD	
		YES	1R1VA0M27YP468247		Ohio	09/19/99	03/13/02		314,640			Hub off	
A	2[illegible] 0164013	YES	1R1VA0M27YP468247		CF	10/19/99	10/19/01		276,738			Axial play of	
P	05299 C110144	YES			Pilot Inc							No rollers, seals or grease, wrapped IRs, worn hub on EPES, broken one ring subspacer wheel, dbs replaced, low clamp load, corrosion in dbs bore	
A		YES			Ryder							Locked up, repaired, no parts, as rcvd	
A/P		YES	1R1VB0M42YP468248		Interstate		01/15/02		88,230			Fire	
A	134[illegible] 0128528	YES	1R1VB0M27YP468247		NLM		01/15/02		269,272			Axial play of [illegible]	
		YES	1R1VB0M27YP468247		Ryder Service							Cone, Wear Cannot Conform, Fire	
	0[illegible] 881882 Fire Notify Allied	YES	No [illegible]									Fe dam, ent in IBF Inner cone still attached to knuckle, both fractured, cone	
		YES	1R1VB0M27YP477781						241,240				

SKF SERIAL #	HIGHLY PROGRESSIVE INCIDENTS	VIN #	CLAIM #	FLEET	M SERVICE DATE	FAILURE DATE	CLAIM DATE	MILES	R/L OR BOTH	SHIP PLAY	SKF / PALAB COMMENTS	AMT PD
	Yes		E1760977		07/00/00	09/11/01		391,000			Rear hub burned up; investigate	
01760											Rear hub & hub bearing burned up;	
0000-000	Yes	1FUYDXCS8YLA29842	E1761005		02/2000	10/16/01		000,000(	B		investigate	
10000												
0143720	Yes	1FUYDXCS8YDP30891	E1761199	CR England	03/04/00	11/8/2001		287,000			Almost wheel off	
20000												
0000-000	Yes	1FUYDCY87YHB48736	E1761918	Millennium Packin	08/00/00	11/8/2001		000,000			Almost wheel off	
20000												
0070430	Yes	1FUPCXBY2YPB48748	E1761988	Prime	04/10/00	10/11/01		000,000			Almost wheel off	
	Yes	1FUYDXCY1LA88977	E1762021	Prime	09/10/00	11/8/2001		000,000				
Too rusty - Adam	Yes	1FUPCXBY8XLA84159	E1762065	Tyson Logistics	12/2001	12/5/2001		000,000			No colors returned; all mounting hardware & inner cones returned; sent to SKF	
	Yes	1FUYDXCY2YLA88988	E1762068	Star Transline		10/2001		000,000			Fine	
14000-0000044	Yes	1FUYDXCS8YDP30792	E1762071	New Prime	09/1999	11/11/01		000,000			Rear hub & hub bearing worse; cones and cups are burned up; almost wheel off	
12000												
0126002	Yes	1FUYDXCS8YDP30972	E1762089	Multi Service	09/1999	12/11/01		000,000			Almost wheel off	
20000-0000000	Yes	1FUYDXCS8YLA89171	E1762074		08/2000	11/1/2001		000,000			Rear hub only; no bags; hub cones are burned up	
15000												
0007187	Yes	1FUNA2BA41PC84471	E1762077	Interstate	00/00/00	10/15/01		000,000			Almost wheel off	
	Yes	1FUYDXCS8YPP30994	E1762081	Star Transline	09/1999	11/2/2001		000,000			Almost wheel off	
34000											HUB & ROLLERS RETURNED; NO INNER CONES; SENT TO SKF	
0017200	Yes	1FUYDCS21PB00000	E1744724	CR England	04/2001	08/1/01		00,000				
10000											Rear hub, bearing cones & cones; bit of Oil cone broke apart; rollers show back of hub, burn up	
0123147	Yes	1FUYDXCS8YLB54994	E1744753	New Penn	04/17/00	07/2/2001		000,000				
30000											Hub returned, all on inside, a few rollers were returned, both inner cones	
0004037	Yes	1FUYDCY81XLA49874	E1744771	Transport America	11/1/00	12/3/2001		000,000			fractured	
20000											Rear hub only, no bearing, bearing rollers	
0022974	Yes	1FUYDXCS8XLA01824	E1744789	New Penn	11/2/00	01/17/02		000,000			fractured on, both ok - L 000	
15000-											Rear hub, drum, no bearings, hub burnt up, inner cones burnt up, cups all	
0142000	Yes	1FUYDCS20YPB8758	E1745000		09/1999	12/1/2001		000,000			OUTER CONE CONDITION UNKNOWN	
11000											LINCRACKED & HUB, ENJOICLE,	
0122000	Yes	1FUYDYDY8YLA29878	E1745005	Ryder	07/01/00	01/1/2002		000,000			TOWED?, SENT TO SKF	
Too rusty - Adam	Yes	1FUYDXCS4YLF82700	E1745076	Consolidated	09/2000	01/5/2002		000,000			Sent to SKF	
01000-											Wheels returned with hub still on. Both	
0000000	Yes	1FUYDXCS2XLA49841	E1745134	New Penn	03/2000	01/31/02		000,000			inner cones fractured, all in bag	
20000											ANNA CONES MISSING TONA RACE CONE HUB CAP STILL INSTALLED BUT BROKEN OUT, SENT TO SKF	
3107000	Yes	1FUYDXCS8YLB89013	E1745174		03/2000	01/15/02		000,000				
12000-												
0120000	Yes	1FUYDXCS8YLA82012	E1745243	Xavier Penn	09/1999	12/2001		000,000			Sent to SKF	
0000110												
Adam	Yes	1FUYDXCS8YPP80439	E1745810	Signature	01/2000	01/2002		000,000			Sent to SKF	
											Inner cones not returned, only 20 rollers returned, half were flat, 3 rollers shows extremely worn heat, both outer & seal washer returned, not on unopened condition - the distinguisher wear on hub Hub cap Reveals there no sign of heat, suspect bearings was out of Shape of Rollers, burn up	
12000												
0120120												
0000000	Yes											
1F7000	Yes	1FUYDXCS8YLA89451	E1745852	Swanson	09/1999	09/2/01		000,000			1999 CR, Cones, Hub all sent with	

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(3)

SKF ASSET #	NEWLY REMANUFACTURED	VIN #	CLAIM #	FLEET	SERVICE DATE	FAILURE DATE	CLAIM DATE	MILES	R/L OR BOTH	SKF PART	SKF / FIELD COMMENTS	AMT PD
											Rear brake up; had to cut inner sleeve off to unbolt; inner sleeve was not cracked at time of return; inner sleeve cracked during removal; slip ring grooved from rotation; circular marks on inner core head	
A	Not tested	Yes	1FUYDXDB76LB17890	01672800	Midwest Transit	04/04/00	09/23/01	07/25/01	468,312	1 of 27		2,000.10
	14800-0147281	Yes	1FUYDXDB7YLB17890	01672845	Midwest Transit	04/03/00	09/23/01	07/25/01	468,312	3 of 27	Rear brake up; inner sleeve cracked; slip ring grooved; inner & outer bag have equal damage & heat indication	2,000.10
		Yes	1FUYDXDB6YLB17890	01672846	Mason	11/01/00	09/13/01		296,892		Rear brake up	
		Yes	1FUYDXDB6YLB17890	01672899		04/01/00	09/19/01	07/16/01	362,788		Shipped to SKF for further inspection / Received disassembled, no internal components, OB rear body cracked, unthreaded	1,638.66
		Yes	1FUYDXDB3YLB17890	01674011	Penske	04/07/00	09/21/01	07/16/01	175,242		Received disassembled, IB rear body damaged, metal embedded rear	237.26
		Yes	1FUYDXDB5YLB17890	01672899	Kass Trucking	01/01/00	04/18/01		182,788		Axle off	
		Yes	1FUYDXDB9YLB17890	01672127		01/05/00	09/24/01		422,674		IB & OB CONE BURNED; NO OTHER SKF PART WERE RECEIVED; INCOMPLETE	
		Yes	1FUYDXDB1YLB17890	01682108		11/01/00	09/25/01				Wheel wheel off	
	34186-0014700	Yes	1FUYDCXA3YLB82408	01682109	CF	11/01/00	07/02/01		145,080		Wheel wheel off	
C		Yes	1FUYDCYB3YDF46178	01682173					264,552		Rear hub burnt up; tear to out inner sleeve off; inner sleeve cut shielded when removed; outer cone cracked during removal; outer cone spun on spindle; excessive galling on spindle; slip ring grooved	
L	34000-0166127	Yes	1FUYDXDB4YDF46264	01682239		04/01/00	07/02/01		361,164	IB	Front wheel loose; truck towed to shop	
A		Yes	1FUYDXDB2YDF46121	01682267		02/01/00	09/17/01		429,815		Rear disassembled, could not find cause of failure	
L		Yes	1FUYDXDB1YDF46272	01682468	Interstate	07/01/00	07/16/01	09/28/01	462,701		Rear hub burnt up; IB & OB cones, slip ring & outer sleeve with burned up seal & bearings; IB & OB cups heavy galling, OB cone heavy, [illegible]	1,884.27
A		Yes	1FUY3DBY1LB82464	01671972		09/01/00	12/28/00		356,634		Rear hub burned up; IB & OB cones, slip ring & outer sleeve with burned up seal & bearings; IB & OB cups heavy galling, OB cone heavy, [illegible]	
A	01600-0097129	Yes	1FUPDXBW1YDB5273	01682081		03/29/00	09/27/01		755,1[illegible]	IB	Rear hub burned up; rear tires bearing race, do not know if is IB or OB, [illegible]	
P	12000-0137000	Yes	1FUPDXBW1YDB5732	01682040		09/21/00	09/20/01	09/17/01	267,031		Rear hub burnt up, cones oxidized, slip ring grooved, rubber shows marks on cone faces, cannot determine if tear down had caused failure due to cones being oxidized, both bags burned in color from heat	11,237.00
L	10700-0179282	Yes	1FUYDXDB[illegible]	01682436	Wayne Foods	10/01/00	09/24/01	09/24/01	338,432		Rear hub burnt up; IB & OB cones, slip ring & outer sleeve, all items were burned up seal & bearings; IB & OB cups heavy galling, OB cone heavy, [illegible]	2,238.62
S	34000-0144000	Yes	1FUYDXDB2YLA99308	01682084		09/09/00	10/12/01		388,264		Rear hub burned up, [illegible]	
	34000-0011000	Yes	1FUYDXDB[illegible]	01682152		10/16/00	09/18/01		418,188		Rear hub only no IB, OB bag slip ring IB race has heavy damage due to bag failure, what caused the failure in conclusion of this [illegible]	
F	31400-[illegible]	Yes	1FUYDXDB[illegible]	01682188		09/29/00	10/01/01		398,882			

SHIP SERIAL #	NEELY PROGRESSIVE INCENTIVE	VIN #	CLASS #	PLANT	IN SERVICE DATE	FAILURE DATE	CLAIM DATE	MILES	R/L OR BOTH	END PLAY	NEF / NS LAB COMMENTS	AMT PD
00000-0000000	YES	1XPDDU9X0YD548530	CWA07099		07/01/97	10/7/1901		450,307			Slew hub orig; no bearings; bearing races are all pulls; burn up - R side	
12000-0128000	YES	1FUYSSZ08YPB84481	CWA07488		9/9/1999	12/3/2001		699,673			Returned hub, drum, shoes, brackets, ABS sensor, lined rim	
Too rusty - Alan	YES	4V4ND1JF0YN758434	CWA08409		09/1/98	12/01/01		344,208			Hub returned still covered on brackets; rusty	
	YES	4FVHGDBW9LA66223	CWA08501	MHC	09/2007	01/2002		607,446			Attempt wheel off	
	YES	1FUYHJCB5WP778005	CWA08864	Road Ranger Inc.	01/07/97	10/2/2001		648,673			Attempt wheel off	
28400-0025401	YES	1FUYDSZB1LA978977	CWA08747	Mack Mfg. Trucking, Hartford, CH	02/01/98	01/1/1902		460,429			Hubs off	
07000-0108536	YES	1N1AB09Y09N881143	CWA08870		06/18/99	11/30/01		677,8005			Knuckle returned with IB inner cone still attached; hub was returned; cones	
12000-0123000	YES	2FBHMBDHC0B8859	CWA10141		07/14/98	01/1/402		397,058			Hub hubs; spindle; bearings rollers & cones found up; cone spinning on spindle; OB cone was more heat than IB cone; rollers are distorted & burnt up; OB cone has signs of high heat; slip ring present; both of hubs	
00000-0107771	YES	1FUYBSYB8NP617788	E1513000		05/1/98	04/07/09	05/05/05	99,400			Loose; unfastened assembly; bearing burn up. Hubs, dust bearing misaligned; L front hub missing, opposed L front the hub & drum; wheel bearing dry on spacer & fell apart	
00000-0178570	YES	1FUYBDYB8NP617788	E1523000		01/2000	09/01/00	09/01/00	394,315			One too much play; 2 years broken, later, complete hood - unfastened assembly? Down shoe wheel bearing has too much play; both F hubs missing; hub in good hubs off spindle	
	YES	1FUYDSZB5YP441393	E1513000		04/2000	09/03/01	09/1/01	395,402	R		Hub off	0.00
	YES	1FUYDSZB1YL317000	E1513000	Internal Trans	09/2000	09/07/01		658,000			Hub off	
	YES	1FUYDSYB8NP617788	E1523000		11/2/99	05/21/01	04/19/01	350,000			OB cone seized, OB had damaged rolled edge & bead, IB roller ends pressed, IB ST RW shaft & ring	500.00
	YES	1FUYDSYB8NL797003	E1551004	ELLW	09/2007	09/2/01	09/07/01	461,000			Received disassembled, IB IR cut & split, worn on spindle, badly damaged and worn out intermediate	1,100.00
	YES	1FUYDSZB0YP449091	E1551132		09/07/00	04/25/01	09/1/01	321,000			Received disassembled, IB OB hub badly deformed, metallurgy confirms over load marked at	1,249.17
	YES	1FUYDSZB8LA66723	E1507017	Port North Tonawanda	10/2/98	09/1/01	09/1/01	317,000			Received disassembled, IB now heated, edge melted, cone lips burned away, OB has grease stained	1,100.00
	YES	1FUYDSZB1LG66419	E1507419		09/2/98	09/3/01	09/06/01	41,512			of OB hub marked hub	612.25
	YES	1FUYDSZB9YP449040	E1507019		10/19/98	09/1/01	07/02/01	334,949			Shipped to NEF for Lifter inspection / received disassembled, rollers, cages, cones & grease gone, OB RWs badly damaged, root cause not determinable. Hub both sh. FW	1,002.00
	YES	1FUYDSZB7YP449040	E1507019		07/2007	09/2/01	01/02/01	782,914			Received disassembled, badly damaged, IB or both-mounted, no rollers, cages, cone or grease, very rusty overall, determine origin of failure due to lack of cone and rollers	1,149.04

SKF C00356

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SKF INVOICE #	NSKLY PROGRESSIVE INCIDENTS	VIN #	CLAIM #	FLEET	SF SERVICE DATE	FAILURE DATE	CLAIM DATE	$$ AMT	F/T, CR, BOTH	SHD PLAY	SKF / FS LAB COMMENTS	AMT PD
A											wheel dropped; inner lug stud eage displaced; slip ring 2 noises visible of light oxidized condition; OB ID stained condition ID side; small amount of small bore; brake shoe flattened one shoe pulled flat side; ID seal was F-NOK; grease was GARZ; one is wavy Outer seal was missing from the assembly, and inner nut located on missing hub, drum, and wheel re-depot does the vehicle; spindle threads were slightly damaged on end, but not under the caps where the nut is torqued; very little damage to bearings and the unit showed no signs of heat.	
L											Burnt up; wheel bearing worn apart; seared, bearing failure damaging studs and bushes, bent pulled to the right, had to replace all studs bushes also bearing failure	
L											Fire	
P				Penske Inc							TRUCK; Was disassembled; logs destroyed; only ID valve from OB & bore ID outer races smashed; ?; Right wheel caught fire from wheel bearing failure, also inspected left front wheel – ok, parts shipped to Troy via Yellow Freight to Rosenthal, msrc is for wheel we due to damage from fire	
P				Metropolitan Trucking							Fire, Hub burn up	
P				Penske (Plymouth Transit							Bearing Burn UP	
A				Nebraska Cold Co.							Hub burned, OB only, appears ID has failed first, cannot assign root cause	$82.16
A											Hub burn up	
A											Nose hub burned up, inconclusive, L. axial rear wheel showing general int, bearing failure on L front wheel damaging	
P											ID bore outer side wheel bearing failure, progressive damage to hub, brake, shooting trouble, the rod cross tube, ABS sensor & hub cap wheel bearing failed causing R hub to wobble violently	
P											Was disassembled, ID inner race scratched, no signs of rotation lug & slip ring, ID inner race spalled, not in outer spacing, axial journal on ID race scratched, all seal lost, nut lip groove completely worn out, bearings have signs of water ingress, ID and inner ID inner race spalled on bottom 180° apart to 2nd	
P											Hub Burned up	
P											Hub burned up, ID bore race scratched, no signs of rotation lug & slip ring, ID inner race spalled, not in outer spacing, axial journal on ID race scratched, all seal lost, nut lip groove completely worn out, bearings have signs of water ingress, ID and inner ID inner race spalled on bottom 180° apart to 2nd	

Monsen Chemical Invest

SKF 000398

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SKF

Title: Monson Steer THU Field Problems Root Cause Analysis

Date: 21 Nov 2001
To: JP Pan, ArvinMeritor Non-Drive Steer Axle Engineering
From: Chris Jones
cc: Mike Lewis, S. Brown, R. Bondy, E. Cotter, A. Mueller

Background:

Three BTF 0052 bearings were returned from Monson due to excessive axial clearance at low mileage. A summary of data on these units is below.

Monson Unit #	378 RH	414 LH	428 LH
Manufacture Julian Date	01999	(rusty)	(rusty)
Serial Number	0078148	(rusty)	(rusty)
Vehicle In-Service Date	12 Apr 1999	3 Apr 2000	22 May 2000
Recorded Clearance as Mfd	XXXX	(rusty)	(rusty)
Measured Clearance	0.002"	0.003"	0.0055"
Mileage	234,000	126,536	116,013

These bearings were very rusty which made it impossible to read their serial numbers on two of the bearings, however from previous experience and taking in account the mileage, and stock levels in Aiken we believe them to have been manufactured some time in the early months of 1999.

Discussion:
After a thorough investigation, one problem was found that could possibly explain the excessive clearance of the three bearings. In the case of these bearings the root cause of manufacture and the cause of non-detection are one and the same.

Root Cause Of Manufacture:
An Axial Clearance Gage problem was noticed in January of 1999. During the initial malfunctioning of the gage, the units in which the gage classified as low axial clearance were adjusted by replacing nominal size inner rings with smaller diameters to increase the axial clearance value. This is a normal SKF practice, if there is an axial clearance rejection; inner rings are replaced accordingly to adjust the axial clearance to within the required specification and re-gaged. Since the axial clearance gage diaphragm was not applying the proper load and nominal inner rings were replaced with smaller ones, the combination resulted in units having excessive axial clearance values, which were classified as acceptable by the gage.

The *Axial Clearance Verification* measurements confirm the effectiveness of the corrective actions on the axial clearance measurements taken at the initial time of manufacture.

Conclusion:

In summary, the problem with axial clearance was identified in January 1999. While attempting to increase axial clearance values of units initially classified as low axial clearance a malfunction of the diaphragm material resulted in an inadequate load being applied to the bearings. Due to the inadequate load the axial clearance gage classified three units with excessive clearance values as acceptable.

As a result 2000 bearings were quarantined. Because the bearings were fully assembled they were unable to be rechecked using the on-line gage, a new off-line *manual* gage was designed and built which in some ways differed mechanically from the on-line gage. Based upon all the above facts it is felt that the three bearings with excessive clearance were manufactured during this time period and were part of the rechecked batch.

Shipments of the 2000 quarantined bearings were delayed for about 10 months from their manufacture due to the time required to manufacture the manual gage and perform gage R&R testing. This accounts for the wide range of in-service dates for the vehicles involved.

Our *recent* experience *has shown* that this axial clearance process is *now* very stable. Therefore the three bearings *in question* should be considered as outliers. ***Corrective actions employed to assure that no more bearings with high clearance will be shipped include periodic checks with 3 masters of varying clearances to check gage drift. A limit of 0.006 mm between gage readings at the beginning of each production shift was set to signal a diaphragm change-out for the gage.***

We *have confidence* that this unfortunate situation has been properly addressed with many corrective and preventative actions are now fully in place.

SKF 000404

VIBRATION PROBE (MCD)

SKF 000414

Field Service Report

For:

SKF Automotive Division
46815 Port Street
Plymouth, MI 48170-6060

Service Date:
June 24-25, 2002
Job No:
????
File: Hub Unit Brg Check.doc

Prepared By:
Johnny A. Simmons Sr.
Reliability Systems /Maintenance Strategy Specialist

Field Service Report

Dates of Service:	June 24-25, 2002	Job No.:	????
Plant Contact:	Michael Lewis	cc:	
Phone No.	734-414-6824		
Machine:	Truck Hub Units		

SKF-CM Hardware/Software/Technology: CMVA60 / SKF Machine Analyst

Report Date: June 26,2002 Service Rep: Johnny A. Simmons Sr.

Purpose:
SKF Automotive Division is experiencing some reliability issues with hub units manufactured for class 8 trucks. Current defective unit identification programs revolve around a service mechanic spinning the wheel by hand and subjectively, by feel and sound, trying to determine if a bearing is in danger of failing. Results have not been acceptable due largely to outside influences i.e. noise and vibration in the shops and lack of experience or skill level required to make this kind of determination under these conditions.

We were asked to determine if a technology was available or could be developed or adapted to allow service shop mechanics to make more accurate decision as to the condition of the bearings.

The constraints given us were:

- A tool that could be used without training.
- Must give repeatable results.
- Preferably a red-light green-light (no display)
- Inexpensive?
- No mechanical rotating (spin wheel by hand)
- One man operation

Tests:
We ran tests on 7 hub units at Arvin Meritor's Heavy Vehicle Systems plant in Troy, Michigan on June 24th and 25th. The test units were selected rather randomly among many available. 4 of the units selected had previously been tested by Meritor and were used to compare our data with theirs.

Our sampling included:
#1 – New unit
#2 – Believed to have defects based on feel and sound.
#3 – Believed to have defects based on feel and sound.
#4 – Bearing endplay; felt and sounded good.
#5 – Bearing endplay; felt and sounded good.
#6 – Believed to have defects based on feel and sound.
#7 – Used but believed to be good.

Robert J Bondy
08/21/2002 08:08 AM

To: Michael D Lewis/DET/SKF@SKF, Bruce Weeks/AMER/SKF@SKF, William J Ferrell/ELG/SKF@SKF
cc:
Subject: Bearing Deterioration Detection

fyi

---------- Forwarded by Robert J Bondy/DET/SKF on 08/21/2002 08:08 AM ----------

Dale.Bell@ArvinMeritor.com on 08/20/2002 06:51:29 PM

To: robert.j.bondy@skf.com
cc: Lichlo.Curtl@ArvinMeritor.com, Thomas.Banko@ArvinMeritor.com, Charles.Smith@ArvinMeritor.com
Subject: Bearing Deterioration Detection

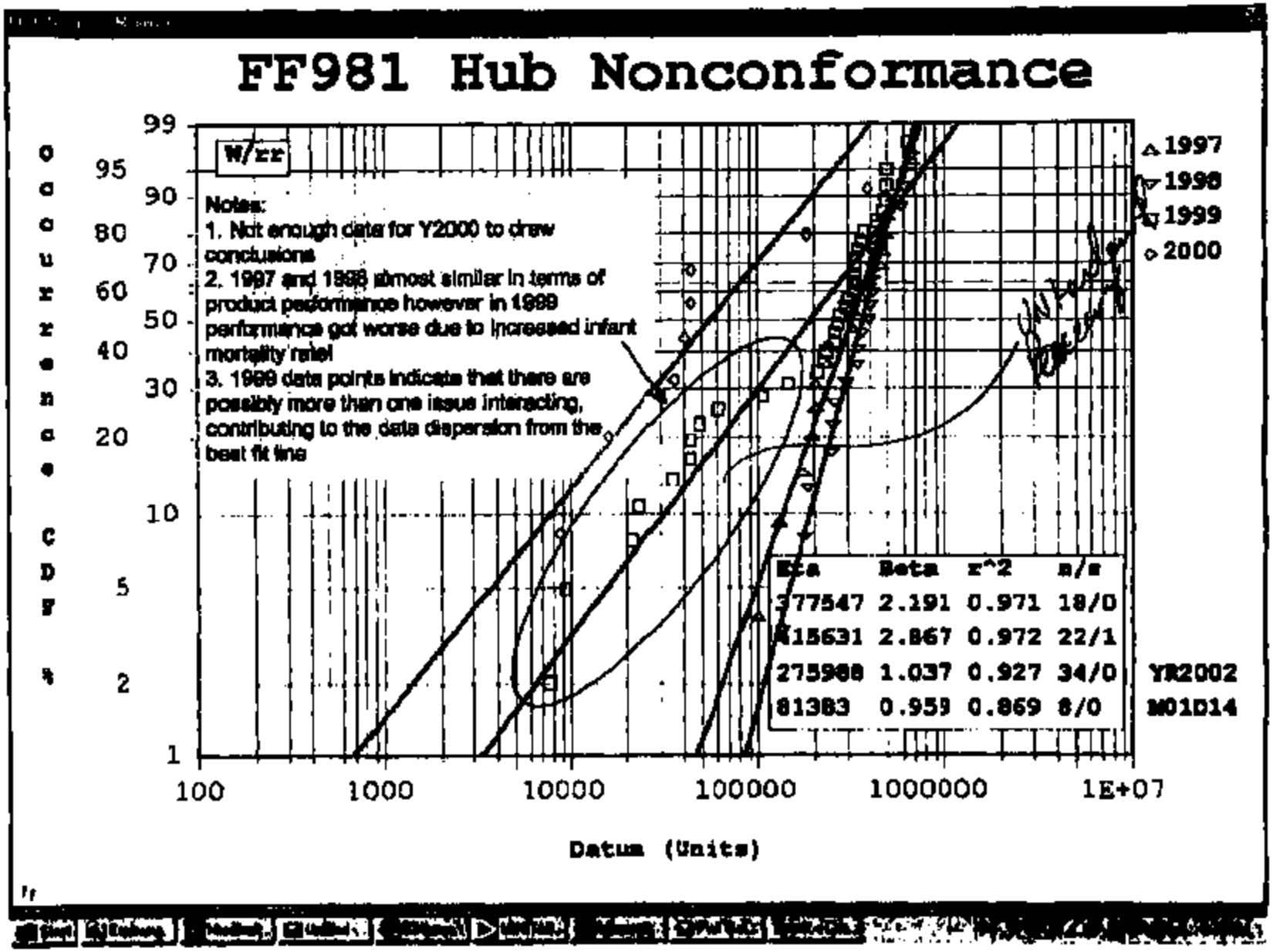
Per advisement yesterday, there may be a possibility to build the subject (per method described), given there is much work yet to do, even to firm-up feasibility. However, if SKF has another idea or approach which will take subjectivity out of the determination and you want to pursue that course, please advise. We plan considerable effort over the next week to establish if the idea will work, including the weekend, to be prepared to discuss with FTL and then Ryder next Friday to try to put off the direction they are heading.
We suggest working the issue concurrently to shorten overall time. We look to SKF for the development of the subject, but recognize time crunch and are willing to help. We've got a name for potential supply of the device, but have not contacted - do you want to? Do you want us to??
What's the timing on approach SKF is pursuing??

We estimate a cost of $165K to get to production, with a piece price range of $50-$75 in a 2000 piece order. At 500, we think double the piece price.

What does SKF plan to do? What do you want us to do?? If you have it under control - pls advise and we'll drop our efforts.

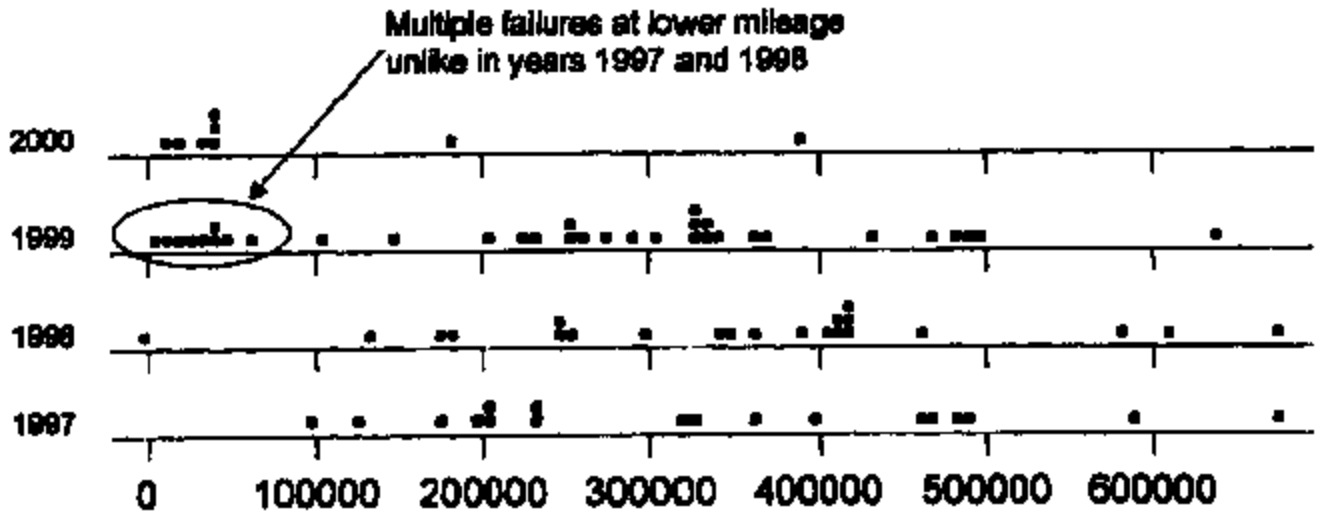
SKF 000436

[illegible] (BACKGROUND)


FF981 Hub Nonconformance
W/zr
Notes:
1. Not enough data for Y2000 to draw conclusions
2. 1997 and 1998 almost similar in terms of product performance however in 1999 performance got worse due to increased infant mortality relief
3. 1999 data points indicate that there are possibly more than one issue interacting, contributing to the data dispersion from the best fit line
Eta Beta r^2 n/s
377547 2.191 0.971 18/0
415631 2.867 0.972 22/1
275988 1.037 0.927 34/0
81383 0.959 0.869 8/0
1997
1998
1999
2000
YR2002
M01D14
Occurrence CDF %
99
95
90
80
70
60
50
40
30
20
10
5
2
1
100
1000
10000
100000
1000000
1E+07
Datum (Units)

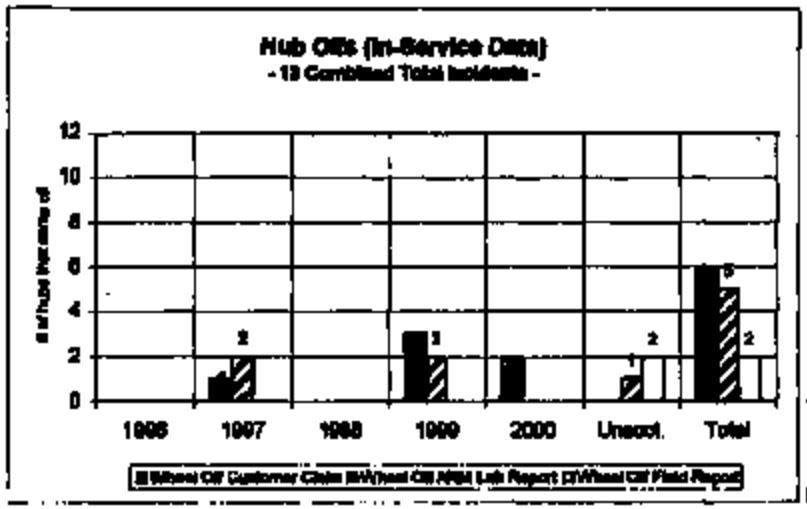
SKF CC0437

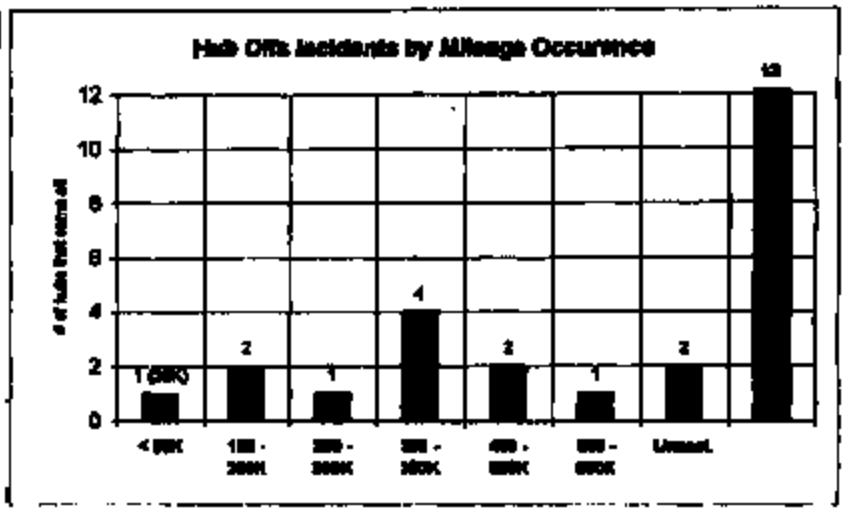
FF981 Hub NonConformance

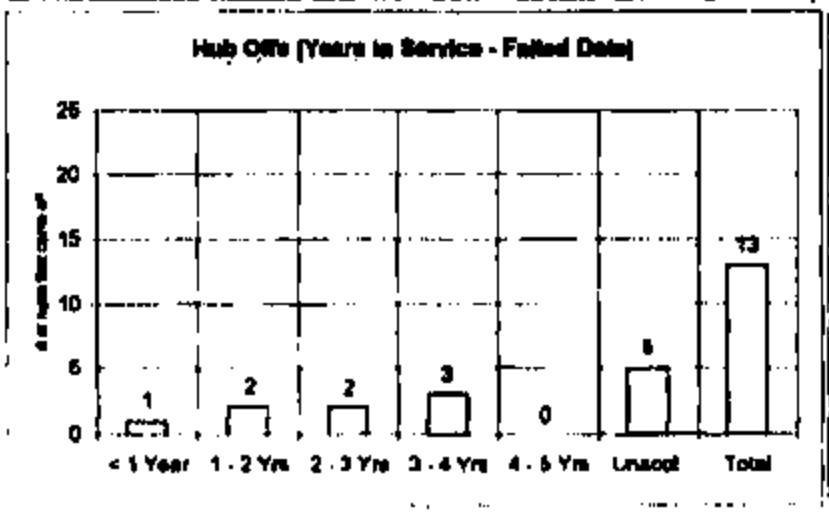


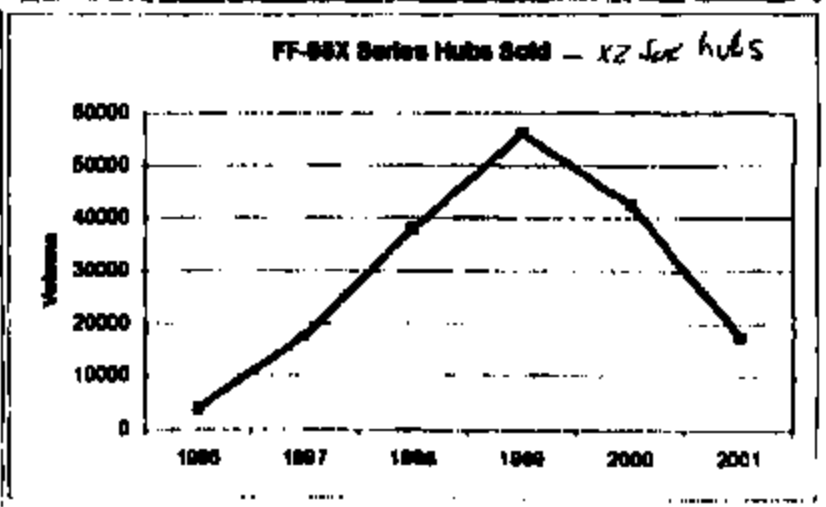
3KF 000438

FF - 981 Hub Failure Analysis







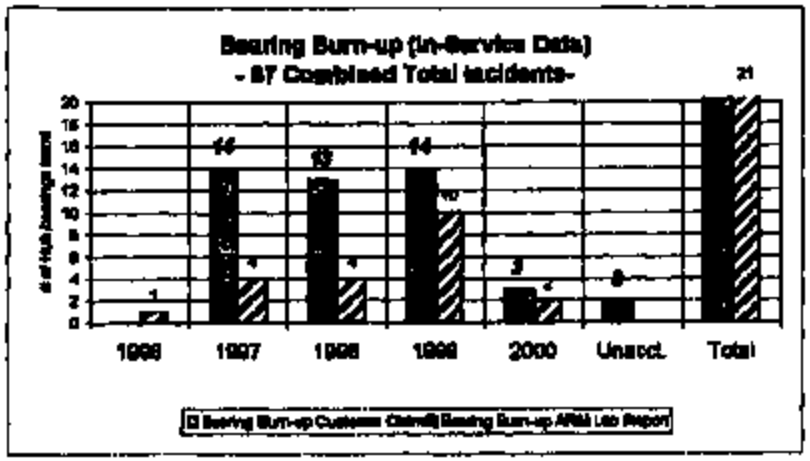


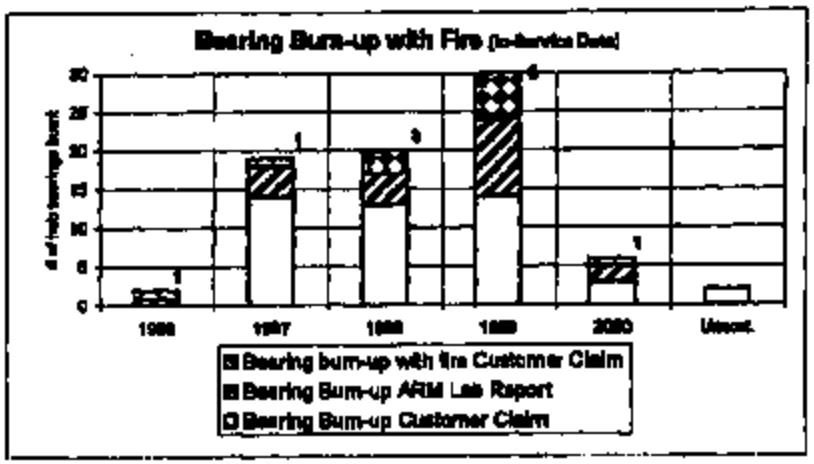
Notes: 1) Customer Claims data were those that were obtained from Rebecca Goodermuel's database
2) Accumulator Lab Reports were compiled by Bill Peterson. This data contains information to be supported in the lab report for customer returns

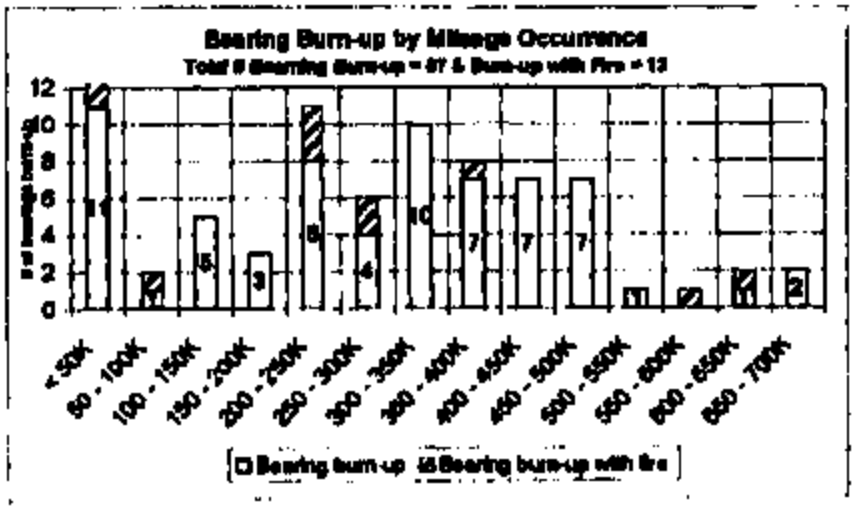
Updated 01/10/02
Nimm Audimoulam

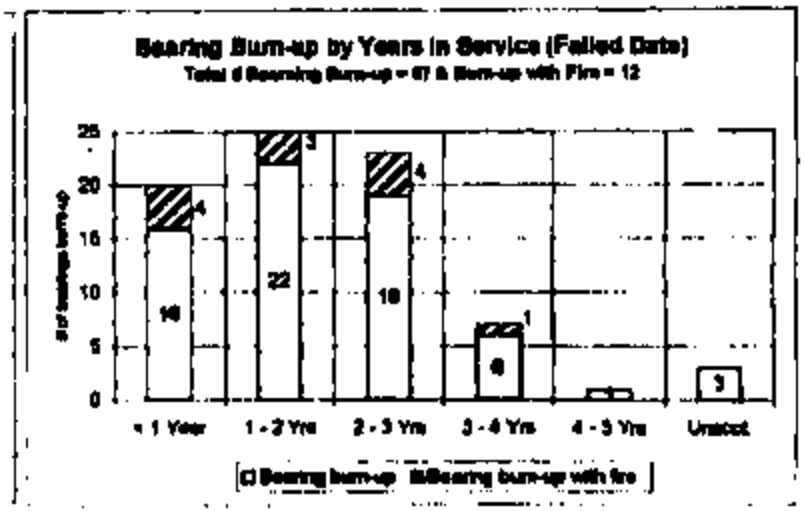
SKF 000439

FF - 981 Hub Failure Analysis









Notes: 1) Customer Claims data were those that were obtained from Rebecca Lieberman's database. Bearing fires are as stated by the customers and are not verified. A number of causes may exist including fires resulting from fires, cable drums etc.
2) Arrhenius Lab Reports were compiled by Bill Paterson, this data contains information as documented in the lab report for customer returns.

Updated 01/10/02
Nick Aufmann

Charles.Smith@ArvinMeritor.com on 03/12/2002 06:37:46 AM

To: bruce.weeks@skf.com, Robert.J.Bondy@skf.com
cc:
Subject: FW: FF98X Hub Analysis.ppt

Good morning

Finally got some data, trying to convert it into information. Below is a list of questions that I asked from another E-mail. I will forward you the answers when I receive them.

* Definition of "progressive incidents." please? I assume this includes wheel offs, burn ups, excessive end play and excessive noise?
* Does this data have any returned hubs removed, like reason code "NTF?"
* I assume all of our data is classed by our Fiscal Year?
* What were the sales for FY 2001?
* Any 2001 failures? Best I know right now, we have had 3
* Was there any data that gave us a hint to the unknowns, like vehicle in service date? If so, we would want to estimate the year of production and reclass out of unknown (use 2 month lag).
* If I told you to eliminate all the infant failures (unhardened raceways) from the data, what would the Weibull's look like then (all less than 150K and 1 1999 less than 200K - I believe Jack found one just above 150K)? The 2000 data is severely skewed due to the infants and we need to segregate this known failure mode. Did you use the "dirty data Weibull analysis method?

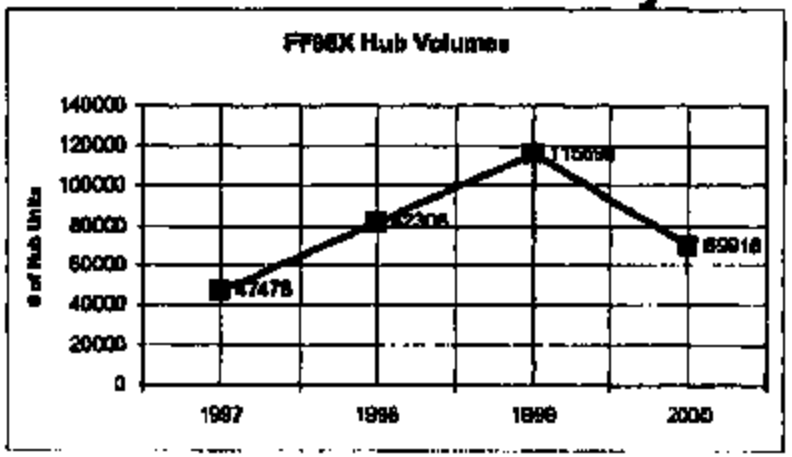
Chuck

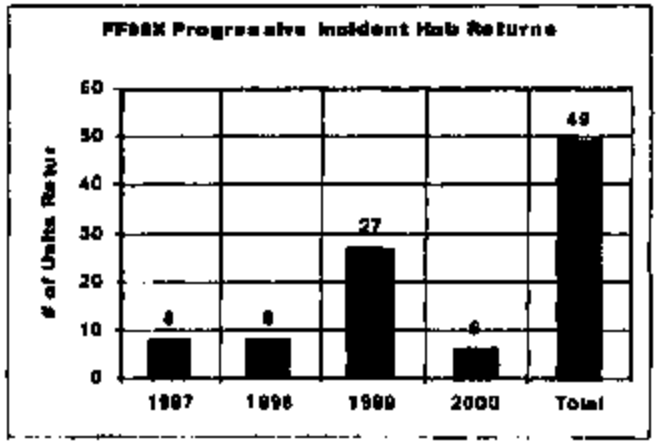
> -----Original Message-----
> From: Audimoolam, Niran
> Sent: Monday, March 11, 2002 6:30 PM
> To: Smith, Charles
> Subject: FF98X Hub Analysis.ppt
>
> Chuck,
>
> The FF98X Hub returns data analysis on those parts that were physically
> inspected by the ARM Product Support Lab (PSL) in Troy.
>
> <<FF98X Hub Analysis.ppt>>
>
> Please let me know if there is any other information that you would need
> Based on your feedback, I can forward this information to Tom Sanko and
> Dale Bell who have also requested this information.
>
> Thanks!
>
> Niran

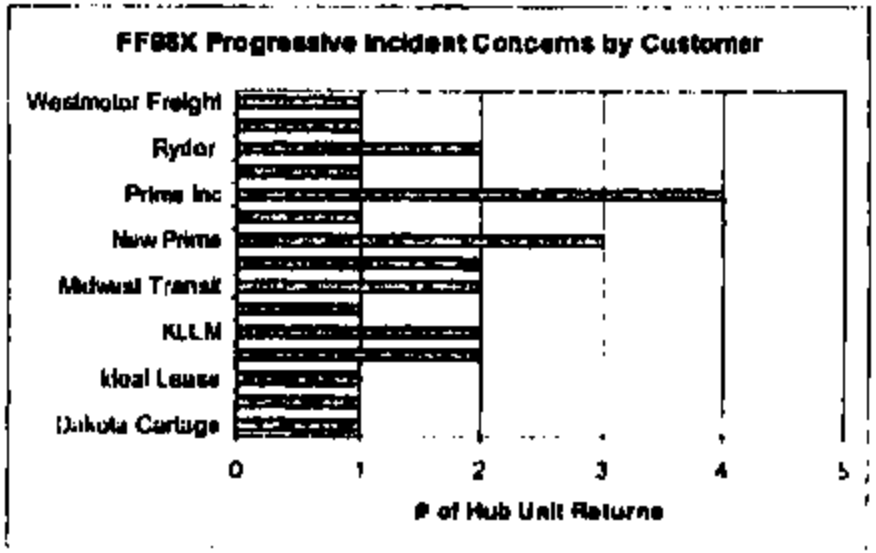
FF98X Hub Analysis.ppt

ArvinMeritor.

FF98X Hub Analysis – Progressive Incidents



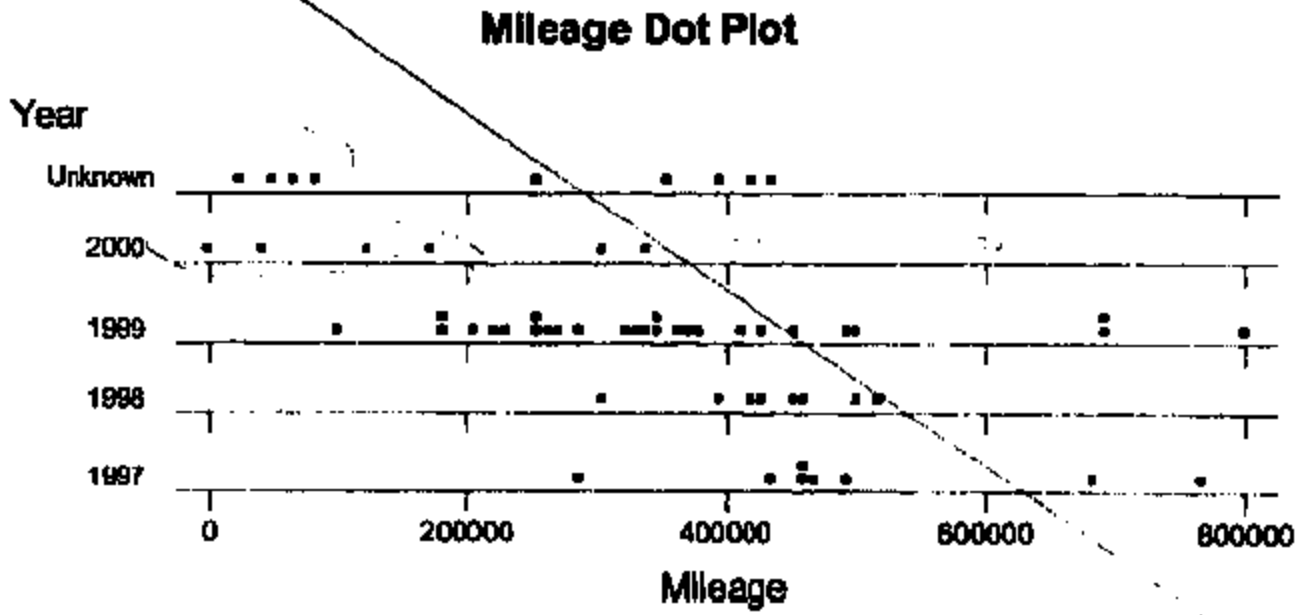




SKF 000442

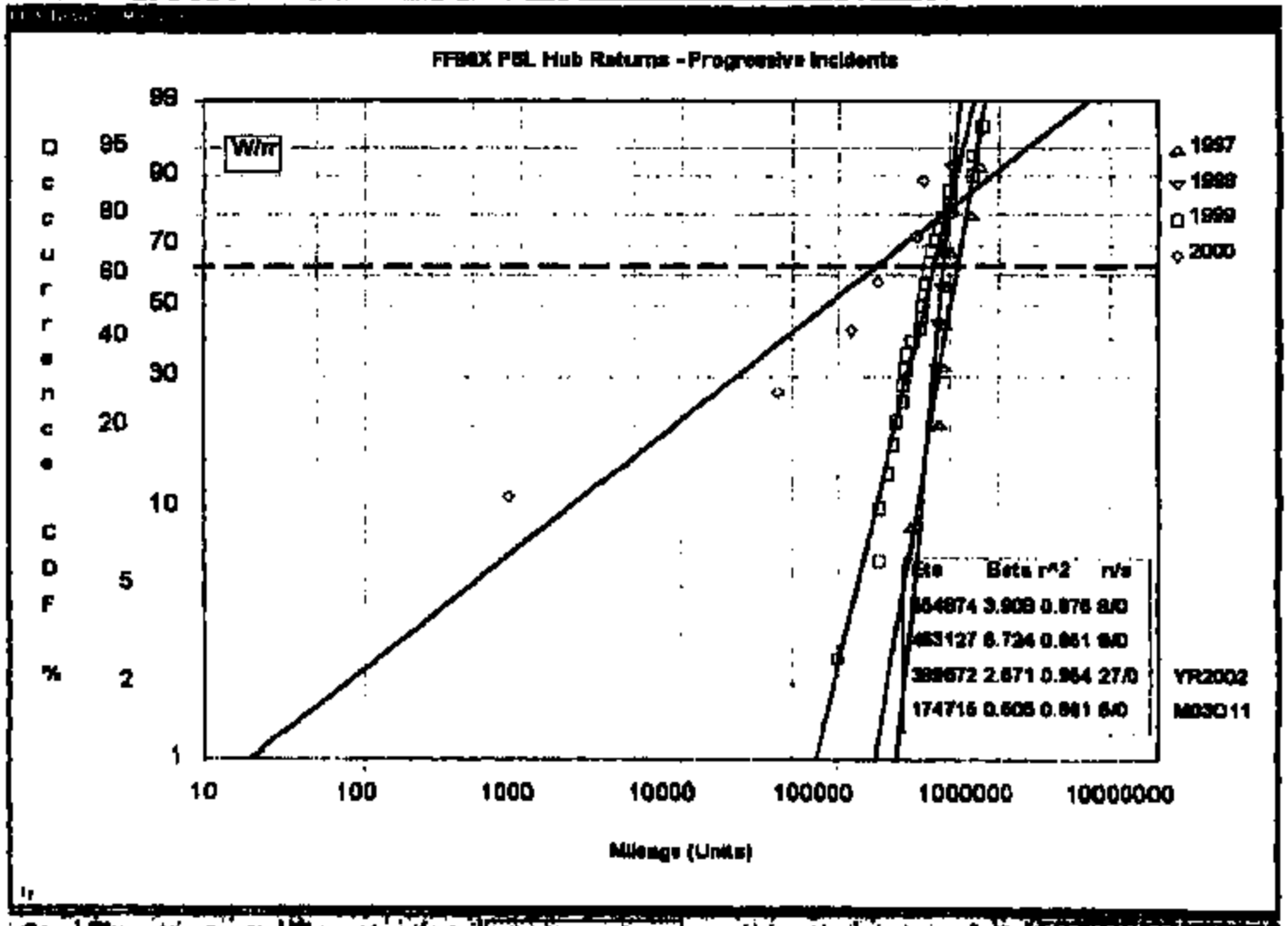
ArvinMeritor.

FF98X Hub Analysis – Progressive Incidents



SKF 000443

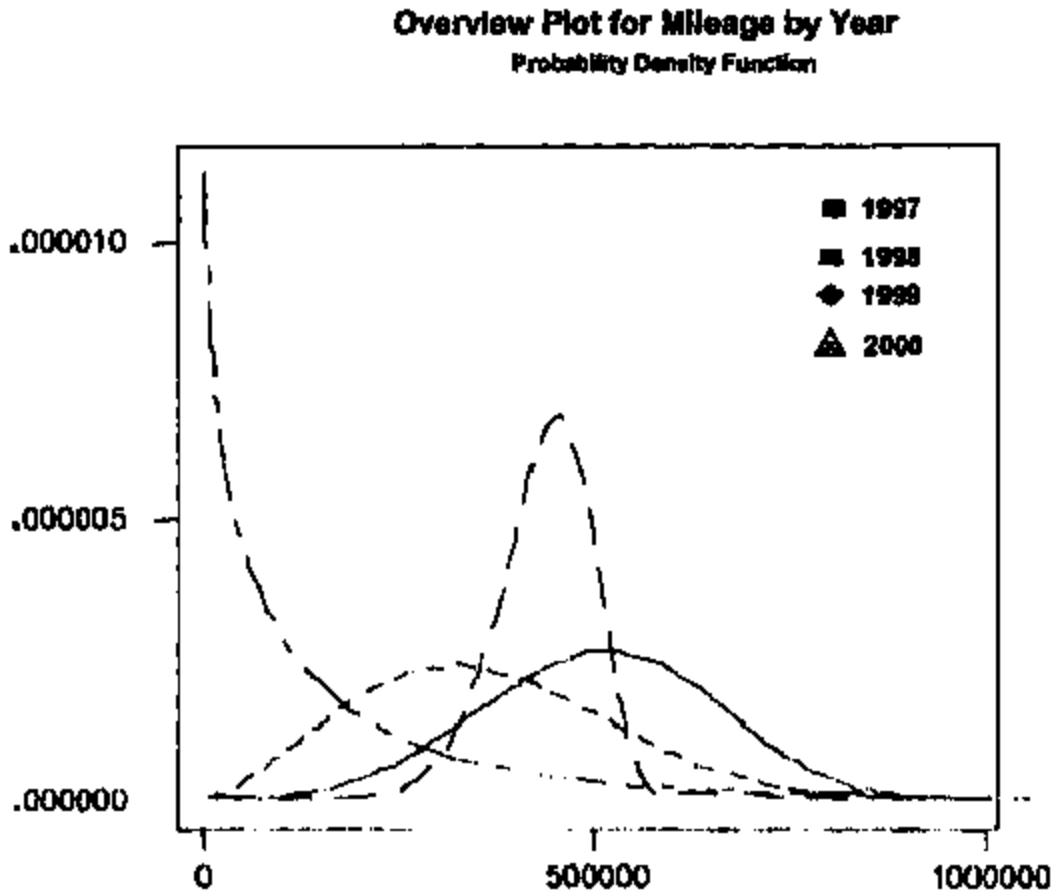
ArvinMeritor.



SKF 000444

ArvinMeritor

FF98X Hub Analysis – Progressive Incidents



SKF 000445

HUBS RETURNED FOR PROBLEM ANALYSIS
LEVEL 1 RETURNS - HIGHLY PROGRESSIVE INCIDENTS
MATERIAL REVIEWED AS OF 03/08/02

SKF SERIAL #	VIN #	CLAIM #	PLANT	IN SERVICE DATE	FAILURE DATE	CLAIM DATE	MILEAGE	ETL OR BOTH	END PLAY	SKF / FELAN COMMENTS	ANT FD	WAST. FD	LAST OTHER FD	SKF VALID OR INVALID
1998 # M122870		01288						Q of 27		Complete failure; worn spindle under IR; groove worn in slip ring; low clamp load				
2000- 0225472	1HSCAAMR6YJ206880	00885	Dakota Carriage	10/0499			259,886			Rear hub lug nuts torn up; low clamp load				Invalid
	1FUYWRZB6YLB80344	109589	Prime Inc				421,464			Bad dismountable; lugs destroyed; only 18 rollers bad; OB & bore IB inner cone spalled; ?				
1998- 0128190	1FUPCBYB6YD787918	787918	KLLM	09/1499			341,649			Owner reasonably determine failure origin; IB IR cracked; OB				Inconclusive
	2HSFTAMR6YC039648	0039681A	Ideal Lease	06/0499	1160781		293,238K			Hub burst up; 38 rollers ejected; IB inner cone fractured into 8 pieces; O outer cracked; cone ring fractured into several pieces; OB inner cone not fractured - above may little damage from ejection				
2000- 0148711		0041467A	Mercer Warranty Resolving							Unhardened raceway				
		0057460A					81,809	1 of 27		4 front wheel passing hot spot; unexplained damage				
1213644	2HSRNAXR1VC034760	034760	Maxsam Unit 318	04/1787	0404491		460,647			Hub "fell off" when visible eye broken up; hub was packed in Tray disappointed, our service mechanic on knee was and found shattered no visible motion between the pieces; Debris in the hub cap inboard & outer seal land - this debris was sampled by SKF - results of analysis not available at this time; corrosion in outer bearing in lines of roller spacing				Invalid
1213771		034774	Maxsam Unit 348	05/1487	09/0491		446,980			Hub separation from spindle; failed hub assembly; spindle worn under inner races, groove worn in slip ring (indication of relative motion between inner rings)				
		06288 0110149	Prime Inc							Hub rollers, cages or races, smeared life, some heat on EPBB, broken lube ring widened outer, IRs fractured, low clamp load, grooves in slip ring				
1998- 0148092	2HSCNAMR7YC049117	10150249	Woodside Freight	10/1498	09/0491		179,069			Hub was returned with OB ring and in place IB, IB was in place, IB lug cone & slip ring missing, seal ring broken off, OB cage starting to melt, all grease dry & still, can only imagine what IB has been like				
07300 0150201		11888648					80,024			Abandoned, unmaintained raceway, all roll bodies, entire hub spalled, melted wheel, unable to IP 'EH				
1998- 0132751		068440								Unhardened raceway				
		06288 0148808 0148808A								Bodies burnt, bearings warp bad, unhardened raceway				
00488 0071888	1FUYSTYB4SP488888	30488 0190479			10/1301		21,309 280,739	N		Bearing high, hub ran on Hub burnt up, inconclusive				

SKF Report #	VIN #	Claim #	Fleet	In Service Date	Failure Date	Claim Date	Mileage	Est. or Both	End Play	SKF / PS Lab Comments	Amt. PS	Mat'l. PS	Labor & Other PS	SKF Valid or Invalid
14450		0000478		10/2000	10/2000	10/2000	000			Wheel departed; inner bag low cage fractured; clip ring 2 races outer bright coated scratches; OB lift cluster scratches all slots; small amount of small face; brake shoe flattened one place (wheel bit off); lift seal was F-NICK; grease was GARZ; axle is wrong. Outer nut was missing from the day 6 inner nut backed off allowing hub, drum, and wheel to depart from the vehicle; spindle threads were slightly damaged on end, but not under the area where the nut is torqued; very little damage to bearings and the unit showed no signs of heat.				
0014848	2HSFBAAR8WC000182	CW100864		09/1997	05/2000	06/1999	264,000			Burnt up; wheel bearing came apart; locked. Causing failure damaging drum and brake, truck pulled to the right, had to replace bill code broken also bearing failure				
	1FUYBDYB92PB88377	CW481121	Weastate Dist. Co, Tacoma, WA	11/2489	04/2001	04/2401	420,000			Hub disassembled, OB only; appears lift row failed first, stencil section not shown	862.18	402.68	220.50	Incomplete
	1FUPDSZB7XLA84174	CW467187		01/0188	07/2001	07/2401	788,767K	B		Rear hub burned up; inconclusive; L axle front wheel smoking (loose lid); bearing failure on L front wheel damaging spindle & cage				
	1FUYDSZB7XLA84174	CW467187		01/0188	10/2401	11/2401	866,284K	B		R front steer axle wheel bearing failure; progressive damage to hub; brakes; steering knuckle; tie rod cross tube; ABS sensor & hub cap wheel bearing failed causing R hub to wobble violently damaging adjacent parts				
	2WER4CR7WC667188	CW466873					999,298K			Rear disassembled, lift inner cone cracked, no signs of rotation fog & slip ring, lift inner cone spalled; out of color spacing; seal journal on lift race corroded, lift seal bad; rust lip groove completely worn out, bearings have signs of water ingress, lift cage faulty				Other
28196-8072611	1HJYSSJ2693 A01533	CW466882		11/1996	10/2001		520,189			King pin KBR 1004, rollex premium, lateral movement across slot causes, engine lower lift fractured				Inconclusive
000617-M716000	1FUYBDYB8WL884422	CW466773		07/1997	10/1401		1,000,2024			Clip ring grooved, rear hub burned up, lift & OB cone show signs of spinning rollers have flaked edge on small end, inconclusive				
000691-M716462 R	1XPBD49X0NDD48809	CW401880		07/2187	10/1401		653,307			Rear hub only; no bearings, bearing cones are all nuts, bolts on				
12388-8126798	2WER4CR7WC667141	CW410141		01/1499	01/1400		767,289			Rear hub, spindle, bearings (others) & cones burnt up, cone spinning on spindle, OB cone cone cone load from lift cone, rollers are elevated & burnt up, OB cone has signs of high heat, slip and unbound, lack of lube, L seal, unbalanced unbalanced, bearing burn up, nuts, bad bearing manufacturer, L front hub missing, removed L front lift hub & drum, wheel bearing dry on grease & bad seal				
02888-0107719	1FUYDSZB7YLB98799	0151730		08/1998	03/2401	08/2000	95,000			One too much play, 2 seals leaked, bolts complete bent, unbalanced necessary? Other steer wheel bearing has too much play with F brake leaking, road to pass hubs of wheels				
0010188-M716762	1FUYDSZB8WP777799	0151888		01/0488	09/2401	09/2400	304,810	F		Rear disassembled, OB lift race missing, some wear in bottom groove	2.50	0.00	2.50	Incomplete
	1FUYDSZB8WP681113	0151888		04/0388	04/2401	05/2401	299,000	B						

SKF REPAIR #	VIN #	CLAIM #	FLEET	SF MANUFACTURE DATE	SF FAILURE DATE	CLAIM DATE	SF MILEAGE	SF F/L OR BOTH	SRO PLAY	SKF / PO LAB COMMENTS	AMT PD	MKTG PD	LABT OTHER PD	SKF/VALID OR INVALID
	1FUYDDYB[illegible]	5165207		11/2000	09/21/01	04/16/01	398,000			SF inv rolled, OB had dented/broken cage & rollers, IB roller ends pegged, IB PI SKF spalls like	[illegible]	492.76	147.30	Invoiceable
	1FUYDDYB2WLT67085	E1661864	HAAM	09/2000	09/2001	05/07/01	461,480			Received disassembled, IB IR out & spit, spun on spindle, badly damaged, root cause not determinable	1,130.69	97.479	183.80	Invoiceable
	1FUYDTDBYPA99991	E1661132		09/2000	04/2001	05/14/01	228,486			Received disassembled, IB OR INV badly scattered, metallurgy confirms wpn heat treated on	1,845.17	1,183.17	263.00	Invoiceable
	1FUYDBBBYPA99[illegible]	E1662337	Pat Notis Transport	10/2000	09/1901	08/11/01	447,885			Received disassembled, IB cut brake cage melted, seal lips burned away, OB raw starts cracked	1,126.69	648.97	263.07	Open
	1FUAXDBB41[illegible]	E1667418		09/2000	09/2001	09/2001	41,472			IB OR INV cracked bolts	573.34	531.39	41.95	Valid
	1FUYDBBBYPB[illegible]	E1670072		10/1999	09/1901	07/02/01	230,649			Shipped to SKF for further inspection / received disassembled, silver, argon, oxide & grease gone, OR RWs badly damaged, root cause not determinable	1,802.56	1,384.54	418.01	Invoiceable
	3FUYDMDBWVL[illegible]	E1672166		01/2000	09/2001	07/05/01	762,611			Received disassembled, badly damaged, IB or ball-smashed, no rollers-cages-balls or grease, very hotly, overall determine origin of failure due to lack of parts and materials	1,149.01	811.89	224.12	Invoiceable
Not legible	8FUYDMDB2YL[illegible]7852	E1672300	Midwest Transit	09/2000	09/2001	07/09/01	666,313	1of21		Rec burnt up, had to cut inner races at knuckle, inner races was not cracked at time of failure, inner races cracked during removal, slip ring grooved from rotation, shoulder marks on inner race face	889.51			
18008-0147221	8FUYDMDB2YL[illegible]7852	E1672255	Midwest Transit	09/2000	09/2001	07/01/01	666,313	2of21		Rec burnt up, inner races trashed, slip ring grooved, inner & outer lap have equal damage & heat indicators				
	1FUYSDYB6YLA91760	E1674208		04/01/00	09/1901	07/19/01	392,739			Shipped to SKF for further inspection / Received disassembled, no internal components, OB rev badly cracked, scrapped	1,638.96	0.00	1,638.96	Valid
	1FUYDBZB01LG44943	E1674311	Perry	09/2000	09/2001	07/16/01	173,349			Received disassembled, IB rev badly damaged, wear unidentified	727.29	0.00	727.29	Valid
	1FUPDYBB5LA16[illegible]7	E1675127		01/1999	09/2001		421,674			IB & OB CONE BURNED; NO OTHER BRG PART WERE RECEIVED, INCONCLUSIVE				
34008-[illegible]	8FUYDCYB4YE[illegible]178	E1683179					399,882			Rec hub burnt up, had to cut inner races off, inner races not cracked when returned, outer cone cracked during removal, outer cone spun on spindle, excessive galling on spindle, slip ring grooved				
	1FUPDNZB44P[illegible]091	E1683330					391,194			Hard steel taper lead levers to wrap				
	1FUYSBYB3YHB[illegible]13	E1683497		02/01/99	09/1901		439,616			Rec disassembled, could not find cause of failure				
	1FUYDYB1YP[illegible]972	E1685299	[illegible]	07/01/99	07/1901	06/2001	467,791			Received disassembled, OB OR IR grooves wide-extra-large, missing, OB spindle and heat damage, suspect OB raw failure, IB raw 3 outstanding damage, overall determine origin of failure due to lack of components	1,995.27	1,009.12	949.10	Invoiceable
[illegible] 00[illegible]	1FUYDBBB1YL[illegible]2999	E1691031		09/1999	12/2000		395,379			Rec hub burned up, rec IB and OB burned, slip ring - both inner races cut with cutting torch, inconclusive				
[illegible] 00[illegible]	1FUPDBZB0YP[illegible]623	E1694281		03/2000	09/2001		746,199			Rec hub burned up, rec 1 brg cone, rb not known if it is IB or OB, inconclusive				
[illegible] 00[illegible]	1FUPDNZB3YP[illegible]013	E1695281		01/2000	09/2001		715,199	B		Rec hub burned up, rec one bearing cone, rb not known if it is IB or OB, inconclusive				

SKF SERIAL #	VIN #	CLAIM #	FLEET	IN SERVICE DATE	FAILURE DATE	CLAIM DATE	MILEAGE	S/L OR BOTH	END PLAY	SKF / FB LAB COMMENTS	AMT PD	MAT'L PD	LABOR / OTHER PD	SKF VALID OR INVALID
12[illegible]-0[illegible]	1FUPD[illegible]	E1[illegible]		[illegible]	0[illegible]/01	0[illegible]/17/01	257,05[illegible]			[illegible]	$1,[illegible]	$[illegible]	$[illegible]2.00	
10770[illegible] M77[illegible]	1FUYD[illegible]	E1[illegible]		10[illegible]	0[illegible]		3[illegible]			[illegible]				
1[illegible] 0144[illegible]	1FUY[illegible]	E17[illegible]		0[illegible]	10/22/01		33[illegible]			[illegible]				
2[illegible] 001[illegible]	1FU[illegible]	E17[illegible]		10[illegible]	0[illegible]		4[illegible]			REC HUB BURNED UP; INCONCLUSIVE				
21[illegible]-0[illegible]	1FUP[illegible]	E17[illegible]		0[illegible]/00	10/01/01		30[illegible]			[illegible]				
	1FUY[illegible]	E17[illegible]		07[illegible]	0[illegible]		3[illegible]			[illegible]				
01[illegible] 00[illegible]	1FUY[illegible]	E1710[illegible]		0[illegible]	10/1[illegible]/01		[illegible]	B		REC HUB & HALF BRG BURNED UP; INCONCLUSIVE				
14[illegible]-012[illegible]	1FUY[illegible]	E17[illegible]	New Prime	0[illegible]	11/11/01		3[illegible],405			[illegible] burned up				
20[illegible] 01[illegible]	1FUY[illegible]	E17[illegible]		0[illegible]	11/[illegible]/01		3[illegible],13[illegible]			[illegible] burned up				
1[illegible]-01[illegible]	1FUY[illegible]	E174[illegible]	New Prime	0[illegible]/17/[illegible]	0[illegible]/01		3[illegible]			[illegible] burn up				
2[illegible] 00[illegible]	1FUY[illegible]	E174[illegible]	New Prime	11/0[illegible]	01/17/02		[illegible],72[illegible]			[illegible] burned up				
1[illegible]-014[illegible]	1FUP[illegible]	E174[illegible]		0[illegible]	1[illegible]/01		4[illegible]			[illegible]				
17[illegible]-012[illegible]		[illegible]								[illegible] burn up				
	[illegible]	[illegible]		0[illegible]/00	01/14/02		1[illegible],71[illegible]			[illegible]				[illegible]
[illegible]		[illegible]								[illegible]				[illegible]
[illegible]		[illegible]	[illegible]				[illegible]			[illegible]				
[illegible]	[illegible]	[illegible]	Ryder Truck Rental [illegible] City, [illegible]	1[illegible]	1[illegible]		[illegible],164			[illegible]				
[illegible]		[illegible]	[illegible]							[illegible]	$[illegible]			[illegible]

SKF 000490

SKF SERIAL #	VIN #	CLAIM #	FLEET	IN SERVICE DATE	FAILURE DATE	CLAIM DATE	MILEAGE	E.F.L. OR BOTH	END PLAY	SKF / PS LAB COMMENTS	AMT PD	MAT'L PD	LAB / OTHER PD	SKF VALID OR INVALID
004817 M043186	WD449455	WD449455	Rancho Trucking Radar							RETURNED KNUCKLE RIGHT SIDE; BOTH CONES & CLIP RING, NO ROLLERS RETURNED; CIRCULAR WITNESS MARKS ON CONE FACES; GROOVES ON SPINDLE FROM CONES ROTATING; LOW CLAMP LOAD				
										Unrelated [illegible]				

Printed for: MICHAEL LEWIS
03/13/2002, 09:20:50 AM, 1

Bruce Weeks 03/12/2002 02:40 PM

To: Michael D Lewis/DET/SKF@SKF, William J Parrish/ELG/SKF@SKF, Robert J Bondy/DET/SKF@SKF, Achim Mueller/SCH/SKF@SKF
cc:
Subject: Re: ACTION: FF-991 Steer THU2 Production Changes and Field Return Corrective Actions Taken

FYI.

---------- Forwarded by Bruce Weeks/AMER/SKF on 03/12/2002 02:41 PM ----------

Bruce Weeks 03/12/2002 02:36 PM

To: George F Wireman/AMER/SKF@SKF
cc: Edward F Cotter/AMER/SKF@SKF, John K Thomas/AKN/SKF@SKF, Robert S Fleming/AKN/SKF@SKF, Robert H Edwards/AKN/SKF@SKF, Christopher Jones/AMER/SKF@SKF, Mike A May/GLA/SKF@SKF, Mario G Winkler/AKN/SKF@SKF

Subject: Re: ACTION: FF-991 Steer THU2 Production Changes and Field Return Corrective Actions Taken

Dear George,

Thanks very much for this information. It will be of great help in analyzing the failure we have been seeing to determine where, when & what changes might be having an effect.

Concerning the outboard seal anchorage issue, we changed from a rubber moulding (snapped into groove, like the trailer THU) to a metal cased mounting at some point, either at Luechow or at Aiken. If you don't know about the older style seal, it probably happened at Luechow. Achim Mueller is working on the Luechow portion of the changes for us.

Thanx again for all your help.

Best regards,

Bruce

George F Wireman

George F Wireman
03/12/2002 01:24 PM

To: Bruce Weeks/AMER/SKF@SKF
cc: Edward F Cotter/AMER/SKF@SKF, John K Thomas/AKN/SKF@SKF, Robert S Fleming/AKN/SKF@SKF, Robert H Edwards/AKN/SKF@SKF, Christopher Jones/AMER/SKF@SKF, Mike A May/GLA/SKF@SKF, Mario G Winkler/AKN/SKF@SKF

Subject: ACTION: FF-991 Steer THU2 Production Changes and Field Return Corrective Actions Taken.

Bruce,

Mario requested I respond to your inquiry attached below. After discussions with several of the Engineers here in Aiken along with Mario, the attached are responses to your questions of historical events that occured on the channel during the period as outlined in the inquiry. I'm sure you have considered the volumes of product produced in Aiken vs. Luchow in your study (i.e. approx. 40,000 Luchow vs. 340,000 Aiken).

Another question you asked was the time when Buderus forgings were being processed in Aiken. According to our records, Oct 2000 was the approx. time when Buderus forgings were initially put into production.
Lastly, if I'm not mistaken, there was an issure raised about dismounting the bearing when the brakes were changed - - - even Mertler questioned the survivability after performing this around 200,000 mile intervals. The initial warranty was that the bearing should not be removed after installation by the OEM. Hopefully this dialogue and the responses that follow will be helpful in your study.

Regards,

GFW

---------- Forwarded by George F Wiseman/ANER/SKF on 03/12/2002 09:21 AM ----------

Bruce Weeks 03/11/2002 09:56 AM

To: Mario G Winkler/AKN/SKF
cc:

Subject: ACTION: FF-991 Steer THU2 Production Changes and Field Return Corrective Actions Taken.

Dear Mario,

One of the things we here do not have a good handle on is the occurrance dates of some of the changes that have happened to the steer THU. Arvin/Meritor has been experiencing a number of wheel offs since December (~15) and this is a change from previous where the tire caught fire burning up the truck. We have been asked by ARM to look at failure rates for each change (we have been doing it by production year until now).

Can you please take a look at the following list where I have highlighted it in red and, if an exact date is not available, make an estimate as to the month the change occurred? I think that you are the one there at Aiken who has the best handle on this (or George Wiseman?). And also please confirm the dates I do have listed. Achim is going to try and do the same for Luechow produced parts for us. I need to complete my analysis this week so if you could please get this to me by Wednesday morning it would be most appreciated.

Thank you for your help

Best regards,

Bruce

Here is a chronology of events on the FF-991 steer unitized hub.

Late 1996 - Production begins in Luechow P/N BTF-0031 - Phase III thin flange.

Early 1997 - Luechow changes to P/N BTF-0052 - Phase IV thin flange.

Mid 1997 - Luechow changes to P/N BTF-0049 - Phase VI + quench & temper, thick flange.

Late 1998 - Production begins in Aiken P/N BTF-0052 - Phase V quench & tempered outer rng. interupted wheel pilot.

Printed for: MICHAEL LEWIS
03/13/2002, 09:20:50 AM, 3.

Aiken Response:
Production actually began around April 1998. The total production was approx. 45,900 pcs. in 1998.

Late 1998 - SKF changes outboard seal anchorage to prevent oil bleed past seal at this point.

Aiken Response:
Do not understand the terminology used in this statement when it mentions seal anchorage ??? What does this mean???

Early 1999 - Production line at Aiken "decoupled", floats added at various points in the line. Clearance gage issue occured causing a small amount of parts to be shipped with excess axial clearance.

Aiken Response:
Line was never decoupled! There were some improvements to reintroduce product back into the channel at the grinder and at 1st line in order to help facilitate using outside turned rings to provide some time to correct machine problems and making the tool sensors operative on the turning machines, i.e. montronics and rainshaw probes which mostly affected production output. The reintroductory conveyor was installed by May, 1999.

March 2000 - Unhardened raceways addressed with corrective actions on the Aiken line.

Aiken Response: :
Unhardened rings was discovered January 2000 and it was discovered that the rework procedure was faulty and allowed rings to be erroneously cut back into the channel. The corrective action was to change the procedure and to install a pin marker at the hardening machine in order to insure the rings were properly hardened. Also only certified operators were to operate the equipment and be able to reintroduce product back onto the channel. The marker was installed into the channel around March 2000.

April 2000 - Inboard seal changed to R-Safe and grease changed to GW-Z P/N BTF-0065.

Aiken Response:
The actual introduction occured around April 2000 and was basically timed to the amount of inventory which was on hand with the previous seal before this change. The reason for the change was a supply issue and the grease had environmental issues related to hazardous waste.

August 2000 - Hubcap installation torque revised from 250-350 ft-lbs to address lost hubcap issues.

July 2001 - ARM adds shoulder seal to prevent water from entering bearing along spindle/bore interface. Anti-fretting paste changed to MolyKote D to help prevent removal damage issues .

July & Aug 2001 - Automatic rotation equipment added to assembly line at Arden to seat rollers adequately preventing low clamp load issues.

Nov 2001 - ARM presents field issues to district representatives to help prevent misdiagnosis issues.

Feb 2002 - ARM publishes new inspection intervals for THU2's.

Please call if you have questions.

Regards,

Bruce

Printed for: MICHAEL LEWIS
03/13/2002, 09:18:33 AM, 1

Bruce Weeks 03/11/2002 04:00 PM

To: Michael D Lewis/DET/SKF@SKF, Robert J Bondy/DET/SKF@SKF
cc:
Subject: INFO: BEACON Life Calculations for Various Bearing Clearances

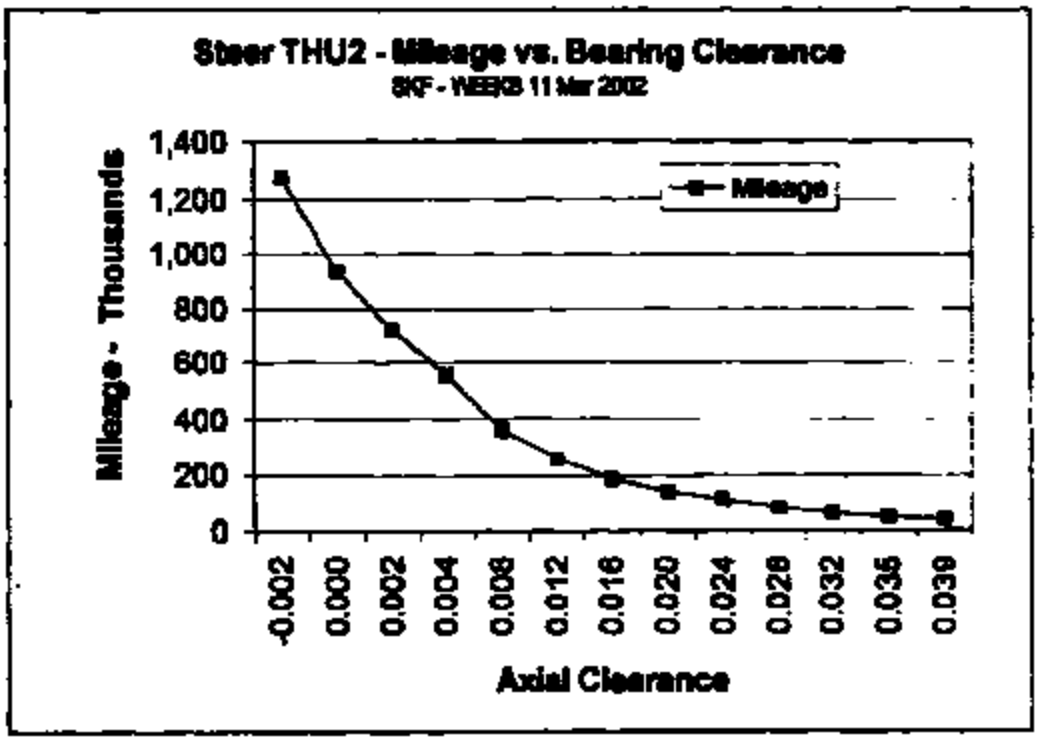
Here is a chart of Steer THU lives calculated by BEACON for clearances from 50 microns pre-load to 1000 microns clearance.

Assumptions:
3.0 mm lip
A23=1.0
Linehaul
13,200 lbs rated axle loading

Note that the scale from 0.002" pre-load to 0.002" clearance is stretched out as the X axis spacing is constant and the scale above 0.002" clearance goes up by 0.004" steps.

Regards,

Bruce



HUBS RETURNED FOR PROBLEM ANALYSIS
LEVEL 1 RETURNS - HIGHLY PROGRESSIVE INCIDENTS
MATERIAL RECEIVED AS OF 03/09/03

SKF Serial #	VIN#	CLAIM #	FLEET	In Service Date	Failure Date	Claim Date	Mileage	W / L OR Both	Mod Play	SKF / FS Lab Comments	Amt PO	Mat'l PO	Lab / Other PO	SKF Valid or Invalid
1998 S M122976		61286						2 of 2?		Complete failure; worst spindle under IR; groove worn in clip ring; low clamp load				
2000- 0126412	1HSCAANN9YJ068865	68865	Dakota Cartage	10/04/00			256,535			Rec hub sig cone bore up; low clamp load				Invalid
	1FUYSSZB2YLB86233	109806	Prime Inc				421,486			Rec disassembled; large displayed; only 10 rollers from OB & from IB inner cones cracked; ?				
12/00- 0129160	1FUPCDYB3YD767519	767519	KLLM	09/14/00			341,648			Cannot accurately determine failure origin; IB IR cracked; OB				Inquestionable
	2HSFTAMR9YC038648	0038661A	Ideal Logis	09/30/00	11/07/01		393,236K			Hub burnt up; 39 rollers recovered; IB inner cone fractured into 3 pieces; D spacer deformed; bore sig fractured into several pieces; OB inner cone not fractured - shows very little damage from rotation				
2000 0166711		0041467A	Meritor Warranty Servicing							Un-fractured recovery				
		0057466A					61,808	1 of 2?		R bent wheel bearing fell apart, unfractured recovery				
6/2/1784	2HSFHAMNYYC034769	034768	Hanson Ind 348	04/17/87	04/01/01		460,647			Hub "fell off" when vehicle was jacked up, hub was received in Troy disassembled; ear shoulder scratches on inner race end faces (indicates no relative motion between the cones); Debris in the hub cap towards IL outer seal bore - this debris was sampled by SKF - results of analysis not available at this time; corrosion in outer bearing in area of roller spacing				Invalid
[illegible]		034774	Hanson Ind 348	05/16/97	07/08/01		466,640			Hub separation from vehicle, failed hub assembly, spacer worn under inner races, groove worn in clip ring (indication of relative motion between inner rings)				
		0[illegible] 0110148	Prime Inc							No rollers, cone or cups, unopened RIs, some heat on LPEB, broken cone ring victimizer notch, life fractures, low clamp load; grooves in clip ring				
10/[illegible] 0146[illegible]	JHDCNAB R1YL[illegible]17	101[illegible]3A	Washington Freight	10/16/99	05/09/01		178,551			Hub was received with OB sig cone in place & IB cup in place, IB sig cone & clip ring missing, loose sig broken off OB cage standing to mast, all grease dry & stiff, can only imagine what all sig cone like Weatherford, unfractured recovery, all RH rollers, entire hub spacer, marked shoe, knuckle @ AP end				
07/[illegible] 6/[illegible] 10/[illegible] 01/[illegible]		1[illegible]35A [illegible]440					0[illegible]			Unfractured recovery				
		[illegible] 0[illegible] 6/[illegible]A J[illegible] 0[illegible]16					21,[illegible]			Bearing fail; hub cap [illegible]				
[illegible]	[illegible]	5/[illegible]44			10/[illegible]		[illegible]0,7[illegible]	[illegible]		Rec hub burnt up, [illegible]				

SKF SERIAL #	VIN #	CLAIM #	FLEET	IN SERVICE DATE	FAILURE DATE	CLAIM DATE	MILEAGE	R/L OR BOTH	END PLAY	SKF / PM LAB COMMENTS	ABT PD	MATL PD	LABT OTHER PD	SKF VALID OR INVALID
14400 6265226		CB000473		10/02/00	10/19/00	10/24/00	333			Wheel departed inner leg rear cage fractured; old leg 2 rollers missing w/light overall scratches; OB IR circular scratches IB side; small amount oil seal face; brake shoe fastened one piece (wheel fell off); IB seal was F-HOR; piece was GARZ; one is wrong. Outer nut was missing from the assy & inner nut backed off allowing hub, drum, and wheel to depart from the vehicle; spindle threads were slightly damaged on end, but not under the area where the nut is torqued; very little damage to bearings and the unit showed no signs of heat.				
091484 S	3HSFRAHR89VC050162	CBY00084		08/15/97	05/25/00	06/13/00	264,000			Stuck up; wheel bearing came apart; busted. Bearing failure damaging drum and brake, truck pulled to the right, had to replace left side brake also bearing failure				
	1FUYSDYB4XP988377	CWH01121	Interstate Dist. Co. Tacoma, WA	11/24/99	04/12/01	04/24/01	420,268			Recd disassembled, OR only, appears ill row failed first, wynot assign not capp	682.16	482.68	226.50	Inconclusive
	1FUPDXZB77XLA84174	CWA02787		01/01/99	07/02/01	07/12/01	796,787K	B		Rec hub burned up; Inconclusive; L side front wheel smoking (found in); bearing failure on L front wheel damaging spindle & seem				
	1FUPDXZB77XLA84174	CWA02787		01/01/99	10/26/01	11/01/01	954,358K	B		R seal wear axle wheel bearing failure, progressive damage to hub, brakes, allowing movable, tire rod grease tube, ABS sensor & hub cap wheel bearing failed causing R hub to [illegible] damaging additional parts				
	2HSFBAER8YC097196	CWH03573					889,239K			Rec disassembled, IB inner cone cracked, no signs of rotation brg & clip ring, IB inner cone spalled, rust at outer spacing, seal pitted on IB race condition, IB seal bad, rust in groove completely worn out, bearings have signs of water ingress, IB seal leaks				Other
28186-4072611	WLAYB6P88XG401339	CWH00983		11/14/98	10/30/01		530,188			Ring pin PAR 100K miss positive, rollers accurately assess and press, maybe loose, pin fractured				Inconclusive
0910171 W7P8332	2HSYBNYB8YH894423	CWH08731		07/11/97	10/11/01		1,880,702K			Clip ring grooved, rec hub burned up, IB & OB cone show signs of spinning rollers have heavy wear on small end, inconclusive				
0909911 W7P8332 H	1APUDUB52WP946910	CWH07995		07/21/97	10/11/01		434,307			Rec hub only no bearings, bearing races are all rusty, burn up				
TJ J09 61J8369	[illegible]	CWA10161		07/14/98	01/14/02		387,000			Rec hub, spindle, bearings (rollers) & races burnt up, wear spinning on spindle, OB cone was worn that kept IB cone, rollers are damaged & burnt up, OB cone has signs of high heat, clip ring grooved, lack of lube [illegible] wheel bearing manipulation, L front hub bearing, removed L front brg hub & drum wheel bearing dry no grease & bit dust				
13886 01V2775	[illegible]	L1317826		05/14/99	01/07/02	05/01/02	55,011							

SKF SERIAL #	VIN #	CLAIM #	FLEET	IN SERVICE DATE	FAILURE DATE	CLAIM DATE	MILEAGE	R / L OR BOTH	END PLAY	SKF / PS LAB COMMENTS	ANY PD	MAT'L PD	LAB / OTHER PD	SKF VALID OR INVALID
001930 M178570	1FUYSDYB8WP917709	E1888888		01/2000	09/01/00	09/21/00	206,316		IF	Drv two mush play; F gear locked; _____ brake; complete load + unbalanced raceway? Drive shaft wheel bearing has too much play; hole F hube bearing; test to prove hube oil adjuster				
	1FUYSDYB8VP917709	E1888888		04/2000	09/01/00	09/13/01	206,483	R		Rec'd dismantled, OR IR easy rotating, some rust in hubcap threads	0.00	0.00	0.00	Inconclusive
	1FUYSDYB8DP986309	E1945367		11/24/00	03/21/01	04/16/01	395,908			IR raw colored, OR heat damaged-melted cage & balls, all outer race pegged, all IR/ OR spall in line	569.95	452.78	147.28	Inconclusive
	1FUYDCYB2WL787086	E1661864	HOLLIS	09/2000?	03/22/01	05/07/01	461,482			Received disassembled, all IR cut & split, scar on spindle, badly damaged, root cause not determinable	1,139.89	974.76	163.60	Inconclusive
	1FUYSDCB01PA98681	E1654132		09/07/00	04/06/01	05/14/01	223,488			Received disassembled, all OR RW badly deformed, metallurgy confirms was heat treated as	1,346.17	1,193.17	152.00	Inconclusive
	1FUYSHB86XLA61765	E1662237	Pine North Transport	10/2000	05/14/01	06/11/01	417,663			Received disassembled, IR raw heated-cage melted, cast lips burned away, OR raw debris dented	1,108.89	845.33	263.07	Open
	1FUJA3CG44LG94585	E1667418		09/97/00	05/30/01	06/25/01	41,412			IR OR RW eroded badly	573.34	531.39	41.95	Valid
	1FUYSHB86XPB40540	E1679077		10/1998	05/1201	07/03/01	230,848			Shipped to SKF for further inspection / received disassembled, rollers, cages, seals & grease gone, OR RWs badly damaged, root cause not determinate	1,307.66	1,384.54	916.81	Inconclusive
	1FUYSHB86XPB40540	E1672169		07/2000	05/2001	07/06/01	762,914			Received disassembled, badly damaged, IR or ball-mounted, no spiders-cages-balls or grease, very rusty, cannot determine origin of failure due to lack of parts and damage	1,146.01	911.89	234.12	Inconclusive
Not legible	1FUYDHYB82YLB17852	E1672366	Universal Transit	08/2000	05/22/01	07/09/01	486,317	no/21		Rec burnt up; had to cut inner cones off trucble, inner cones were not cracked at time of return, inner cones cracked during removal, slip ring grooved from station, answer starts on inner cone face	1401.31			
M808-0142781	1FUYDHYB82YLB17852	E1672366	Universal Transit	08/2000	05/2001	07/09/01	486,317	no/21		Rec burnt up; inner cones cracked; slip ring grooved, outer & balls by have signal damage & heat indicators				
	1FUYSDYB64LA61760	E1674309		09/01/00	05/18/01	07/18/01	452,748			Shipped to SKF for further inspection / Received disassembled, no internal components. OR raw badly eroded, unbalanced	1,839.88	0.00	1,839.88	Valid
	1FUYSHJB82YLB44343	E1674311	Prime	05/2000	05/21/01	07/19/01	173,242			Received disassembled, IR raw badly damaged, pitted embedded raw	737.28	0.00	737.28	Valid
	1FUPDHYB64LA14917	E1676127		01/00/00	07/2001		411,874			IR & OR CONE BURNED, NO OTHER SKF PART HERE RECEIVED, INCONCLUSIVE Rec hub burnt up; had to cut inner cones off inner cones not cracked when returned; outer cone cracked during removal; outer cone spun on spindle, bearings getting on spindle slip ring grooved				
M808-M1811F	1FUYDHYB64LA14917	E1682173					206,962							
	1FUPDHYB64LA14917	E1682778					281,181			Front wheel bearin' hub needs to ship Rec disassembled, could not find cause of failure				
	1FUYSHJB82YLB44343	E1683497		04/01/00	05/13/01		478,315							

BKF SERIAL #	VIN #	CLAIM #	FLEET	IN SERVICE DATE	FAILURE DATE	CLAIM DATE	MI/FAIL	R T L OR BOTH	2ND PLAY	BKF / FS LAB COMMENTS	ANT PD	MAT'L PD	LAB / OTHER PD	BKF VALID OR INVALID
	1FUY5DYB1XP6B0273	E1636488	Interstate	07/31/00	07/2001	08/2001	452,701			Received disassembled, OR-OR tilt-gooseneck-rollers-cages missing, OB spindle and seal damage, suspect OB race failure, IB race is considering damage, cannot determine origin of failure due to lack of components	1,686.37	1,008.17	648.19	Inconclusive
	1FUY3MDB4YLB09488	E1691023		09/15/00	12/2000		206,806			Rec. hub burned spc rev. IB and OB steels, clip ring - both cones were cut with cutting torch; inconclusive				
0198888 0007128	1FUPDBZB3XPA88373	E1695291		03/28/00	08/27/01		785,186			Rec hub burned up; rollers cracked; clip ring grooved; station witness marks on cone bores; cannot determine if low clamp load caused failure due to cones being cracked; both legs burned in color from legs				
05888 0007128	1FUPDBZB3XPA88373	E1695291		03/28/00	08/27/01		785,186	B		Rec hub burned up; reverse bearing cones do not know if it is IB or OB; inconclusive				
12289 0131000	1FUPDSZB1YLF69730	E1695343		09/01/00	08/2001	09/2001	267,031			Rec. hub LB & OB cones, clipring & some rollers; all races were burned up; lack of lubricant	$1,287.68	$826.00	$972.08	
107784 M278332	1FUYDKYB1YPB46809	E1698435		10/21/00	05/04/01		329,433			Rec. disassembled; IB & OB races heavy galling; OB cone heavy; inconclusive				
15888 0144483	1FUYSSEB0YLA86308	E1700864		09/08/00	10/2001		350,884							
31888 0011838	1FUBSDZB7XPB83703	E1704732		10/08/00	09/1901		415,196			REC HUB BURNED UP; INCONCLUSIVE				
31488 0208534	1FUPCSZB7YP882034	E1705169		02/05/00	10/01/01		308,952			Rec hub only as IB, OB brg clip ring; IB race has heavy damage due to brg failure; what caused the failure is unknown at this time because of lack of information; unknown				
	1FUY5ATB9YLB64922	E1705917		02/28/00	09/11/01		331,938			Rec hub burned up; inconclusive				
01788 0038484	1FUY2WYB4XPA22843	E1710588		09/2000	10/15/01		462,888	B		REC HUB & HALF BRG BURNED UP; INCONCLUSIVE				
14888 0139814	1FUY5SJB7XPY23053	E1730571	Jeep Prime	08/18/00	11/1101		320,618			Rec hub & both bearing cones, cones and rollers are burned up				
23188 0145588	1FUYHHZB1LC62171	E1730774		09/01/00	11/1201		326,134			Rec hub only, no bags, hub races are burned up				
08888 013847	1FUYSSJB3YL864864	E1744752	Jeep Prime	09/17/00	07/2001		376,227			Rec hub, bearing cones & rollers; IB & OB cone bores spun, spun show look of hub, NOT IB				
22888 0023874	1FUYSSJB3YLAA1534	E1744753	Jeep Prime	11/2000	01/1702		861,735			Rec hub only; no bearing, bearing races burned up				
15388 0143884	1FUPCA3B1YP86788	E1745078		09/17/00	12/1401		443,128			Rec hub, drum, no bearings, hub burnt up, inconclusive, bolt up, rings off				
12388 0126178		UNIT DETAIL 01								Inner cones not returned, only 20 rollers returned, half cone bit, D section shows substantial down hoist; both hubs & bolt retainer returned; not an interference relativity - flow extinguished when on hub; hub cap threads pipes no sign of rust; support bushings were on at time of failure, bent up; LIB has hardly inflated corrosion or OR thrust all race cones, chips in the IB clip ring, inner cones have screws both IR FAY specific hand showed off & pulled out of one bite corrosion to bearing appears to be post failure (no chattering), impact total; Rec'd disassembled, no rollers or cages in over total bag				

SKF 000440

SKF SERIAL #	VIN #	CLASS #	FLEET	IN SERVICE DATE	FAILURE DATE	CLAIM DATE	MILEAGE	R / L OR BOTH	END PLAY	SKF / FS LAB COMMENTS	ANT PD	NAT'L PD	LAB / OTHER PD	SKF VALID OR INVALID
		RD 38188 18390 8188311	Wal-Mart				48,087			Locked up; unfamiliar [illegible] IB				
08798 0087988		TNPD0808A 718	Prime Inc.							Bearing locked up; tile fractured; IB IR spalled				
SM148798 00 1/81	1FUYDDYB4WLB22888	Unit 302882	Ryder Truck Rental; Oklahoma City, Ok	12/10/97	12/18/01		491,164			18 rollers from OB; 18 flat rollers from IB returned; both inner cones torched off spindle; not all pieces of IB inner cone ring returned; cannot determine if inner cones were cracked causing loss of clamp load; oil inner cone did not crack; bare up				
8123778		Unit 3036	Fleet Pride							Returned disassembled, badly damaged, no rollers-cages-grease or seals, cannot determine origin of failure due to lack of components	52,161.16			Inconclusive
004617 WD43188	WD448455	WD448455	Rendig Trucking Ryder							RETURNED KNUCKLE RIGHT SIDE; BOTH CONES & CLIP RING, NO ROLLERS RETURNED; CIRCULAR WITNESS MARKS ON CONE FACES; GROOVES ON SPINDLE FROM CONES ROTATING; LOW CLAMP LOAD				
										Unfamiliar [illegible]				

FF-981 Hub Failure - ArvinMeritor Lab Report - Bill Polesnak

AXLE NO.	SERIAL #	VIN #/style #	CLAIM #	FLEET	IN-SERVICE DATE	FAILED DATE	CLAIM DATE	MILEAGE	CUSTOMER COMMENTS	ARM LAB COMMENTS
Service Bureau (ARM Lab Confirmed)										
FF-98K	0880 17 1777[illegible]32	1FUYBKYB84LB84483	CWA05721	Freightliner	07/1787	10/11/01		1,080,782 Kilo	Ft. wheel falling off, Bearing failure	Clip ring grooved – Rec- Hub burned up- IB and OB cone show signs of spinning. Rollers have heavy wear on small end.
FF-98K	N/A	1FUYBSEBOYLA86407	CWA05970	Freightliner Effingham Truck Sales	08/1488	10/30/01		433,105	Hub Bearing failure	Rec - Hub no IB or OB Bearings, No clip ring
FF-98K	21988 0811585	1FUBBDZB7XP983759	E1704782	Freightliner	10/1888	08/19/01		415,196	Hub Bearing spinned up	Rec - Hub bynned up
FF-98K	00488 0021885	1FUYBDYB4XPA65888	AM33544 (Dealer #)	Peterbilt	N/A	10/12/01		360,736	Hub & Spindle burned up	Rec - Hub burned up
FF-98K	N/A	1FUYBSZB8YLB98823	E1708817	Freightliner	07/2088	09/11/01		391,836	Hub bearing failed	Rec - Hub burned up
FF-98K	N/A	1FUPCJBB8WHA65084	E1674441	Freightliner	03/2088	09/07/01		873,845 Kilo	Bearing spacer causing wheel to wobble fire	Excessive wear on small end of rollers - OB cone cracked
FF-98K	N/A	1FUYDMDB4YLB83456	E1691022	Freightliner	08/1888	12/28/00		208,536	Hub bearings binds, sticks	Rec - Hub burned up - Rec IB and OB cones + clip ring - both cones were cut with cutting torch
FF-98K	00/706 1776332	1FUYDXYB1YP846888	E1888426	Freightliner	10/2/98	08/04/01		326,433	Hub Brg bands, sticks (burned up)	Rec - Hub IB and OB cones, clip ring, and some rollers, all items were burned up
FF-98K	05888 0087128	1FUPDBZB3XPA68323	E1888281	Freightliner	03/2488	08/27/01		796,198 Kilo	Hub bearing failed	Rec - Hub burned up - Rec (1) brg cone - do not know if it is IB or OB
FF-98K	N/A	1FUYDBZB7XLA84174	CWA 02787	Freightliner Kurtz Int Taylo	01/01/88	07/22/01		798,787 Kilo	Left side wheel loosing	Rec - Hub burned up
FF-98K	Not legible	1FUYDMYB2YP817832	CWA02744	Midwest Transmi	N/A	N/A		647,800	Bearing hub bad	Rec - Burnt up - had to cut inner cones off Knuckle Inner cones were not cracked at time of return, cracked during removal Clip ring grooved from rotation Crusty marks on inner cone faces
FF-98K	3L2253 1788778	1FUYDSYB7YLB97817	E1689423	Freightliner	08/2787	07/13/01		798,488 Kilo	Bearing seized	Brg spinning on spindle
FF-98K	25388 0126412	1FUCJAAH8BY J08885	N/A	Dakota Carriage	12/0488	N/A		288 888	Found bearing was out of wheel hub	Rec - Hub , brg cone burned up
98-98K	12288 D217282	1F UFDBJB8YLB86479	(BNFD01 M8837) E1684388	New Penn	01/21/00	07/28/01		388 888	Left hand wheel brg failed	All rollers missing, hub still on knuckle, removed nut and found spindle had severe grooves on it from cones rotating Grooves repaired on OB Clip ring grooved IB & OB were not cracked, hub should of still had stamp seal
11981		1FUYMMB8CYLB81881	E1681230	Freightliner	10/0888	11/2/188		388 887	Hub Assembly Broken	Spindle still IB head decattered, stamp brg recovered with chips
11981	4V8 MM0M0P8	1F UYBFYB8Y P648163	E1680 [illegible]	Freightliner	08/1888	08/2388		43,881	Wheel is loose, bearing bad, caught fire	IB roller not seized, heavily on opposite RW Unhardened Racemay
11981		1F[illegible]	[illegible]	Freightliner	07/21/88	08/3088		488 701	Hub bearing seized up	Rec'd disassembled. OH-OB IR grease seals rollers slight rotating OB spindle and heat damage, suspect OB race failure IB run 0 upon assembly clearance origin
11981	4V8 0M1P4MC	4F1531	[illegible]	Freightliner	11/1/88	08/10/01	10/1/01	127,000		Stamp broken brg damage
11981		1F[illegible]	[illegible]	Penn	11/1/88	08/10/01	08/10/01	288 882	Hub failure - hub burn up	Hub burn up
		1F[illegible]		New Penn						
		1F[illegible]	[illegible]	New Penn	07/2888	08/31/01	08/29/01	48[illegible]		Hub burn up, engine fire, aluminum wheel melted, hub stayed on spindle, hub burn up Damaged brg
11981		4V8[illegible]	[illegible]	Midwest Transmi	08/21/01	10/08/01	10/08/01	61371		
[illegible]										

FF-961 Hub Failure - ArvinMeritor Lab Report - Bill Polesnak

AXLE MDL	SERIAL #	VIN/Unit #	CLAIM #	FLEET	IN-SERVICE DATE	FAILED DATE	CLAIM DATE	MILEAGE	CUSTOMER COMMENTS	ARM LAB COMMENTS
FF961		1FUYDSEB7YP8403	Watchum	Dick Simon				17,000	Truck fire	Tractor fire. Bl roller set seized, heavily eroded to RR. Unhardened Raceway
FF961		#31189		Interstate Distributor		11/28/01				Tractor fire
FF961		1FUYDSEB7YLA33788	CM100153	EP96	03/1998	09/11/00	07/24/00	249,709		Tractor fire. Hub failure (Labor to remove axle)
Hub Off to Conformal ARM Lab)										
FF961	AVF98100235	1FUYDSYBCYLB97895		Nordic Express	09/1998	09/04/01		325,132		Hub and knuckle separated.
FF961		1FUYDWDB1YLB17923	Z1941386	Highland	05/01/98	03/07/01	05/07/01	535,238		Hub and knuckle separated.
FF961	AVF98161214	1M1AA12Y2CM088261		MCA						Hub off - Hub lost in yard.
FF961		2H9FMAXR8VC034774 8343		Monson Trucking	05/98/97	03/08/01	04/03/01	466,880		Hub and knuckle separated.
FF961		2H9FMAXR1VC034759		Monson Trucking	04/1997	04/01/01	04/04/01	480,547		Left side, bearing fell apart - Jacked up truck, hub fell off.
Hub Off Customer Complaint Of Noise (Unknown)										
FF961		YJ088555	RO 49459	Dakota Cartage	10/04/99			278,580	LF wheel falling off	Fell skated in fill row, IR's smeared spun & ratcheted off, cannot accurately determine failure origin
FF961	AVF9811375I	1FUYSDYB6YPA8900	RB864848	Interstate	08/2000			302,048	Wheel off	Endplay 0.021", easy rotation, fill seal worn lip badly worn, grease dark and thick, high H20 content at fill row, corrosion pits
FF961		1FUYDYB1LH13715	Unit # 924386	Ryder	03/18/00			35,185	Wheel Fell off	NB OR raceway heavily smeared - unhardened raceway, main picture only.
Hub Off (Field Issues Reliability)										
FF961		2H9FMAXR4VC034779 8324	CA003740	Monson Trucking		02/05/00	03/04/00	337,433		Hub Bearing - Inboard fell off.
				Interstate						
Hub Off (Customer Complaint)										
FF961		1FUYNDM2YPC8943J	11FDC001 B187A B187A3D0	Fore Trucking	01/04/00	04/16/01		157,368	Hearing noise	

FF-691 Hub Failure - Rebecca's Database

CLAIM #	FLEET	IN-SERVICE DATE	FAILED DATE	CLAIM DATE	MILEAGE	ASIT PD	MAFL PD	LABOR / OTHER PD	CUSTOMER COMMENTS	Wheel off = 1; Bearing from up = 2; Tractor fire = 3
E1330001		02/3x/97	03/10/97	06/3/98	88002	357	428	132	DMG: HUBS,FRONT ASSEMBLY BROKE/BEARING BURNED UP AND DAMAGED HUB AND SPINDLE. REPLACE SPINDLE,HUB AND BEARINGS,RIGHT FRONT WHEEL BEARING BURNED UP. HUB WAS SUPPLIED BY SKF,BEARING FAILURE	2
E1336007		01/2097	08/11/98	08/2/98	221636	618	488	87	DMG: HUBS,FRONT BEARING BROKE/LEFT STEERING WHEEL BEARING OUT-REMOVED HUB - WHEEL BEARING DONE FROM HUB - CAME IN ON WRECKER-R & I BRAKE PADS - INSTALLED NEW HUB AND HARDWARE - INSTALLED NEW HUB CAP ON LEFT FRONT WHEEL WITH SEALANT - CHECKED TOLERANCES ON RIGHT SIDE BEARING ON/BEARING FAILED, BURNT UP,BEARING FAILURE	2
E1335178		09/08/97	04/2/98	07/02/98	269035	197	31	188	DMG: HUBS,FRONT BEARING BURNED/CUSTOMER COMPLAINS OF PLAY IN STEERING/FOUND THE BEARING HAD BURNED UP CAUSING DAMAGE TO BRK SHOES/BEARINGS,KINGPN,FULL TIE ROD,DLINK,BRAKES,ETC/REPLACE HUBS/HOES,K-PIN,ASSEMBLE,STEAM OFF AND ROAD TEST EXTRA TIME TO DIAGNOSE/INSPECT FRONT END	2
E1335178		09/08/97	05/2/98	07/02/98	269035	197	31	188	DMG: HUBS,FRONT BEARING BURNED/CUSTOMER COMPLAINS OF PLAY IN STEERING/FOUND THE BEARING HAD BURNED UP CAUSING DAMAGE TO BRK SHOES/BEARINGS,KINGPN,FULL TIE ROD,DLINK,BRAKES,ETC/REPLACE HUBS/HOES,K-PIN,ASSEMBLE,STEAM OFF AND ROAD TEST EXTRA TIME TO DIAGNOSE/INSPECT FRONT END	2
E1336121		03/14/97	08/14/98	07/21/98	317459	1441	900	541	DMG: HUBS,FRONT BEARING BURNED/FRONT BRAKES CAM JAMMED AND LEFT HUB BEARING SEIZED >>>HAD TO CUT HUB WITH TORCH WAS JAMMED LH SIDE ,,HAD TO REPLACE LEFT KUBJKNUCKLE ASSY,,BEARING FOR KN PIN AND BOTH CAMSHAFT AND BUSHINGS/ROCKWELL REP. WAS HERE TO CHECK UNIT" MAKE FRONT WHEEL ALIGNMENT/HUB UNIT SEIZED UP AND RAN OUT OF GREASE OR HAD INSUFFICIENTGREASE AT ASSEMBLY,BEARING FAILURE	2
CE1317Bx		05/15/97	04/xx/98	11/16/98	174691	886	0	886	MATERIAL PREVIOUSLY RETURNED TO TROY ON WARRANTY CLAIM. THEPOLICY CLAIM FOR TOWING AND FREIGHT CHARGES AS RELATED TO HUB FAILURE. THE HUB WAS NOT AVAILABLE FROM FLORENCE AND UNIT WASDOWN,POLICY ON EMERGENCY FREIGHT COST AND TOWING COST TO SUPPORTFLEET (FIRST HUB FAILURE WITH BURNT SPINDLE AND DAMAGED BRAKES ANDDAMAGED WHEEL)	2
E1331210		06/8/97	01/26/98	02/03/98	230609	1019	801	211	CK FOR DAMAGE TO LEFT FNT HUB. LOST OIL FROM HUB,BEARING BURNED SPINDLE AND HUB,CONTACTED HANS HENRY, MENTOR, INSTRUCTED US TO REPLACEHUB, DRUMS, SPINDLE, BEARINGS, FAX WAS A/VBRINNER BEARING FAILED ON UNITLEU WHEEL END BURNED SPINDLE BEARING FAILURE	2
E1334278		11/8/97	01/2/98	02/13/98	236008	616	358	57	DMG: HUBS,FRONT BEARING WORN/SERVICE INSTALLED RIGHT SIDE BEARINGS ARE OK LEFT SIDE ARE WORN OUT, FOUND EXCESSIVE BURNELLING THE HUB I WAS GIVE WAS THE WRONG ONE THEY'RE BACK AND INSTALLED THE CORRECT HUB CHECKED OPERATION- GOOD ENDPLAY	2
E1334611		12/4/96	12/16/98	12/17/98	383	331	381	70	DMG: HUBS,FRONT ASSEMBLY LEAKING/PAINT OUT GROVE END NOSE SEAL HUB IS MOVED WHEEL/AXLE ASSY FOUND THE HUB WAS NO OIL IN EITHER FRT HUB, WAS NOT DRILL AT FACTORY LH WHEEL BEARINGS AND SEAL WERE OUT OF HOUSING. HUB IS CRACKED - REPLACE ALL NECESSARY PARTS - REMOVE RH HUB AND CK BEARINGS BEARINGS OK SEAL BURNT UP - REPLACE SEAL REMAIN PLEASE INSPECT PARTS BEFORE USE EITHER HUB ASSY BE ARRIVAL EARLIER	2
E1334611		12/4/96	12/16/98	12/17/98	46707	628	417	212	DMG: HUBS,FRONT BEARING BROKE/LEFT STEER AXLE WHEEL BEARING SEIZED TO SPINDLE HUB HAD SEIZED TO SPINDLE AND WOULD NOT COME OFF, BURNING HUB,SPINDLE AND REPLACE HUB WITH NEW TIRE WITH HAVE TO REMOVE DRUM TO BE CAN SEAL NUT TO REMAIN SPINDLE FOR BEARING WEAR	2

FF-661 Hub Failure - Rebecca's Database

CLAIM #	FLEET	IN-SERVICE DATE	FAILED DATE	CLAIM DATE	MILEAGE	ASIT PD	MATL PD	LABOR / OTHER PD	CUSTOMER COMMENTS	What all = 1; Bushing Burn up = 2; Trailer Fire = 3
E1401349		05/14/97	12/14/98	09/22/00	192279	340	238	46	DMG: HUBS,FRONT ASSEMBLY WORN HUB BURNED OUT. REPLACED HUB/BEARING FAILURE	2
E1425869		07/14/98	8/18/99	08/30/00	34259	1811	1088	743	DMG: HUBS,FRONT BEARING SEIZED,STICKS,RIGHT WHEEL AND BEARINGS BURNED UP.REMOVED AND REPLACED EVERYTHING ON RIGHT FRONT. WHEEL AND HUB DAMAGED DUE TO FIRE ATA#26. DAMAGED BRAKES AND CHAMBER. CONTACT ROCKWELL BEFORE REPAIRS. UNIT WAS INSPECTED BY JOHN BEASLEY DSM PLEASE CONFIRM DEALER COMMENTS AND IF WARRANTABLE SHIP PARTS TO TROY FOR TESTING. USE CLAIM NUMBER AS IT WAS INSPECTED AT TIME OF FAILURE. PARTS DESTROYED DURING FAILURE	2
E1429985		04/30/97	04/29/99	08/30/00	338827	1559	1088	503	DMG: AXLE,FRONT ASSEMBLY BINDS,STICKS,REPAIR FOR RIGHT STEERING BEARING OUT. FOUND BEARING SEIZED IN HUB TO SPINDLE. CAUGHT ON FIRE. DAMAGED TIRE. REMOVED SPINDLE. REPLACED SPINDLE AND KING PIN ASSEMBLY. HOOKED UP TIE RODS. REMOVE AND REPLACE ABS SENSRO FROM DAMAGE. REPLACED BRAKE SHOES AND TIGHTEN INNER BEARING NUT TO 600LBS. GREASED HUB SEIZED TO SPINDLE, CANNOT REMOVE FROM SPINDLE DSM PLEASE INSPECT FOR WARRANTABLE FAILURE. IF WARRANTABLE DSM STOP A BRIEF DESCRIPTION OF THE FAILURE "ONE STOP BEARING FAILURE	1
L1438878		03/06/98	05/19/99	07/14/99	23202	1428	1130	288	DMG: AXLE,FRONT BEARING BINDS,STICKS,BURNED, #1KUCKLE PIN. OWN THE LEFT FRONT HUB LOCKED UP AND CAUGHT ON FIRE. DEFECTIVE HUB. WE INSPECTED THE DAMAGE AND FOUND THE HUB, BEARINGS,BRAKES, AND DRUM SEVERLY DAMAGED. WE DISASSEMBLED THE LEFT FRONT HUB ASSEMBLY AND SPINDLE. WE INSTALLED A NEW SPINDLE DSM PLEASE INSPECT FOR WARRANTABLE FAILURE, AND PLEASE PROVIDE BRIEF DESCRIPTION OF FAILURE "FF661 HUB BEARING FAILED AND CAUSED PROGRESSIVE DAMAGE TO THE SPINDLE AND WHEEL INSPECTED PARTS "22WHEEBEARING FAILURE	2"
E1440378		03/31/99	04/29/99	08/30/00	9291	2012	995	1117	DMG: AXLE,FRONT BEARING WORN/CHECK FOR LEFT FRONT WHEEL BEARING FAILURE. LEFT FRONT WHEEL BEARING CAME APART. DAMAGE CAUSED TO SPINDLE, HUB, LEFT TIE ROD END, BRAKE SENSOR, KING PIN, BRAKE SHOE, TIRE AND RIM REMOVED AND REPLACED ALL DAMAGED PIECES. SUBLET TO REPLACE TIRE AND RIM. CLEANED, TEST DROVE. ADJUSTED BRAKES NO FURTHER DSM PLEASE INSPECT FOR WARRANTABLE FAILURE, AND PLEASE PROVIDE BRIEF DESCRIPTION OF FAILURE "HUB WAS COMPLETELY BURNT UP IN THE BEARINGS. THE OUTER BIG WASHERS WHEEL NUTS WERE IN PLACE SPINDLE WAS RUINED BEARING FAILURE	2
E1447811		11/18/98	07/14/99	08/31/00	134212	1809	1397	602	DMG: HUBS,FRONT BEARING BROKEN OR RIGHT STEERING SPINDLE, HUB, BRAKE SHOES, WHEEL AND TIRE PLUS SMALL PARTS DUE TO WHEEL BEARING FAILURE PER J. MEHEZ AT ROCKWELL TIRE AMOUNT CLAIMED IS PRORATED DSM PLEASE INSPECT FOR WARRANTABLE FAILURE AND PLEASE PROVIDE BRIEF DESCRIPTION OF FAILURE " BEARINGS BURNED UP PARTS SUBJECT TO PREMATURE BEARING FAILURE	2
E1449193		05/10/99	08/13/99	09/18/00	43801	2137	1580	1037	DMG: HUBS FRONT BEARING BINDS,STICKS,RIGHT FRONT STEER WHEEL IS LOOSE, BEARING SAID CAUGHT FIRE REMOVED TIRE HUB ASSEMBLY AND SPINDLE INSPECTED S-CAM AND KINGPINS INSTALLED NEW SPINDLE ON LEFT REPLACED TIE ROD ENDS REPLACED BRAKE SHOES,HUB,DRUM,ETC ADJUSTED BRAKES AND INSTALLED DRIVE RIP REMOVED BY WHEELER CO ADJUSTED TOE IN SPUN BALANCED PLEASE INSPECT FOR WARRANTABLE FAILURE, AND PLEASE PROVIDE BRIEF DESCRIPTION OF FAILURE "EXTENSIVE DAMAGE & LOW MILEAGE , PLEASE NOTE LEFT PARTS BEARING TURNED TO TROY BEARING FAILURE	2"

SKF 000466

FF-661 Hub Failure - Rebecca's Database

CLAIM #	FLEET	IN-SERVICE DATE	FAILED DATE	CLAIM DATE	MILEAGE	ABIT PD	MAFL PD	LABOR / OTHER PD	CUSTOMER COMMENTS	Wheel off = 1; Bearing burn up = 2; Tractor Fire = 3
E1427[illegible]		07/24/99	08/19/99	11/23/99	7895	846	350	466	DMG: HUB,FRONT BEARING BINDS,STICKS,RF WHEEL BEARINGS FAILED. LOCKED UP. WAS CHARGED FREIGHT TO HAVE SHIPPED IN. R/R OTHER HUB. ALSO REFERENCE CLAIM TO66648 FOR TOWING TO SHOP. 661 FRONT AXLE LH HUB BEARINGS BURNED TO SPINDLE HARD TIME REMOVING BEARING FAILURE	2
E1457535		12/01/98	05/10/99	01/28/00	174807	1738	1107	838	DMG: HUB,FRONT BEARING BIND,STICK,UNITS WHEEL FELL OFF, FOUND WHEEL END SEIZED, EXTENSIVE DAMAGE, PIECE OF END DAMAGED FUEL TANK SEND TO BURLEY, REARE ALL BURNT & DAMAGED PARTS, REARE KNUCKE ASSY, HUB STUD, DRUM, Rbs. SEND TIRE TO BUR. TO HAVE REPAIRED. NOTE: XTRA TIME TO REMOVE SEIZED PARTS,HUB BRG. SEIZED TO KNUCKLE,BEARING FAILURE	1
E1457785		05/19/97	12/29/99	03/07/00	80453	649	397	161	DMG: HUB,FRONT ASSEMBLY BROKEN,DRIVER SIDE STEER HUB CAUGHT ON FIRE- REMOVED TIRE & DRUM HUB- ALONG WITH BEARINGS & SEAL- HUB BAD... REPLACED STEER HUB ASSY- REMOUNTED DRUM & TIRE- ADJUSTED BOTH STEAR AXLE BRAKES TO SPEC- INSTALLED DRIVELINE-- TEST DROVE OKBEARING FAILURE	2*
CF601668		01/28/98	04/05/00	04/05/00	362948	676	675	0	FF661 BEARING BURNED UP. CUSTOMER INSTALLED NEW HUB,BEARING BURN-UP	2
6 1529681		05/01/00	05/24/00	05/15/00	8707	1284	1005	108	DMG: FRONT AXLE /HUB ASSEMBLY LOOSE,CHECKED AND FOUND THAT THE WHEEL BEARING HAD BE EN HOT AND BURNED THE SPINDLE AND HUB REMOVED AND REPLACED THE HUB AND BEARINGS,REPLACED THE B BEARING AND LUBE,CHECKED THE ANTROCK SENSOR AND FOUND IT TO BE SHOP FROM THE HEAT,REPLACED THE S ENSOR,RE INSTALLED ALL PARTS REMOVED AND RECHECKED OK PLEASE HAVE HUB SHIPPED TO TROY FOR FURTHER TESTING. USE CLAIM NUMBER AS ID "BEARING FAILURE AT 8,000 MILES. FAILED PARTS SHIPPED TO TROY,BEARING BURN UP	2
6 1542858		11/21/97	06/23/00	07/27/00	322348	1573	1387	288	DMG: FRONT AXLE,KNUCKLE SPINDLE BROKEN,PULLED WHEEL AND HUB,PULLED DRUM, SHOES,REMOVED SPINDLE,CLEANED AXLE,INSTALLED NEW SPINDLE INSTALLED NEW 3 CAM BUSHINGS,INSTALLED SLACK ADJUSTER,CLEVIS PINS WITH NEW COTTER PINS,INSTALLED NEW BRAKE SHOES,INSTALLED HUB CAP,INSTALLED ANTI LOCK WHEEL SENSOR AND ADJUSTED,INSTALLED DRUM PLEASE INSPECT FOR WARRANTABLE FAILURE" THE WRONM FAILURE CODE WAS ENTERED BY THE DEALER. THE SPINDLE DID NOT WEAR THIS IS A UNITIZED WHEEL END FAILURE THE INNER BEARING FAILED AND BURNED THE SPINDLE DEALER REPLACED BOTH CLAIM OK UNKNOWN	2
E 1548858		08/06/00	08/24/00	09/27/00	16788	1675	1343	288	DMG: WHEEL,FRONT BEARING BINDS,STICKS,BUSHING, KNUCKLE, PIN FAILURE AT RIGHT FRONT WHEEL. TRUCK TOWED TO SHOP. FOUND RIGHT STEER WHEEL BEARING HAD SEIZED CAUSING FIRE WHICH CAUSED FURTHER PROXIMATE DAMAGE. OWN ACCESS REPLACE PARTS ASSISTED CLEANUP AREAS OF FIRE CHECK DPF REPRESENTATIVE ARRIVED BURN UP	2*
E 1548818		08/06/00	08/24/00	09/27/00	16788	1675	1343	288	DMG: WHEEL,FRONT BEARING BINDS,STICKS,BUSHING, KNUCKLE, PIN FAILURE AT RIGHT FRONT WHEEL. TRUCK TOWED TO SHOP. FOUND RIGHT STEER WHEEL BEARING HAD SEIZED CAUSING FIRE WHICH CAUSED FURTHER PROXIMATE DAMAGE. OWN ACCESS REPLACE PARTS ASSISTED CLEANUP AREAS OF FIRE CHECK DPF REPRESENTATIVE ARRIVED BURN UP	2*
E 1548[illegible]		11/27/98	05/18/00	09/28/00	21338	997	397	313	CHECK AND REPAIR LEFT FRONT STEER AXLE FOR SMOKING HUB W/O REMOVE 1ST AXLE DRAG BRAKE ASSEMBLY,RE MOVE CAMSHAFT,UPPER & LOWER KING PIN CAPS,KING PIN FORCE REMOVE KING PIN & SPINDLE,FREE UP WORN PARTS,INSTALL NEW KING PIN BEARING BURN UP	2
E 1548[illegible]		11/27/98	05/18/00	09/28/00	21338	997	397	313	LEFT FRONT WHEEL BEARING HEATING UP LEFT STEERING AXLE WHEEL ASSEMBLY DEFECTIVE WHEEL BEARING BURNED AND DAMAGED WHEEL ASSEMBLY PARTS REMOVED ON 1ST ASSEMBLY AND MOUNTED ONLY VERY SLIGHT DAMAGE TO SPINDLE CLEANED UP & PARTS OF NEW PARTS INSTALLED NO OTHER FACTORY REPAIRS BEARING BURN UP	2

FF-981 Hub Failure - Rebecca's Database

CLAIM #	FLEET	IN-SERVICE DATE	FAILED DATE	CLAIM DATE	MILEAGE	ART PD	MAT'L PD	LABET OTHER PD	CUSTOMER COMMENTS	Wheel end = 1; Steering Axle up = 2; Tractor Fire = 3
E1308671		09/17/00	09/1/00	09/27/00	44252	816	538	182	DMG: FRONT AXLE,HUB BEARING BINDS,STICKS,RIGHT FRONT BRAKES ARE LOCKED UP#UB, FRONT AXLE, R/RCHECK FRONT WHEEL ,FOUND RIGHT FRONT WHEEL BEARINGS OUTR BURNT UP DRUM,R/R HUB,DRUM,SHOES & REASEM,ADJ & RECHECK-DKBEARING BURN-UP	2
CCV00049		08/24/00	10/05/00	10/05/00	45671	1732	1180	863	CONTINUATION OF FRONT AXLE CLAIM FOR BURNT HUB**********CONFIRMED CONFIRMED CONFIRMED**********MISC SUPPLIES INCLUD DRUM, TIRE, RIMM DUE TO FAILURE/AM-PER MIKE BARNETT THIS IS AN SKF HUB PROBLEM	2
E1573pp		01/08/00	09/29/00	10/13/00	348891	0	0	0	AIR FREIGHT/LEFT STEERING SPINDLE CAUGHT FIRE. BEARINGS WELDED TO SPINDLE,HUB DAMAGED. SEAL DAMAGED. HUB CAP MELTED. REMOVE DAMAGEDPARTS, REPLACE DAMAGED PARTS.	1
C9620879		11/1/99	07/05/00	11/09/00	164011	3529	2304	935	THE TRUCK HUB FAILED CAUSING DAMAGE TO THE TIRE, WHEEL ANDRELATED PARTS FROM CATCHING ON FIRE.BEARING BURN-UP	2
E1581584		01/01/98	11/03/00	11/13/00	354888	1475	1111	364	DMG: FRONT AXLE BEARING BINDS,STICKS,RT STR WHEEL BEARING SEIZED TO FOUND WHEEL BEARING IN PIECES SEIZED TO KNUCHLE HAD TO HEAT TO DISASSEMBLE HAD MELTED ABS SENSOR, BLACK SHOES, HAD MELTED CK OTHER BEARINGS OK HADCAUGHT FIRE PROGRESSIVE DAMAGEBEARING BURN-UP	2
E1587484		10/13/98	10/23/00	11/20/00	348232	1488	952	543	DMG: FRONT AXLE,HUB ASSEMBLY BINDS,STICKS,CHECK RIGHT FRONT WHEEL WAS ON FIRE.CHECKED AND FOUND WHEELBRG SEIZED TO SPINDLE,THIS LOOKS LIKE CAUSE OF FIRE.NECESSAR Y TO REPLACE SPINDLE HUB AND SHOES AND HARDWARE AND BRG AND ABS SENSORBEARING BURN-UP	2'
E [illegible]197		08/[illegible]98	10/17/00	12/1/00	338981	441	293	152	DMG: FRONT AXLE,HUB BEARING BINDS,STICKS, RESLUB,REFER TO CLAIM DE0847,ATTACK BURNS FAXING DETAILED STORY & COPY OF DEALER WORK ORDER FR1 HUB COMING LOOSE&CATCHING FIRE,FREIGHTLINER OF CHARLOTTE REPAIRED UNDER WARRANTYON 10/12/00,HOWEVER, THERE WAS PROGRESSIVE DAMAGE TO THE RelPART NOT AVAILFOR 60DYS,REMB. BEARING BURN-UP	1
E 1604157		10/2/98	11/07/00	12/1 1/00	403239	1319	297	1007	DMG: FRONT AXLE BEARING BROKEN/STEER AXLE BEARING FAILURE SEE CLAIM IN SERVICE ADVISOR FROM TEAM TRUCK FREIGHTLINER FAILURE CAUSE DAMAGED TO FOLLOWINGPART FRONT TIRE & WHEEL IN FAX TO R SUPORT,ALSO RIGHT FUEL FAIRING BROKEN BY TIRE AND RIGHT FENDER SCRATCH REPLACE AND PAINT FAIRING AND POLISH IN FENDER ON RI SIDE/DOM THIS IS THE SAME TRUCK AR L19886 PLEASE ADVISE IF THIS IS A WARRANTABLE FAILURE"OK APPROVE THIS REPAIR P PERFORMER:AHING FAILURE	2
P 1614/0		08/01/98	11/10/00	01/09/01	143804	1109	1016	181	DMG: FRONT AXLE,HUB BEARING BINDS STICKS,SEIZED/BROKEN RIGHT HUB BEARINGS OUT WHEEL BEARING LOCKED UP,DMG SPINDLE AND HUB CAUGHT ON FIRE R/R ALL COMPONENTS TO LEFT RIGHT WHEEL ASSY AND ADJ BRAKES OK ONBEARING BURN-UP	2
1.96/2048		04/15/98	01/1.3/01	02/19/01	421808	1513	999	514	THE RIGHT STEER AXLE HUB AND BEARINGS CAUGHT ON FIRE BEARING BURN UP	3
[illegible]		[illegible]	[illegible]	02/28/01	2 [illegible]	3261	1636	894	DMG: FRONT AXLE BEARING BINDS,STICKS,WHEEL BRG SEIZED CAUGHT ON FIRE PRIOR DRIVE DAMAGE TO HUB,BRAKE DRUM SPINDLE WHEEL RIM TIRE & HUB CAP BEARING S HUB SEIZED, HAD TO CUT APART WITH CUTTING TORCH REPL HUB, BRAKE PARTS, SPINDLE, DRUM, HUB NUT CAP & TIRE WHEEL TO FOR TIRE & TO HAVE MOUNTED BALANCED ALSO TRUCK OUT OF SERVICE FOR REPAIR INSPECT AND ADVISE IF THIS WAS A WARRANTABLE FAILURE "BEARING SEIZED DAMAGING RELATED PARTS BEARING FAILURE	2'

FF-981 Hub Failure - Rebecca's Database

CLAIM #	FLEET	IN-SERVICE DATE	FAILED DATE	CLAIM DATE	MILEAGE	ABIT PD	BATT PD	LABOR / OTHER PD	CUSTOMER COMMENTS	Wheel off = 1; Bearing Side cp = 2; Tractor Flat = 3
E1623884		06/30/00	08/07/01	08/13/01	340612	1779	1151	827	DIAG: FRONT AXLE BEARING BINDS,STICKS,RF WHEEL BEARING FAILURE BUSHINGS, BOTH, KNUCKLE PIN, CV/HLTS AND FOUND WHEEL BRGS SEIZED AND BURNED UP THE FRONT AXLE/HUB, BRAKE SHOES, BRAKE DRUM, SPINDLE & KNUCKLE PINS RR ALL NECESSARY PARTS TO REPAIR/ASSM PLEASE INSPECT AND ADVISE IF THIS WAS A WARRANTABLE FAILURE/PLEASE HAVE HUB SHIPPED TO TROY/THIS IS A WARRANTABLE CLAIM/ THE BRGS IN THE HUB UNIT WERE LOOSE/AND DAMAGED. DEALER WILL SHIP HUB TO TROY/BEARING FAILURE	3
E1841568		03/11/00	03/26/01	04/02/01	365819	1408	1038	348	DIAG: FRONT AXLE BEARING BIND/LUBRICATION/WHEEL BEARINGS AND RIGHT FRONT HUB BURNED UP.REMOVE RIGHT STEER AXLE HUB & SPINDLE ASSY,REPLACE SPINDLE,HUB ASSY,ABS SENSOR,BRAKE CHAMBER,AIR SUPPLY HOSE TO CAMBER,BRAKE SHOES,SPRING NUT,BRAKE DRUM,REINSTALL ALL RELATED PARTS,TORQUE SPINDLE NUT TO SPEC,REPLACE R/TIE ROD END,SET TOE.WAS/BEARING BURNED UP	2
CWA00836		10/01/97	03/22/01	04/10/01	588474	1169	944	220	DC-EXCESSIVE NOISES AT LEFT FRT WHEEL.CS-BRGS INSIDE INTEGRAL HUB SEIZED, DAMAGING KNUCKLE ASSY.CS-(GROOVED & BURNT)CA-CHECKED. DE-ASSED. FOUND DAMAGES. ORDERED R&R ALL DAMAGED.CA-PARTS.	2
CWA00864		09/21/95	03/30/01	04/10/01	582588	1733	1200	533	DC-R/T/F RT WHEEL BEARING CATCHING FIRE.CS-BEARING FAILED, OVERHEATING AND CATCHING ON FIRE.CA-REPLACED HUB AND BEARING ASSY, AND DAMAGED ABS SENSOR,DRUM.CA-BRAKE SHOES, KING PIN	2*
E1848268		05/21/98	03/04/01	04/18/01	327498	1188	1021	188	DIAG: FRONT AXLE BEARING BIND&STICK,23001: GH LEFT STEER WHEEL BEARING TH, FOUND LEFT STEER BEARING BURNT UP DRUM, SPINDLE, WHEEL, TIRE, BRAKE SHOES & BEARINGS ALL HEAT DAMAGED REPLACED ALL. DRIVER PURCHASED TIRE CHECKED ON FAIL PART. TDA A0226E1366BM PLEASE INSPECT FOR WARRANTABLE FAILURE. HAVE HUB SHIPPED TO TROY ATTENTION JESSE LAYCOCK*	2
E1843243		09/26/98	03/27/01	04/18/01	263931	2373	1791	982	DIAG: FRONT AXLE BEARING BROKEN/PULLED TIRE, DRUM, BRAKES, HUB COVER, LOCK NUT & WASHER, AND RETAINING NUT HAD TO CUT WASHER DUE TO RACE MELTED TO THE SPINDLE.FOUND HUB MOVING IN ALL DIRECTIONS BEARINGS FAILED CAUSING RIM & TIRE TO RUB SPINDLE AND BURN UP KING PINS, K NUCKLE PINS, BRAKE SHOES, HUB, DRUM, ABS SENSOR, HARNESS AND ABS PLEASE INSPECT FOR WARRANTABLE FAILURE. HAVE HUB SHIPPED TO TROY ATTENTION JESSE LAYCOCK*WHEEL BRG FAILURE - SEIZED & DAMAGED SPINDLE / BRAKES / ABS TIRE & WHEEL INNER BEAD RING DAMAGE	2
E1848243		09/26/98	04/04/01	04/18/01	358756	2315	1747	918	DIAG: FRONT AXLE HUB BEARING BINDS,STICKS CHECK LEFT STEER AXLE, WHEEL FALLING OFF PULLED WHEEL END, DISASSEMBLED, FOUND BEARINGS WERE BURNED UP HUB, SPINDLE, TONE RING, R/ ROD END, WHEEL AND HUB TAPPING NUTS WERE DAMAGED DISASSEMBLED LEFT SPINDLE COMPLETE HAD A DIFFICULT TIME REMOVING KINGALDEN.PLEASE INSPECT AND ADVISE IF THIS WAS A WARRANTABLE FAILURE.SHIP HUB TO TROY ATTENTION JESSE LAYCOCK* PARTS ARE BEING RE-FURNISHED TO TROY	2
E1848238		09/26/98	04/11/01	04/27/01	384438	4275	3510	748	RIGHT WHEEL BEARING FAILURE, CAUSING PIN, DAMAGED [illegible] RIGHT TIE ROD END,COOLANT SHUTOFF VALVE [illegible] LABLE. THESE PARTS ARE LISTED AS MISC CHARGES ALSO/R.A.C#11 LEFT HUB UNIT HUB TO BE RECEIVED ON/PLAY. THE HUBS WERE SENT TO TROY. ATTN BILL PURPURA/ PER TOM BOWMAN FOR ANALYSIS/ TOM ALSO SAYS THAT DRAKIN SHOULD PAY FOR THE CONSEQUENTIAL DAMAGES	2*

FF-881 Hub Failure - Rebecca's Database

CLAIM #	FLEET	IN-SERVICE DATE	FAILED DATE	CLAIM DATE	MILEAGE	AMT PD	MAT'L PD	LABOR / OTHER PD	CUSTOMER COMMENTS	Wheel off = 1; Bearing Burn up = 2; Tractor Fire = 3
E1548202		07/23/99	04/05/01	04/20/01	203919	1852	1447	405	DIAG: FRONT AXLE BEARING BINDS,STICKS,CHECKED AND FOUND THAT THE RIGHT FRONT WHEEL BEA RINGS CAUGHT ON FIRE REMOVED THE WHEEL,HUB,S-CA M,KING PIN,SHOCK,AND DRAG LINK REPLACED WHEEL B EARINGS,HUB,KNUCK ASSY,SHOCK,BRAKES,ABS SENSOR,AND DRUM RECHECKED THE OPREATION ALL OKDSM PLEASE INSPECT AND ADVISE IF THIS IS A WARRANTABLE FAILURE"FLEET ALSO HAD A HUB FAILURE IN FLA. PLEASE ADVISE ROSEY OF FINDINGS ONCE INSPECTION COMPLETE"SYSTEM ERROR DENIED IN ERROR	3*
E1851591		11/12/98	04/09/01	05/09/01	309888	1449	1008	441	DIAG: FRONT AXLE HUB BEARING BINDS,STICKS,LEFT FRONT WHEEL CAUGHT FIRE CHECK/ADVISE WHEEL WONT TURN REMOVED LEFT STEER WHEEL/HUB ASSEMBLY REMOVED BRAKES,AIR CHAMBER,S-CAM HOUSING/ACCESSORIES,DRAG LINK,TIEROD,SPINDLE & KINGPIN REPLACED WHEED SENSOR INSTALLED FRONT SPINDLE,KINGPIN, BRAKES,DRUM,HUB,WHEEL & GREASED ADJUSTED BOTH FRONTAL KING PI/SSM PLEASE INSPECT AND ADVISE IF THIS WAS A WARRANTABLE FAILURE"PARTS BEING RETURNED TO TROY ATTN.: JESSIE LAYCOCK	2*
E1851720		09/27/99	04/19/01	05/07/01	369150	1691	1343	258	DIAG: FRONT AXLE BEARING BROKEN/REPAIR FOR STEER AXLE BEARING CAME APART/HUB BURNED UP-WHEEL BEARINGS CAME APART R & R SPINDLE REINSTALLED HUB AND TORQUED INSTALLED BRK, WHEEL SENSOR, CROSS MEMBER INSTALLED WHEEL AND TIRE/TESTED OKS	2
E1854133		09/17/99	04/09/01	05/14/01	223486	1845	1183	362	DIAG: FRONT AXLE,HUB BEARING BINDS,STICKS,FRONT HUB BURNT UP INSTALL DRIVELINE CUT BURNT UP HUB AND BEARINGS OFF SPIN FOUND SPIN DAMAGED, S-CAM BRACKET AND ABS SENSOR AND HARNESS BURNT UP (NOTE: TIRE CAUGHT FIRE)REPLACED SPINDLE ASSY ALL BRAKE HARDWARE AND LINING HUB ASSY AND DRUM ADJUST/BRAKE SET TOE IN CLEAN FIRE DAMAG WIRE ASSA/DSM PLEASE INSPECT AND ADVISE IF THIS IS A WARRANTABLE FAILURE"SHIP HUB TO TROY ATTENTION JESSIE LAYCOCK/HUB UNIT BRG FAILURE, INTERSTATE TRANS. UNIT RECOVERED BY/FREIGHTLINER CORP.	2*
E-W401589		10/2/98	03/14/01	05/23/01	417189	1278	816	462	OC WHEEL BEARING ON LEFT STEER IS BURNT UP.CS-FOUND RETAINING WASHER HAD SPUN IN THE BEARING FAILURE.SCS-LOCKED INTO SPINDLE.CA-REMOVE INNER BEARING RACES. TIE ROD DRY LINK, SLACK ADJUSTERS,CA-S-CAM & BRAKE SHOES. REMOVE KING PIN WEDGES, WITHINT SPEC.CA-REMOVE SPINDLE ASSY. SWAPPED OVER STEER STOP. SENSORS HOLDER &CA DRAG LINK ADAPTER TO NEW SPINDLE. INSTALL & TRIMMED NEW/CA SPINDLE & KING	2
E-W401589		10/2/98	03/14/01	05/23/01	417189	1278	816	462	OC WHEEL BEARING ON LEFT STEER IS BURNT UP.CS-FOUND RETAINING WASHER HAD SPUN IN THE BEARING FAILURE.SCS-LOCKED INTO SPINDLE.CA-REMOVE INNER BEARING RACES. TIE ROD DRY LINK, SLACK ADJUSTERS,CA-S-CAM & BRAKE SHOES. REMOVE KING PIN WEDGES, WITHINT SPEC.CA-REMOVE SPINDLE ASSY. SWAPPED OVER STEER STOP. SENSORS HOLDER &CA DRAG LINK ADAPTER TO NEW SPINDLE. INSTALL & TRIMMED NEW/CA SPINDLE & KING	2
E-W401583		10/2/98	03/14/01	05/11/01	408419	1381	1108	273	DIAG: FRONT AXLE,HUB BEARING BINDS,STICKS,RT FRONT WHEEL BEARING BURNED TO/MD ON BY MACONE & DRIVELINE STILL ENGAGED CHECKED AND FOUND BEARING AND SPEED AND BURNED UP REMOVED WHEEL AND FOUND HUB SPINDLE BRAKE SHOES DRUM AND SLACK ADJUSTER DAMAGED INSTALLED ALL/USED AXLE/DSM PLEASE HAVE HUB SHIPPED TO TROY ATTENTION DALE SELLOW MILEAGE TIRE FAILURE"HUB BEARING FAILURE REMOVED PARTS AS NECESSARY TAG & BAG COPY & SUBMIT/TRUCK GIVEN TO DEALER TO SHIP HUB	2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	DIAG: FRONT AXLE HUB ASSEMBLY (NON NATIVE) OUTER WHEEL BEARING FAILED HUB BURNT UP RAN SPINDLE. TIE ROD SHAKE CHAMBER,S-CAM,SLACK ADJUSTER,BRAKE SHOES,ABS SENSOR AND HUB CAP	2

SKF 000469

FF-981 Hub Failure - Rebecca's Database

CLAIM #	FLEET	IN-SERVICE DATE	FAILED DATE	CLAIM DATE	MILEAGE	AMT PD	MATL PD	LABR / OTHER PD	CUSTOMER COMMENTS	Wheel off = 1; Bearing Burn up = 2; Tractor Fire = 3
E1570370		10/18/99	05/12/01	07/02/01	230848	1693	1385	418	DMG: FRONT AXLE,HUB BEARING BINDS,STICKS,VEHICLE TOWED IN BY CUSTOMER, FOUND R/STEERING HUB AND SPINDLE DAMAGED BY BEARING FAILURE. IN HUB, NEC TO REPLACE ALL DAMAGED COMPONENTS, EXTRA TIME TO R&I SPINDLE. FIT KINGPIN ASSE MBLY & TRANSFER COMPONENTS, SUBLET MOUNT TIRE ON WHEEL	2
E1574441		02/02/99	03/07/01	07/16/01	573848	1050	931	129	DMG: FRONT AXLE HUB BEARING BINDS,STICKS,REPAIR WHY UNIT HAS SMOKE COMING FROM LH FRONT STEER AXLE FOUND BRG TO HAVE SEIZED CAUSING THE WHEEL TO CATCH FIRE REMOVED AND REPLACED ALL DAMAGED PARTS SUPPLIER CODE FOR EXTENDED WARRANTY #409-600300	2
E1576002		07/09/99	05/30/01	07/23/01	466480	1462	1204	238	DMG: FRONT AXLE HUB BEARING BINDS,STICKS,TOWED IN BY MALONES FRONT PASS SIDE WHEEL BEARING BURNED UP.COMMENTS:INSTALLED NEW SPINDLE,KINGPIN,HUB,BRAKE SHOES,BRAKE SHOE SPRING KIT,AND DRUM, ADJUSTED BRAKES,GREASED SPINDLE AND TIE ROD END,INSTALLED DRIVE LAT PERATIO	2

FF-981 Hub Failure - Category - Hub Off

AXLE MDL	SERIAL #	VIN #	CLAIM #	FLEET	IN-SERVICE DATE	FAILED DATE	Yr In Service	MILEAGE
FF981		2HSFMAXR1VC034789		Monson Trucking	04/14/97	04/01/01	3.96	460,547
FF981		2HSFMAXR4VC034779 #324	CAI09740	Monson Trucking	04/21/97	02/05/00	2.79	337,133
FF981		2HSFMAXR5VC034774 #345		Monson Trucking	05/05/97	03/08/01	3.84	469,550
		1FUYSSZB8WL889451	E1706838	Simmons Trucking	09/15/97	07/01/01	3.79	548,830
FF981	AVF99163077	1FUYNMDB0XL827718	E1487635		12/01/98	08/10/99	0.69	174007
FF981		1FUYDWDB1YLB17923	E1541805	Midwest	05/01/99	03/07/01	1.85	638,238
FF981	AVF99113751	1FUYSDYB5YPA883	R0884648	Interstate	06/29/99			302,048
FF981	AVF99109835	1FUYDDYB0YLB97956		Nordic Express	06/15/99	08/04/01	2.04	335,132
FF981		YJ068865	RO 48480	Dakota Cartage	10/04/99			256,880
FF981		1FUYNEDB2YPG89432	TTFD0001B 187A E1874330	Foss Trucking	01/04/00	04/16/01	1.28	182,369
FF981		1FUYOYB1LH13716	Unit # 824385	Ryder	03/16/00			35,186
FF981	AVF98151314	1M1AA12YX0W099251		MCA				
				Interstate				

FF-001 Hub Failure - Category - Bearing Burn-up													
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SKF 000472

FF-[illegible] Hub Failure - Category - Bearing Burn-up

[illegible]	[illegible]	[illegible]	[illegible]	FLEET	[illegible]	[illegible]	[illegible]	MILEAGE	[illegible]	[illegible]	[illegible]	CUSTOMER COMMENTS	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

SKF 000473

FF-481 Hub Failure - Category - Bearing Burn-up

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SALED DATE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CUSTOMER COMMENTS	[illegible] COMMENTS
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]
		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]
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[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]

SKF 050474

PF-961 Hub Failure - Category - Bearing Burn-up

AXLE NO.	SERIAL #	VIN #	CLASS #	FLEET	IN-SERVICE DATE	FAILED DATE	Yrs in Service	[illegible]	AMT PS	[illegible]	LAST DTSER PS	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	1
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]

FF-681 Hub Failure - Category - Bearing Burn-up													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

- SKF 000478

FF-981 Hub Failure - Category - Bearing Burn-up and Fire

AXLE SEL	SERIAL #	VIN #	CLAIM #	FLEET	IN-SERVICE DATE	FAILED DATE	Yrs. in Service	MILEAGE	AMT PD	MAT'L PD	LABOR / OTHER PD	CUSTOMER COMMENTS
FF981		[illegible]	[illegible]	Prochilne r	[illegible]	11/01/[illegible]	2.13	[illegible]				Hub Assembly Broken
FF981	AVF9P113836	3HSPBAMRMHC000000	CBV[illegible]		11/[illegible]/97	4/[illegible]/01	3.37	[illegible]	4279	3530	749	FRONT WHEEL BEARING FAILURE, CAUSING FIRE. DAMAGED DRUM,WHEEL,TIRE,RIGHT TIE ROD END,COOLANT SHUTOFF VALVE ONENGINE,HEATERHOSE,INNER FENDER SHIELD,WHEEL NUTS,BRAKE HOSE,HOOD CABLE. THESE PARTS ARE LISTED AS MISC CHARGES. AL SOREPLACED LEFT HUB UNIT DUE TO EXCESSIVE ENDPLAY. THE HUBS WERESENT TO TROY . ATTN BILL POLESNIAK PER TOM BOWMAN POR ANALYSIS.TOM ADVISES THAT DIVISION SHOULD PAY FOR THE COLLATERAL DAMAGES.
FF981	AVF9P113836	3HSPBAMRMHC000000	CBV[illegible]		[illegible]	[illegible]	2.36	[illegible]	1193	1200	503	DC-RIGHT WHEEL BEARING CATCHING FIRE,DE-BEARING FAILED, OVERHEATING AND CATCHING ON FIRE,CA-REPLACED HUB AND BEARING ASSY, AND DAMAGED ABS SENSOR,DRUM,CA-BRAKE SHOES, LONG PIN
FF981	AVF981512953	1FUYSEEB00P968949	E1397484		10/13/99	10/20/00	3.83	345732	1465	852	543	DME: FRONT AXLE HUB ASSEMBLY BADE,LETTERS,CHECK RIGHT FRONT WHEEL WAS ON FIRE,CHECKED AND FOUND WHEELING SEIZED TO SPINDLE,THIS LOOKS LIKE CAUSE OF FIRE,NECESSAR Y TO REPLACE SPINDLE HUB AND SHOES AND HARDWARE AND BKS AND ABS SENSORBEARING BURN-UP
FF981	AVF981512953	1FUYSEEB00P968949	E1397484		11/13/00	04/[illegible]/01	2.41	[illegible]	1449	1008	441	DMG: FRONT AXLE HUB BEARING BADE,STICKE,LEFT FRONT WHEEL CAUGHT FIRE CHECKDRIVE WHEEL WONT TURN REMOVED LEFT STEER WHEEL,HUB ASSEMBLY REMOVED BRAKESHAIR CHAMBER,S-CAM HOUSINGACCESSORIES,DRAGLINK,TIEROD,SPINDLE & KINGPIN REPLACED WHEEL SENSOR INSTALLED FRONT SPINDLE,KINGPIN BRAKES,DRUM,HUB WHEEL & GREASED ADJUSTED BOTH FRONTAL KING PIGSN PLEASE INSPECT AND ADVISE IF THIS WAS A WARRANTABLE FAILURE*PARTS BEING RETURNED TO TROY ATTN. JESSE LAYCOCK
FF981	AVF981128538	1FUYEEBB0XLA08178	[illegible]		[illegible]	[illegible]	P 39	33902	1424	1136	288	DMG: AXLE,FRONT BEARING BADE,STICKE,BURNING, KNUCKLE PIN, OWN THE LEFT FRONT HUB LOCKED UP AND CAUGHT ON FIRE DEFECTIVEHUB WE INSPECTED THE DAMAGE AND FOUND THE HUB, BEARINGS,BRAKES, AND DRUM SEVERLY DAMAGED WE DISASSEMBLED THE LEFTFRONT HUB ASSEMBLY AND SPINDLE WE INSTALLED A NEW SPINDLEDRM PLEASE INSPECT FOR WARRANTABLE FAILURE, AND PLEASE PROVIDEBRIEF DESCRIPTION OF FAILURE*FF981 HUB BEARING FAILED AND CAUSED PROGRESSIVE DAMAGE TO THESPINDLE AND WHEEL INSPECTED PARTS 7/28/99BEARING FAILURE
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	D 23	[illegible]	2122	1884	1587	DMG: HUBS,FRONT BEARING BADE STICKE,RIGHT FRONT STEER WHEEL IS LOOSE BEARING BAD CAUGHT FIRE REMOVED TIRE, HUB ASSEMBLY AND SPINDLE INSPECTED S-CAM AND KINGPINS INSTALLED NEW SPINDLE UNIT REPLACED TIE ROD END REPLACED BRAKE SHOES,HUB,DRUM,ETC ADJUSTED BRAKES AND INSTALLED DRAKE INCHANGED BY VEHICLE CO ADJUSTED TOE IN SPLIN BALANCEDSN PLEASE INSPECT FOR WARRANTABLE FAILURE AND PLEASE PROVIDEBRIEF DESCRIPTION OF FAILURE EXTENSIVE DAMAGE & LOW MILEAGE, PLEASE INSPECT PARTS BEING RETURNED TO TROY BEARING FAILURE
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	0.84	[illegible]	648	357	151	DMG: HUBS,FRONT ASSEMBLY BROKENDRIVER SIDE STEER HUB CAUGHT ON FIRE- REMOVED TIRE & DRUM &HUB ALONG WITH BEARINGS & SEAL HUB WAS REPLACED STEER HUB ASSY REMOUNTED DRUM & TIRE- ADJUSTED BOTH STEER AXLE BRAKES TO SPEC INSTALLED DRIVE HUB TEST DROVE UNIT AWAITING INVOICE
FF981	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	1.88	[illegible]	[illegible]	2861	1429	668 DMG: FRONT AXLE BEARING BADE STICKE WHEEL SEAL SEIZED CAUGHT ON FIRE PRIOUR SEAL DAMAGE TO HUB BRAKES DRUM SPINDLE WHEEL NUTS TIRE & HUB CAP BEARING & HUB SEIZED HAD TO CUT APART WITH CUTTING TORCH REP HUB BRAKE DRUMS SPINDLE DRUM NUTS CAP & TIRE BURNT IS PORTONE & TU HAVE MOUNTED BURNT W AXLE FOR FAILURE PLEASE INSPECT AND ADVISE IF THIS WAS A WARRANTABLE FAILURE*BEARING & SEAL CAUSING RELATED PARTS BURNT FAILURE
[illegible]	[illegible]	[illegible]	[illegible]									

SKF 000477

FF-981 Hub Failure - Category - Bearing Burn-up and Fire												
AXLE SO1	SERIAL #	VIN #	CLAIM #	FLEET	IN-SERVICE DATE	FAILED DATE	Yrs in Service	MILEAGE	ABT PD	MAPL PD	LABR / OTHER PD	CUSTOMER COMMENTS
FF981	AVA6g12435	1FUYSDYB7YPA5D458	E1846202		07/21/99	04/05/01	1.70	2889[illegible]	1643	1497	488	DIAG FRONT AXLE BEARING SENSOR,STICKS,CHCKED AND FOUND THAT THE RIGHT FRONT WHEEL SEA RINGS CAUGHT ON FIRE REMOVED THE WHEEL,HUB,S-CA M,HUB PILRI,DOR,AND DRAG LINK REPLACED WHEEL B EARINGS,HUB,ROUGH ASSY,SHOCK,BRAKES,ABS SENSOR ,AND DRUM RECHCKED THE OPERATION ALL ORDER PLEASE INSPECT AND ADVISE IF THIS IS A WARRANTABLE FAILURE*FLEET ALSO HAD A HUB FAILURE IN FLA. PLEASE ADVISE ROBEY OF FINDINGS DADE INSPECTION COMPLETE/SYSTEM ERROR OSNED IN ERROR
FF981	AVA6g12435	1FUYSDYB7YPA5D458	E1846202		08/07/00	04/09/01	1.58	225465	1645	1195	382	DIAG FRONT AXLE,HUB BEARING ABNORMALITIONS,FRONT HUB BURNT UP INSTALL DRIVELINE CUT BURNT UP HUB AND BEARINGS OFF SPIN FOUND SPIN DAMAGED, S-CAM BRACKET AND ABS SENSOR AND HARNESS BURNT UP (NOTE: TIRE CAUGHT FIRE.) REPLACED SPINDLE ASSY ALL BRAKE HARDWARE AND LINING HUB ASSY AND DRUM ADJUST/BRAKE SET TOE IN CLEAN FIRE DAMAGE WIRE ARNADOM PLEASE INSPECT AND ADVISE IF THIS IS A WARRANTABLE FAILURE*SHIP HUB TO TROY ATTENTION JESSIE LAYCOCK/HUB UNIT BRG FAILURE, INTERSTATE TRANS, UNIT RECOVERED BY/FREIGHTLINER CORP.
FF981		1FUYSDZB81LB55362	E1846811		04/28/00	08/24/00	0.07	15[illegible]	1[illegible]	1343	388	DIAG WHEEL,FRONT BEARING SENSOR,STICKS,BURNING, KNUCKLE PIN, CAME FIRE AT RIGHT FRONT WHEEL, TRUCK TOWED TO SHOP. FOUND RIGHTSTEER WHEEL BEARING HAD SEIZED CAUSING FIRE WHICH CAUSED FURTHER PROGRESSIVE DAMAGE. SHIN ACCESS. REPLACE PARTS AS NEED ED. CLEAN UP AREAS OF FIRE CHECK OPE REF FSA#254663BEARING BURN-UP

SKF 009478

FF-081 Hub Failure - Category - Tractor Fire

MILE SEQ.	[illegible]	VOLT	[illegible]	[illegible]	[illegible]	FAILED DATE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]
[illegible]		[illegible]	[illegible]	[illegible]				[illegible]				[illegible]	[illegible]
[illegible]		[illegible]		[illegible]		[illegible]							[illegible]

In Service Data

Year	Wheel Off			Bearing Burn-up		Combined	Bearing burn-up with fire	
	Customer	ARM Lab R	Field Repo	Customer	ARM Lab Report		Customer	Combined
1996					1		1	
1997	1	2		14	4		1	
1998				13	4		3	
1999	3	2		14	10		6	
2000	2			3	2		1	
Unaccl.		1	2	2				
Total	6	5	2	46	21	67	12	79

Mileage data

Miles	Wheel Off	Miles	Bearing burn-up		Bearing burn-up with fire	
< 50K	1	< 50K	11		3	
150 - 200K	2	50 - 100K	1		1	
250 - 300K	1	100 - 150K	5			
300 - 350K	4	150 - 200K	3			
450 - 500K	2	200 - 250K	8		3	
600 - 650K	1	250 - 300K	4		2	
Unaccl.	2	300 - 350K	10			
	13	350 - 400K	7		1	
		400 - 450K	7			
		450 - 500K	7			
		500 - 550K	1			
		550 - 600K			1	
		600 - 650K	1		1	
		650 - 700K	2			
		Total	67		12	

Years In Service In data

	Wheel Off		Bearing burn-up		Bearing burn-up with fire		
< 1 Year	1		16		4		20
1 - 2 Yrs	2		22		3		25
2 - 3 Yrs	2		19		4		23
3 - 4 Yrs	3		6		1		7
4 - 5 Yrs	0		1				1
Unaccl.	5		3				3
Total	13		67		12		79

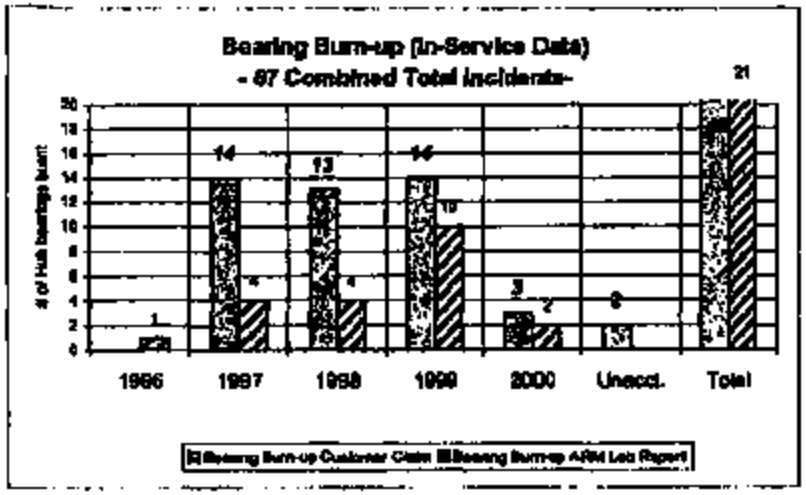
Volume of Product Sold FF-98X series

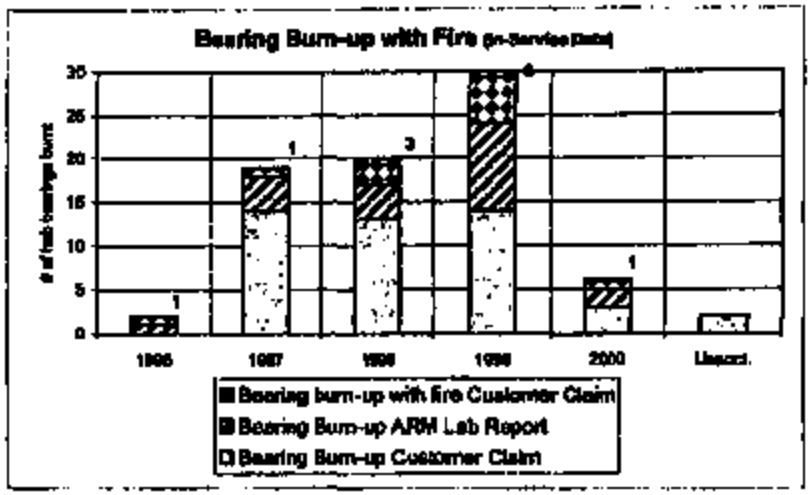
Year	Volume
1996	3743
1997	17551
1998	39019

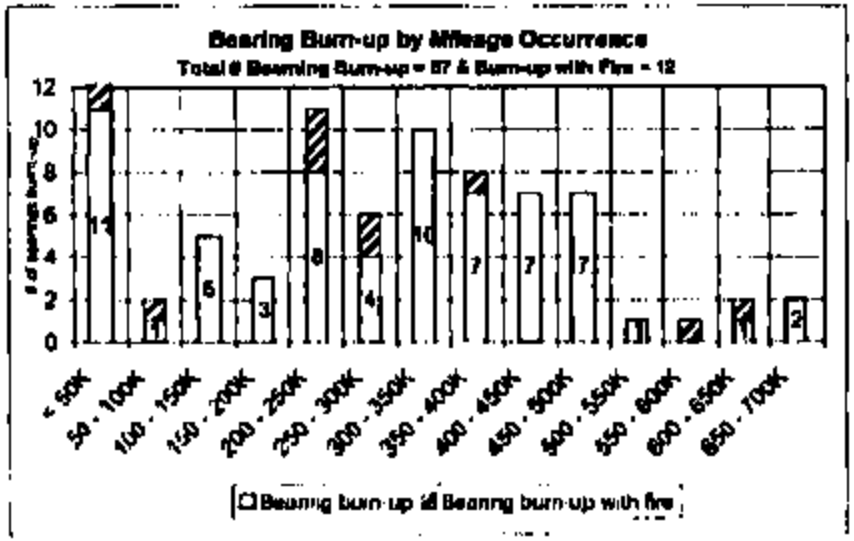
1999	58072
2000	42607
2001	17500

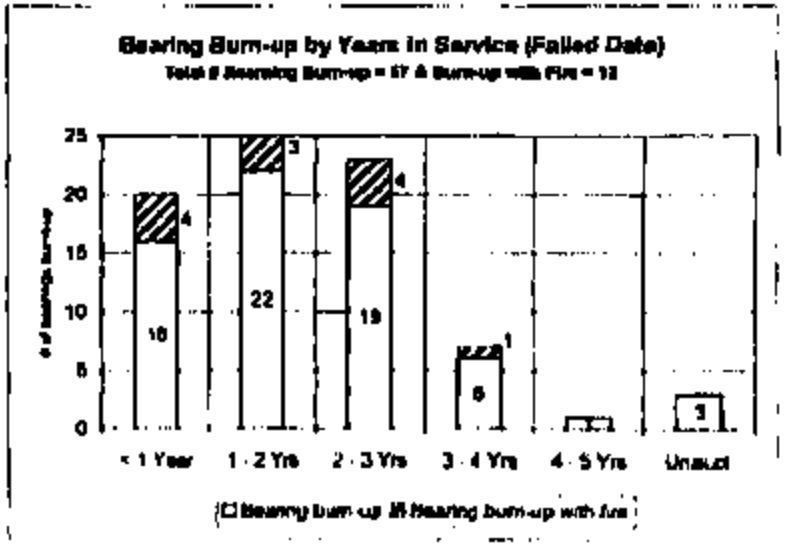
Total

FF - 981 Hub Failure Analysis









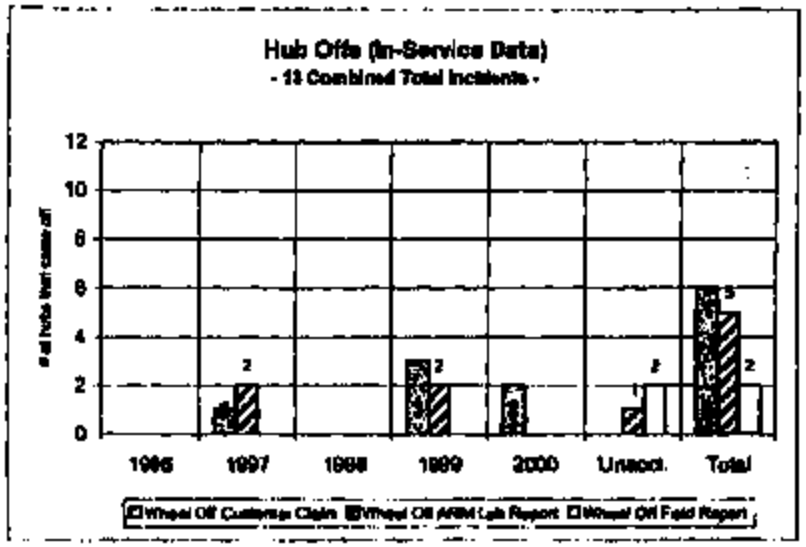
Notes: 1) Customer Claims data were those that were obtained from Rebecca Goodemont's database. Bearing fires are as stated by the customers and are not verified. A number of causes may exist including fires resulting from fires, brake shoes etc.

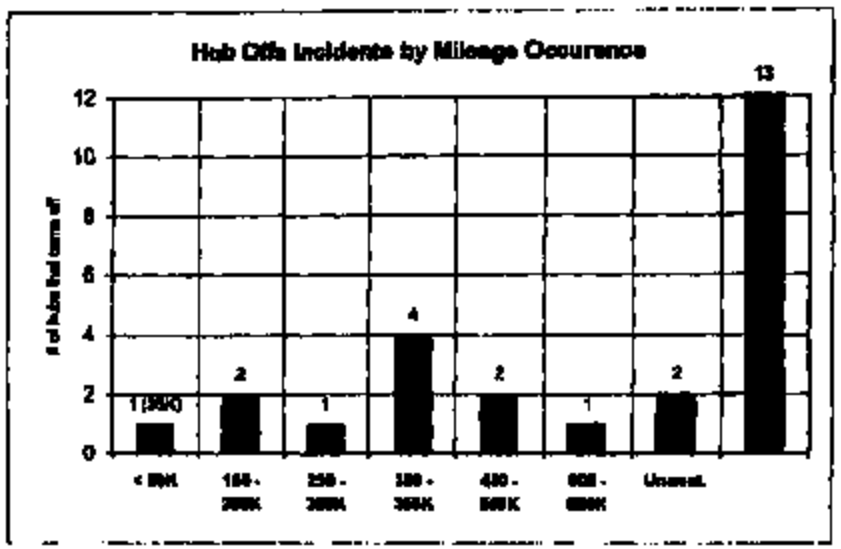
2) Amendment Lab Reports were compiled by [illegible] [illegible] information as presented in the lab report for customer returns.

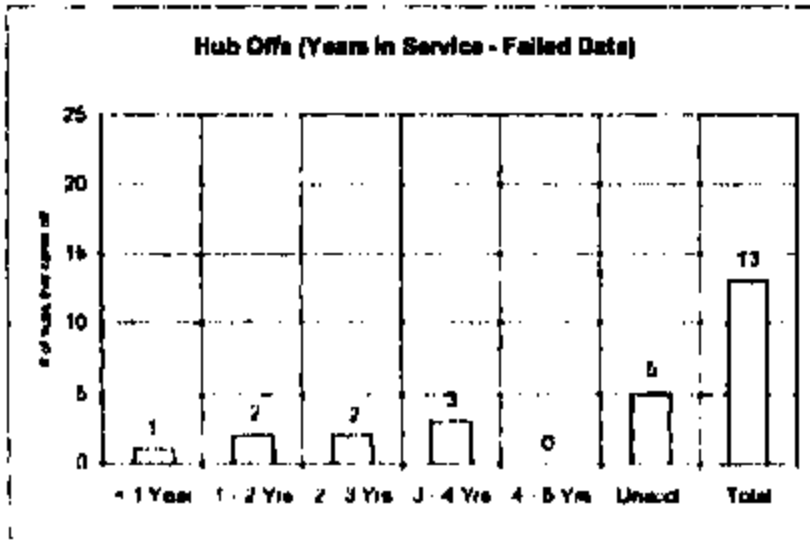
Updated 01/10/02
[illegible]

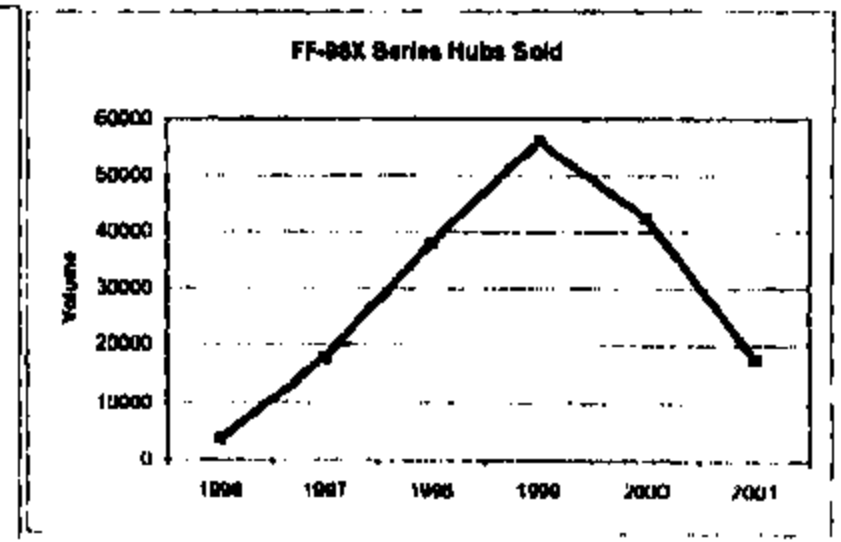
SKF 000483

FF - 981 Hub Failure Analysis









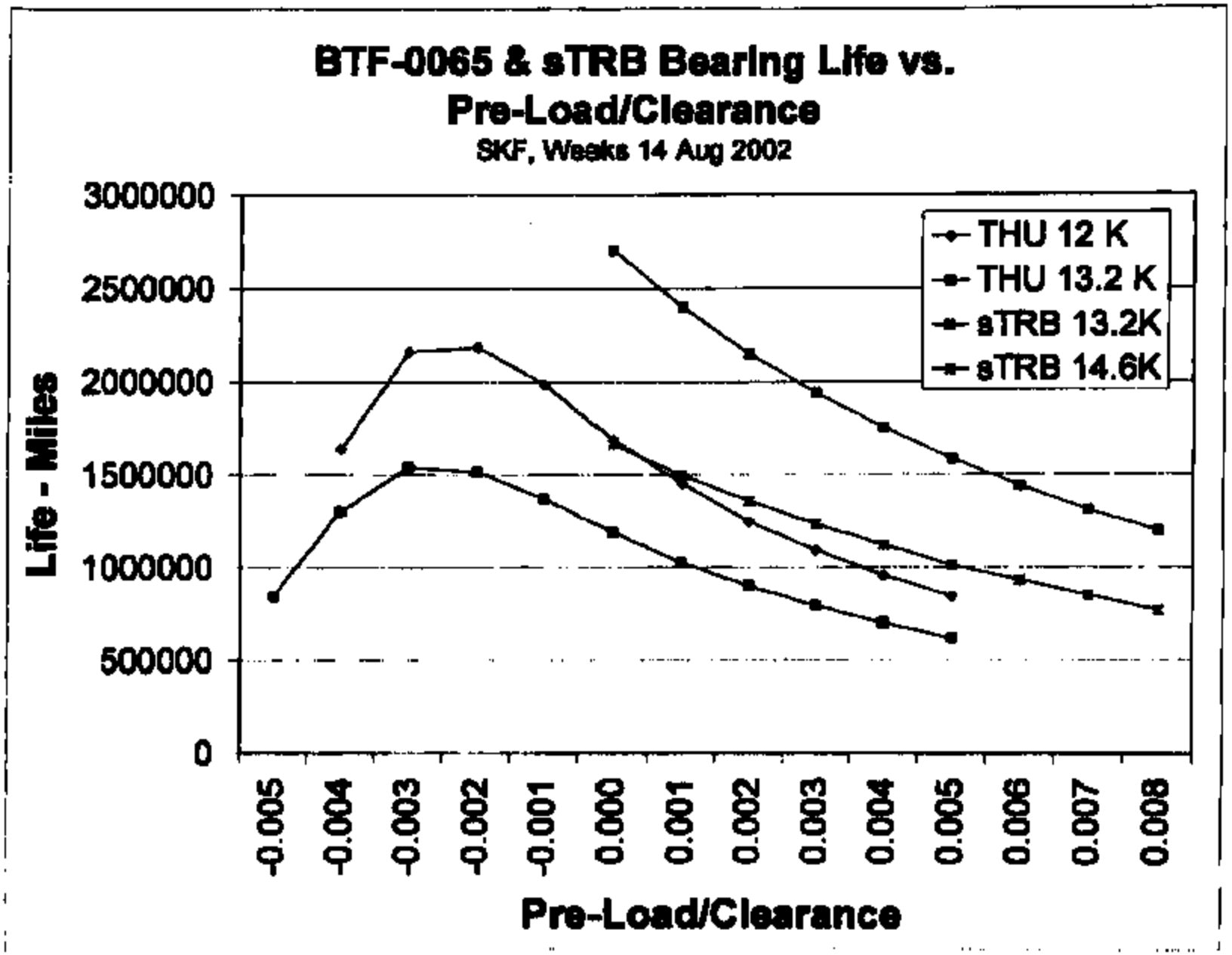
Notes: 1) Customer Claims data were those that were obtained from Webasco Development's database
2) ARM Marine Lab Reports were compiled by R.F. Polesnak. The data contains information as documented in the lab report for customer returns

Updated: 01/10/03
Mike Andrusyszyn

SKF 000484

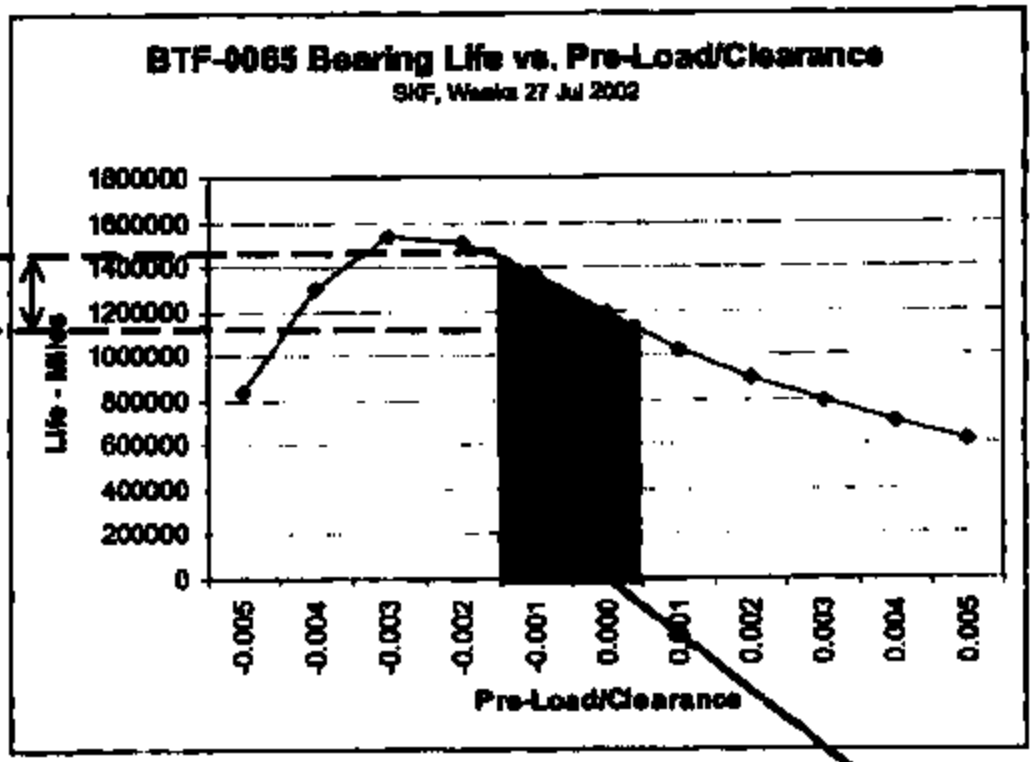
Steer RW L2 Calculation

SKF 000485


BTF-0065 & sTRB Bearing Life vs.
Pre-Load/Clearance
SKF, Weeks 14 Aug 2002
Life - Miles
3000000
2500000
2000000
1500000
1000000
500000
0
THU 12 K
THU 13.2 K
sTRB 13.2K
sTRB 14.6K
-0.005
-0.004
-0.003
-0.002
-0.001
0.000
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
Pre-Load/Clearance

SKF 000664

ArvinMeritor



Life Range B-10

The above is for 13,200 lb axle
For 12,000 lb axle life increases by approx 1.5

Factory Settings

August 1, 2002

SKF 8

SKF 000665

WATER NEEDS / ISSUES 2002

SKF 000789

ARM Water Issue 25 Jul 02

Dale Bell JP Pan Bruce Weeks
Dave Donnegan Bruce McGlone Bob Bondy
Tom Sanko Mel Parker Mike Lewis
Dave Dessecker Kim Lang

Ryder BS Nr. 186/02
intergranular - could be an inclusion? How many cracks?

e-mail ~~Dave Donnegan~~ report Nr. 186/02
& Bruce McGlone

considerable oil separation
- Why is there no black staining?
- Explain what would be seen from lubricant breakdown w/o water -

X-Ray diffraction arrange to converse Dave D to Aiden -

Grease - "Myrtis" from ARM has done some water in grease canal
at what % point does "emulsification" begin to show?
at what % does SKF indicate is "bad"?
what % is in grease as installed?
Have Grease analyst talk to Bruce McGlone
More lightly loaded outboard row - why more damage?

RQ - used GW-Z? Should have been calithia
can we get calithia & repeat?

SKF 000790

P2
25 Jul 02

Wab cap
1.0 bar - 14.5 psi
JP to check w/ Loctite - Bruce McGlone

~180 Power wash o/s Threads - Mel
360 psi
405
315 evaluate O-ring also
585
1845 new design was powerwashed @1000psi

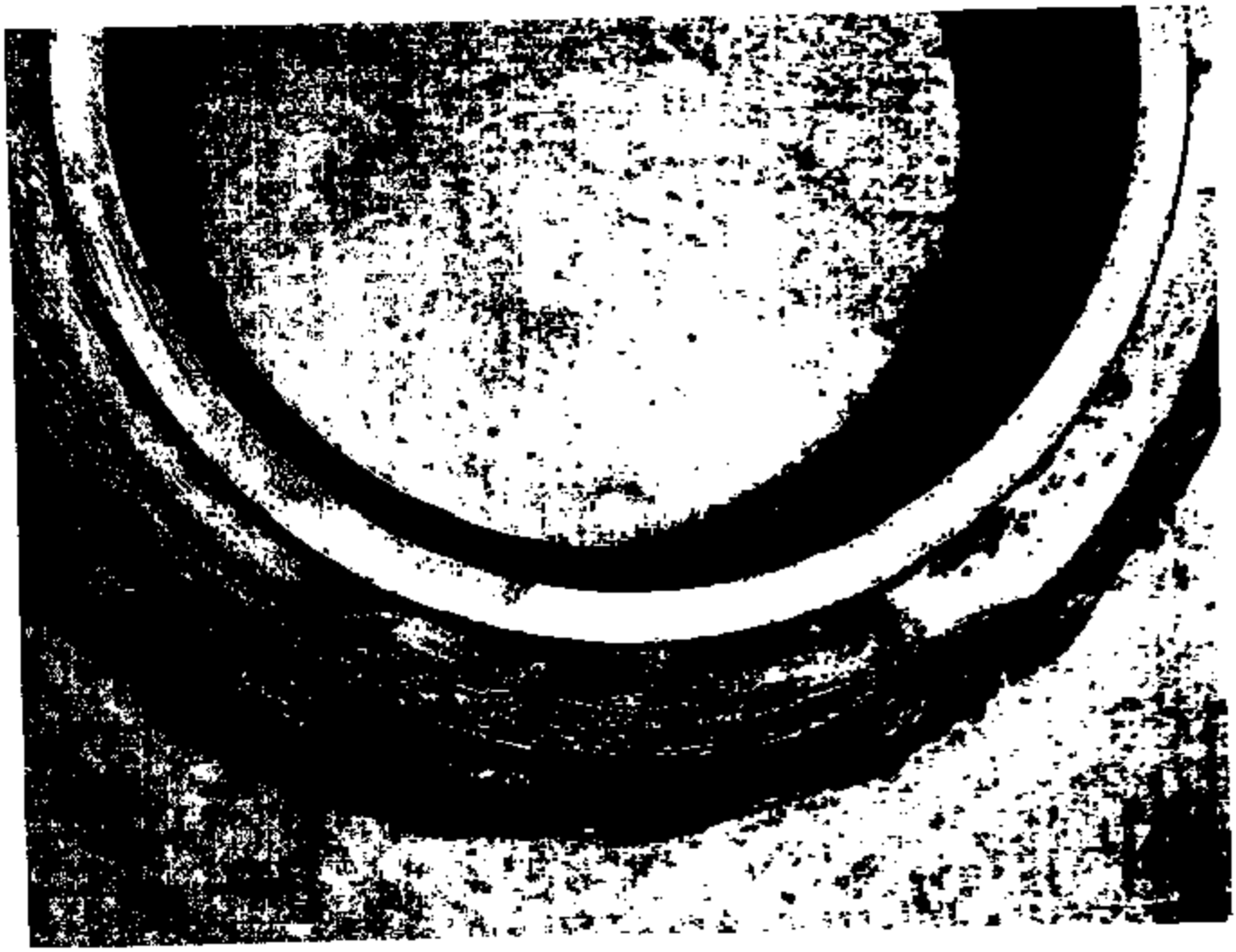
Sauer - get picture of set up & cross section

Seal Anchorage - Bore ovality
seal ovality
Bore tile thickness control
STBM

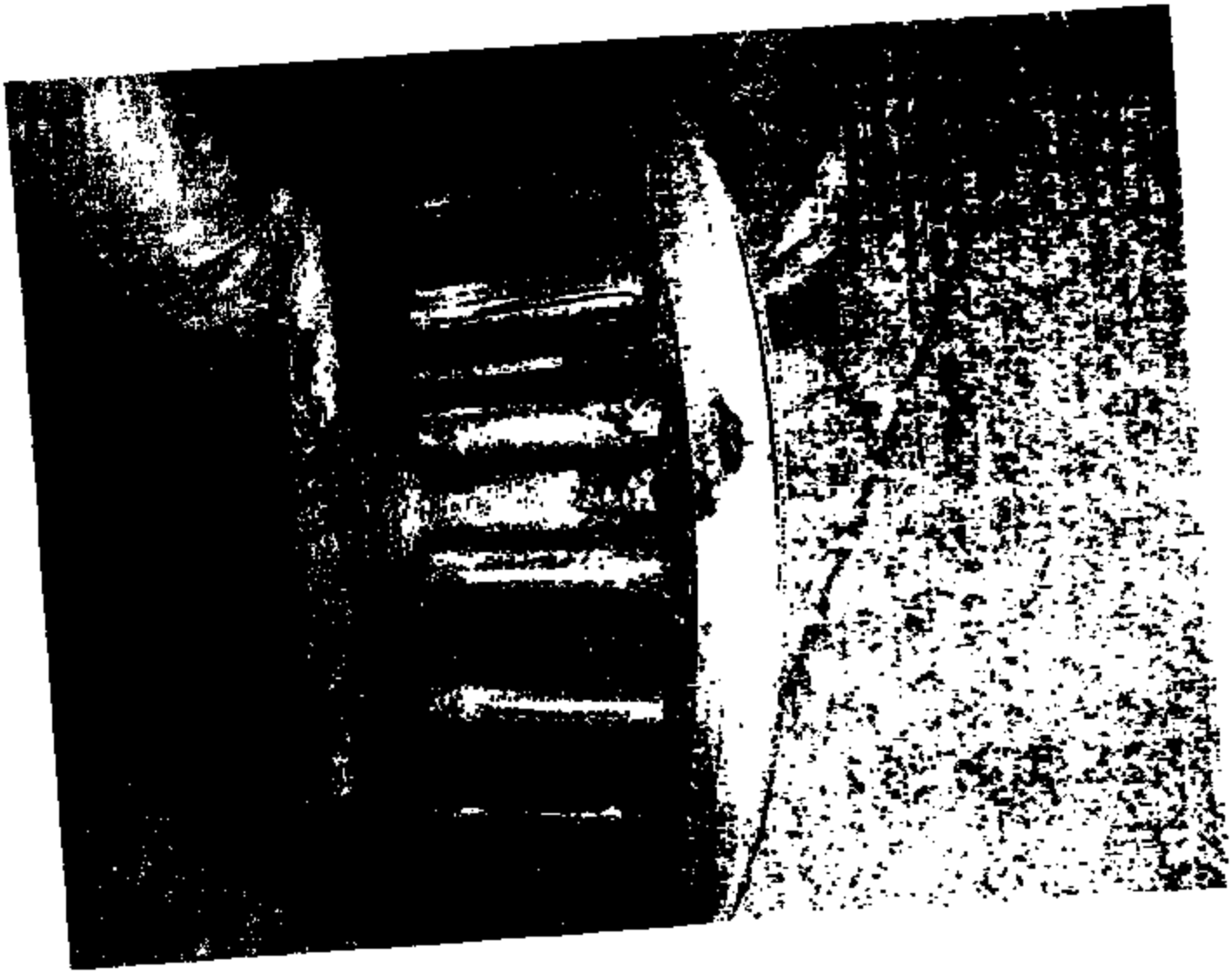
FED - DRM does not include TWU -

OB.R Corrosion

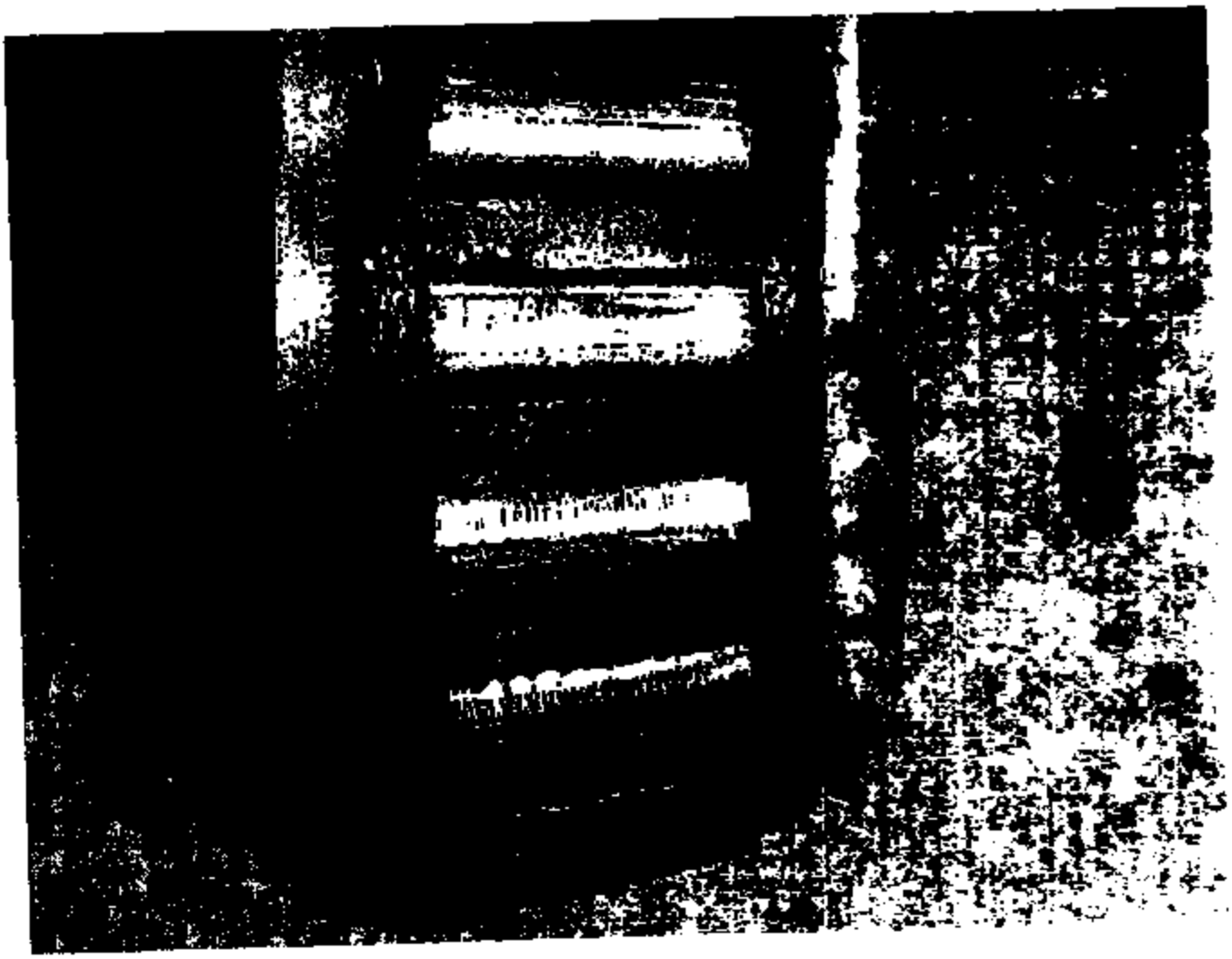
OB1R Surface Corrosion



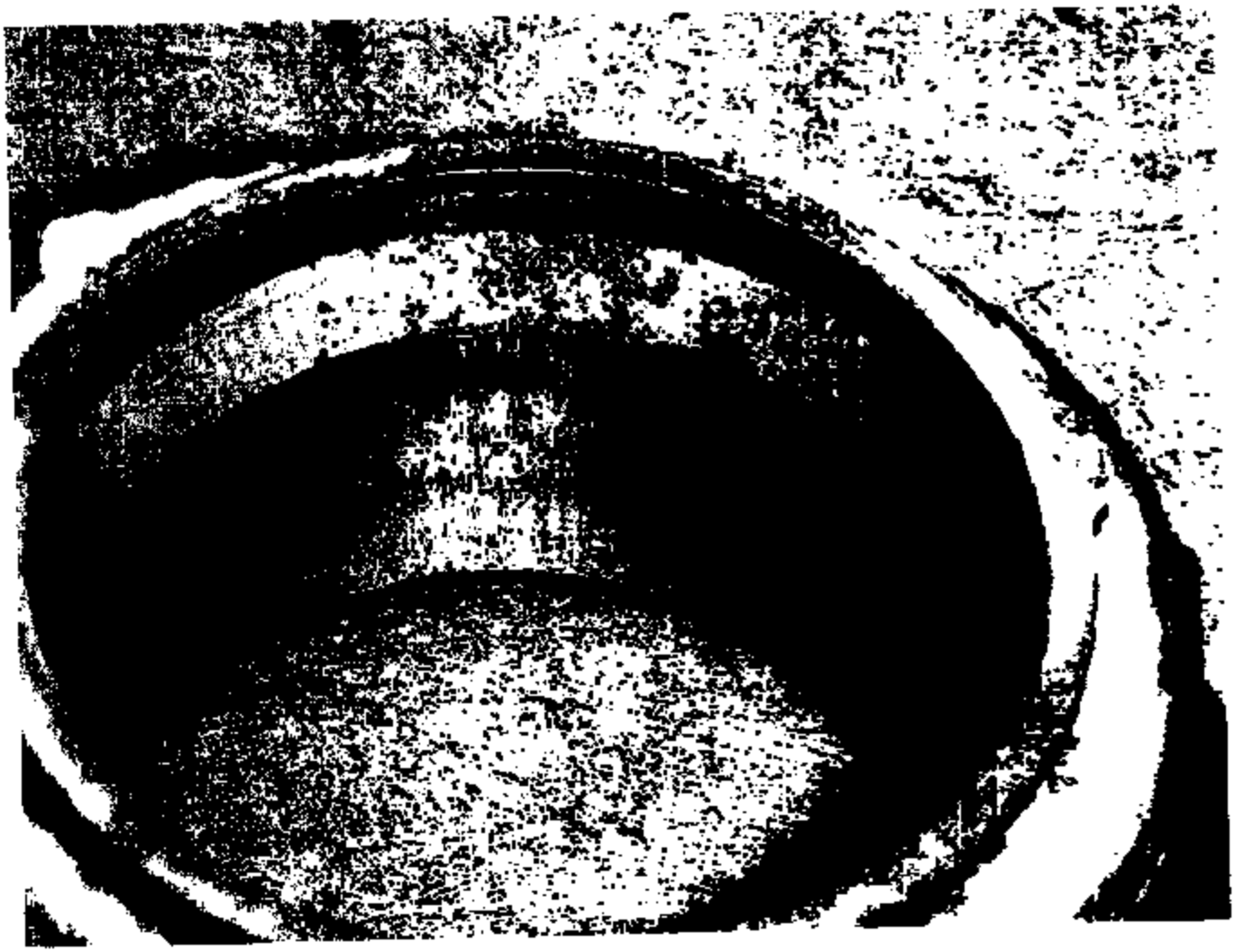
1B IR Corrosion



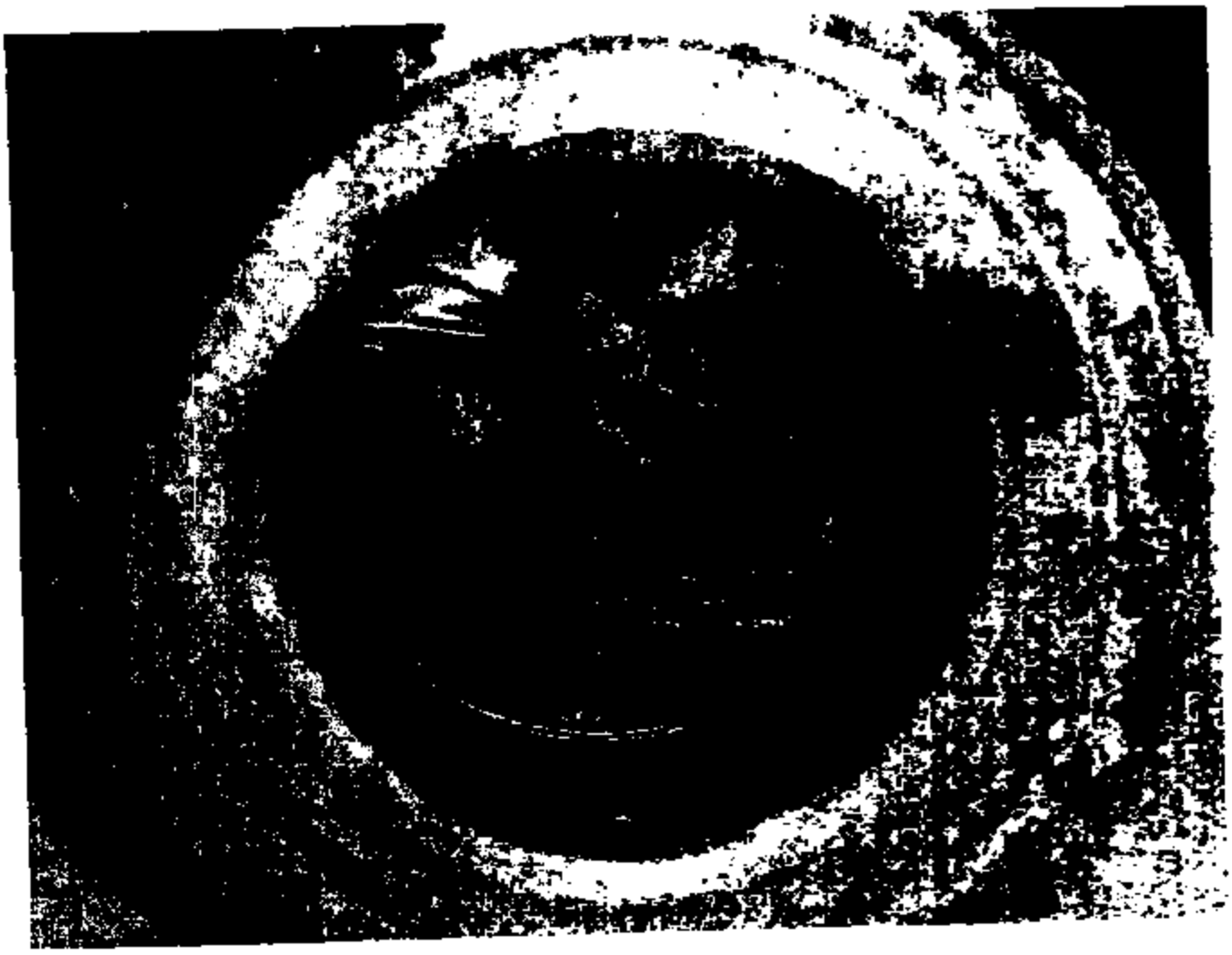
OB IR Condition



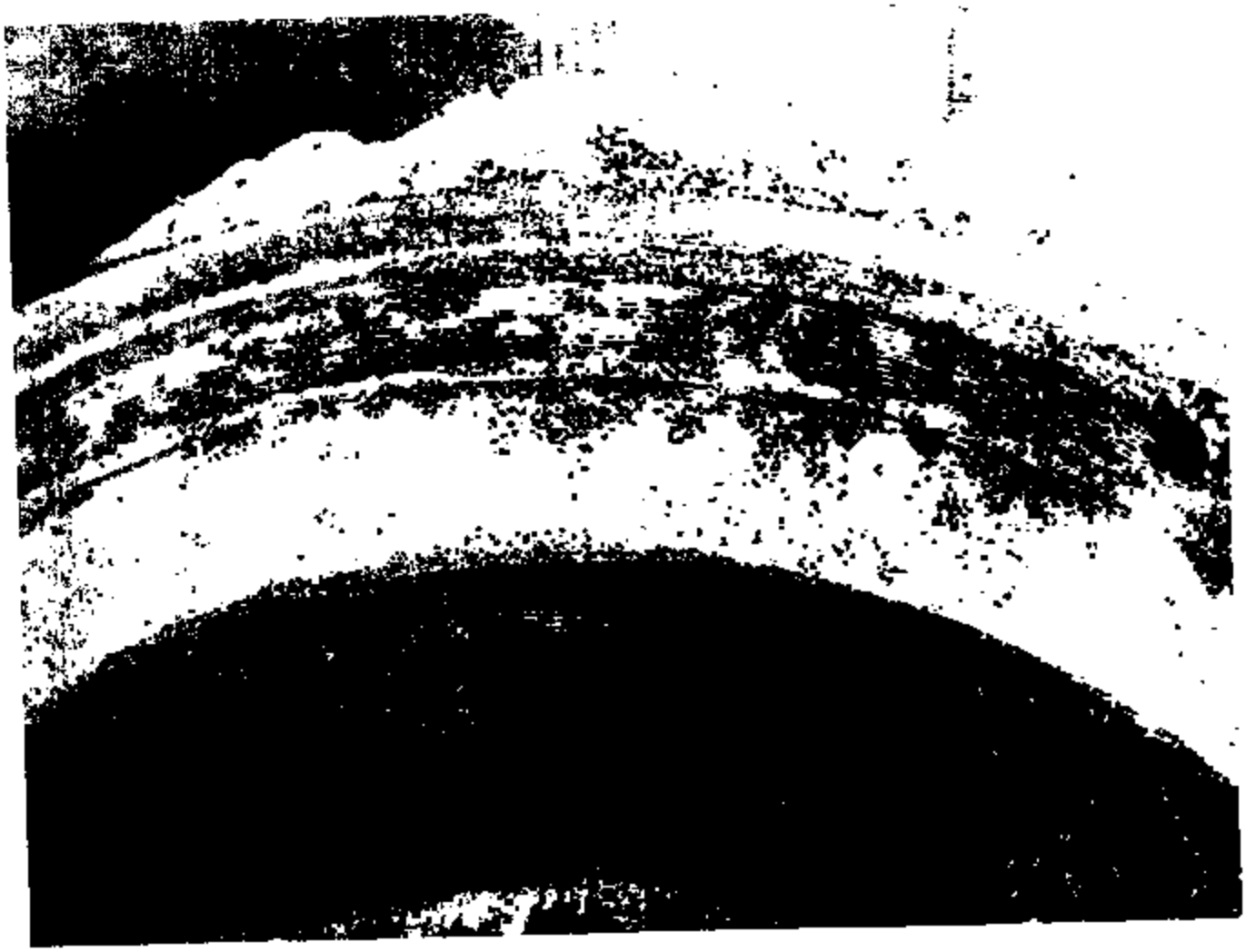
IR Bore Corrosion



1B1R Large Side Face Corrosion



Clip Ring Corrosion



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Report Supplement

Supplementary Information for Interim Report NL02MT903e

2002-07-31

ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis

Aidan Kerrigan

Materials Theory & Testing

SKF 000799

EXTERNAL CUSTOMER
Report Supplement on Project No. N02 184

Supplementary Information on:

NL02MT903a
2002-07-31

ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis

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Key Words	University of Surrey, x-ray photoelectron spectroscopy, iron oxide, corrosion, aqueous, humid

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SKF 000800

ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis

Abstract The inner ring of a THU from the field was supplied to the University of Surrey, UK. for analysis using x-ray photoelectron spectroscopy. The objective was to determine the chemical species of various areas of the bore, which were different in appearance.

Project background

There have been incidents with THUs in the field in the USA. Examples of THUs from the field were supplied to ERC for investigation. One specific question was regarding the corrosion products seen on the bore of the inner rings. In the bore, at the highest loaded position (nominated as 0°), there was a darkened red area, which would normally be classed as fretting corrosion. However, there was also a light red area at the 180° position, which was regarded as unusual. In general, the chamfer was not discoloured but there was a free-standing red area on the chamfer i.e. in a non-contacting location.

In order to classify these products, an inner ring was supplied to the University of Surrey, UK. for analysis using x-ray photoelectron spectroscopy (XPS). This technique is used to determine the chemical species by measurement of the chemical bonding energies.

It is important to state that the University of Surrey were not given any information other than that the part supplied was a taper roller bearing inner ring and given clear instructions of the item to analyse. No manufacturing, application or customer information was given. As a result, the investigation and report from the University (incorporated into this report in its entirety) covers more than just the oxide species.

Objectives

To determine the chemical species present in the bore of a THU inner ring returned from the field.

Main results

According to the results and interpretation from the University of Surrey, the products in the bore of the THU inner ring at the 0° and 180° positions were an Fe(III) compound, most probably FeOOH, which were formed in a humid environment i.e. in the presence of water.

It should be noted that at the 0° position, the finish machining marks were not apparent but that at 180°, the finish machining marks were still visible.

On the (non-contacting) chamfer, the non-discoloured surface had an Fe_2O_3 type of deposit. This was stated to have been formed in a dry environment, at a 'slightly elevated' temperature, probably during heat treatment.

The free-standing red area on the chamfer was analysed and also found to be an Fe_2O_3 type of deposit, again formed in a dry environment.

The remarks about carbon for the areas on the chamfer are possibly explained by the fact that the general surface will have an oxide which formed during austenitising and was then oil quenched, picking up carbon. The other area may have formed after the quenching treatment, giving a lower carbon content. Note that this is very speculative.

The results at the 0° and 180° positions in the bore, as compared to the results from the chamfer, indicate that the technique can differentiate between different oxide species.

Main conclusions and recommendations

The products in the bore of the THU inner ring at the 0° and 180° positions were an Fe(III) compound, most probably FeOOH, which were formed in a humid environment i.e. in the presence of water.

Additional comments

For clarity, the codes used by the University of Surrey will be explained here in relation to the ERC description of the products in the bore.

	ERC	University
0° in bore :	Darkened red area	SKF 01
180° in bore :	Light red area	SKF 02
Chamfer :	Free-standing red area	SKF 03
Chamfer :	Non-discoloured area	SKF 04

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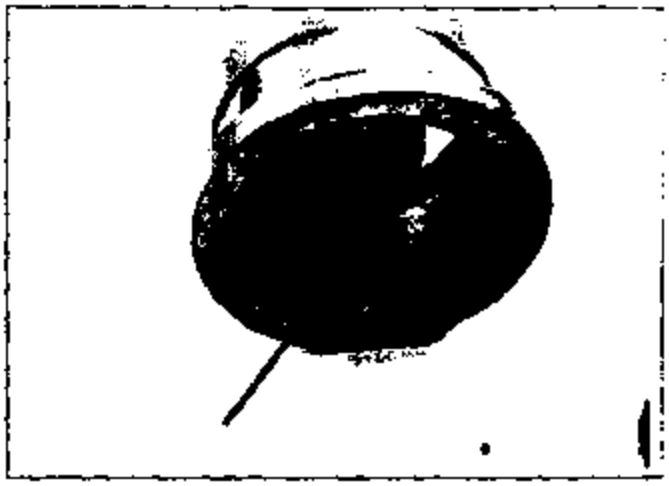
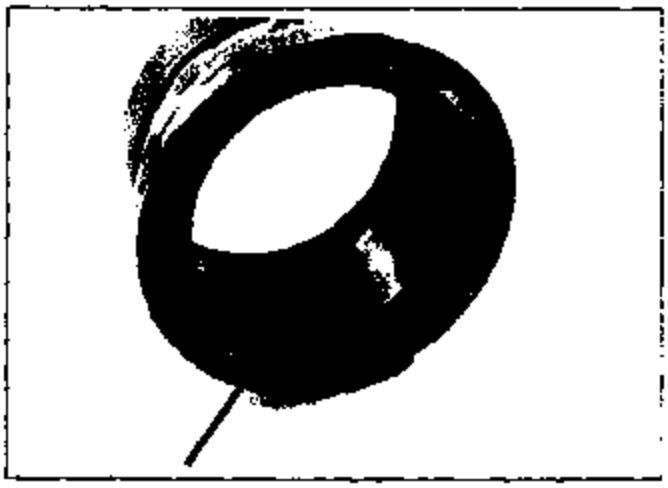
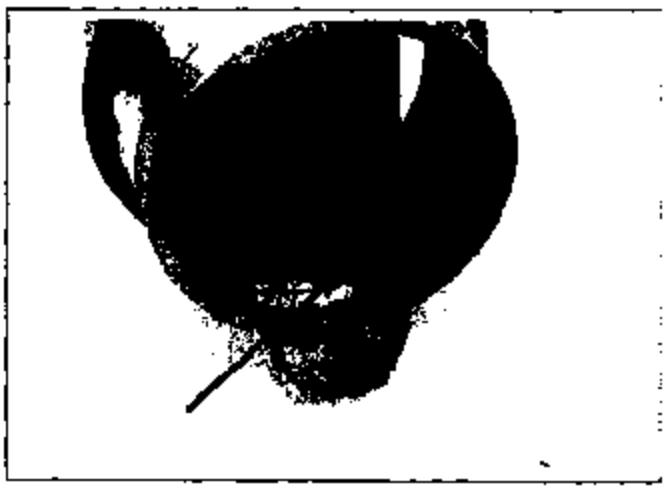
Photographs supplied to the University of Surrey



Darkened red area on bore (0°)



Light red area on bore (180°)



Free-standing red area on chamfer

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UniS

XPS Analysis of Discolouration on Bearing Inner Ring #11

J F Watts & S J Greaves

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July 2002

Prepared for:
SKF Engineering & Research Centre BV

Commercial in Confidence

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XPS Analysis of Discolouration on Bearing Inner Ring #11

J F Watts, S J Greaves

Executive Summary

Surface chemical analysis of "Bearing Inner Ring #11" was carried out by X-ray photoelectron spectroscopy (XPS). XPS is a surface chemical analytical technique with an analysis depth of approximately 5 nm. Samples were cut from the bore and the chamfer of "Bearing Inner Ring #11", these were identified (by the customer) as darkened red area in bore (SKF01), light red area in bore (SKF02), free-standing red area on chamfer (SKF03). In addition an analysis from an unblemished region of the chamfer (SKF04) was also required.

Analyses from specimens within the bore indicate both the darkened red and the light red discolouration (SKF's descriptions) to arise from an Fe(III) compound, most probably FeOOH, which has been formed in a humid environment.

Both analyses indicate significant surface concentrations of surface carbon contamination which is predominantly hydrocarbon in nature with the presence of some C=O organic functionalities.

The analyses from the chamfer are both of an Fe_2O_3 type of deposit. The one identified as a free-standing red area on the chamfer is a voluminous (high surface area) form whilst that from the unblemished region of the chamfer is a thin passive film of the same composition probably resulting from a heat treatment procedure at some point in the ring's thermal history.

Minor elements (Ca, Na, F, K and N) are detected in low concentrations at all analysis positions but it is not possible to relate these, either qualitatively or quantitatively, to the performance of the bearing ring in service on the information supplied.

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SKF 000804

XPS Analysis of Discolouration on Bearing Inner Ring

J F Watts, S J Greaves

Preamble

A bearing shell identified as "Inner Bearing Ring #11" was supplied complete by the customer along with a series of digital photographs that identified regions of concern regarding the physical appearance on both the bore of the bearing and the region identified as the chamfer. The descriptions of these regions of discolouration, and those that are used in the following reports are as follows.

Darkened red area in bore
Light red area in bore
Free-standing red area on chamfer

In addition we were also instructed to carry out analysis on a region of the "chamfer" that was not discoloured, this is identified as:

Non-discoloured area on chamfer

In the attached spectra these analysis zones are given the following codes:

SKF01
SKF02
SKF03
SKF04

The bearing shell was sectioned in University of Surrey workshops to provide relatively large pieces of the bearing ring for analysis, with the regions of interest identified in the customers photographs. Large specimens were used in order to avoid thermal effects that will be present near the machined surfaces, no cutting fluid was used to avoid the possibility of the modification of the surface chemistry of the regions of interest by the use of such reagents. A series of views of the sectioned bearing ring is shown in Figure 1.

XPS Analysis

The sectioned specimens were mounted for analysis on the platen of our Thermo VG Scientific Sigma Probe spectrometer. Analysis was carried out using AlKα radiation, and a survey spectrum over the region 0 – 1340 eV (binding energy) was first recorded from each region at a channel width of 0.4 eV. High resolution spectra were recorded on the basis of the elements identified in the survey spectrum. These were typically C1s, O1s, N1s, F1s, Ca2p, Fe2p, Na1s, depending on the specimen. All survey spectra and high resolution spectra acquired are appended to this report. The binding energies of the principal photoelectron core levels observed are listed in Table 1.

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Carbon 1s Data

The concentrations of carbon observed on these specimens are, in three cases, at a level to be expected from samples that have been exposed to the ambient environment in a relatively uncontrolled manner, with perhaps the presence of residual carbonaceous material from previous processes. In the case of the spectra recorded from the free-standing red area on the chamfer (SKF03) this value is much lower at 15 at %. This is unusual and provides significant clues to the form of the visually identified deposit, it is of a high surface area type and has formed within a relatively recent timescale, as it has not been contaminated in the manner the other regions have experienced.

Minor Elements

Small surface concentrations of Ca, Na, F, K and N are detected on all specimens. Ca is often associated with tap water and is slightly higher on analyses recorded from the bore than the chamfer regions. F is significantly higher on analyses from the bore than the chamfer and it is not possible at this stage to speculate on the source of this element. Na is a common contaminant from physiological media and does not vary significantly between the different specimens. Likewise the N levels seem fairly consistent from one to another. K is significantly higher on the specimen SKF03 and thus most likely indicates it is intimately associated with the corrosion product. In other samples the higher surface concentration of carbon attenuating the K2p signal.

Chemical State Information

Although most of the high resolution spectra contain little information of spectroscopic significance the Fe2p, O1s and C1s spectra are particularly informative.

Iron 2p Spectra

The 2p region recorded shows both the Fe2p3/2 and Fe2p1/2 components resulting from the spin orbit splitting of the Fe2p electrons. The binding energy is consistent with the Fe(III) state and this is confirmed by the presence of Fe2p3/2 satellite structure on the higher binding energy side of the valley between the Fe2p3/2 and Fe2p1/2. Thus the outer regions of the deposit (at the depth analysed by XPS, ca. 8 nm) is Fe(III) state in all cases. Fe(III) is the equilibrium phase likely to be formed in an excess of corrodent (oxygen or water), in a reduced partial pressure of oxygen Fe(II) is more likely to form.

Oxygen 1s Spectra

In the case of spectra SKF01 and SKF02, the O1s spectra [figures 8 and 16] have two well defined components at approximately 530 and 533 eV. Such observations are consistent with oxide and hydroxide components, indicating that the terminal phase is most probably FeOOH. This is the reaction product associated with the corrosion of iron in an aqueous (damp) environment. Indeed the exposure of pure iron to water vapour in clean, UHV conditions gives rise to a thin film this compound as does the exposure of mild steel to the ambient environment for short times of a few days.

The other spectra, SKF03 and SKF04 have an altogether different form of O1s line [figures 24 and 32]. In these cases the oxide component at 530 eV is dominant and the hydroxide contribution is merely observed as a broadening on the higher binding energy side. This is consistent with an oxide formed in a dry environment, possible at a slightly elevated temperature. The Fe2p and O1s data taken together indicate that the non-discoloured region (Specimen SKF04) is probably a thin (passive) film of Fe_2O_3 formed during the production process. The corrosion product (SKF03) is of similar chemical composition (Fe_2O_3) but of a more voluminous physical form.

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Carbon 1s Spectra

In all cases the spectrum is centred at a binding energy of ca. 285 eV as expected. This is the position typical of adventitious carbon and for charge referencing purposes this can be set to exactly 285.0 eV if required. All spectra have a higher binding energy component centred at approximately 288 eV which is attributed to carbon bonded to oxygen in the form C=O. In the case of the low carbon concentration (SKF03) this is associated with polar carbon adsorbed from the atmosphere but in the case of higher carbon concentrations such those observed on specimens SKF01, 02, 04, such polar contributions would be swamped by the apolar carbon. This leads to the conclusion that the source of carbon on these samples is something other than the usual adventitious material, i.e. a specific source which includes a carbonyl functionality.

Conclusions

The analysis by XPS of four regions of "Inner Bearing Ring #11" enable the following conclusions to be drawn:

- The characteristics of the analyses taken from the two regions within the bore ("darkened red area" and "light red area") are very similar.
- These two analyses (SKF01 and 02) show iron in the Fe(III) state and equivalent contributions of oxide and hydroxide which would arise from the formation of a FeOOH phase in a damp environment:

$$Fe + H_2O \rightarrow FeOOH$$

- $Fe_2O_3.2H_2O$ would have a dominant oxide component of the O1s spectrum but cannot be completely ruled out.
- The surface concentration of F is significantly higher for the SKF01 and 02 specimens than for SKF03 and 04.
- Analyses taken from the chamfer region (SKF03 and SKF04) both yield O1s spectra dominated by an oxide component, consistent with the corrosion product (SK03) and passive film (SK04) having formed in a dry environment, possible at elevated temperature.
- The corrosion product on the chamfer (SKF03) is of a high surface area and has not been exposed to gross hydrocarbon contamination (e.g. oil) since its formation.
- The surface concentration of potassium is higher in analyses taken from the chamfer than the bore.

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SKF Comment - by Aidan Kerrigan

The first and second conclusions in the report from the University of Surrey state that the species in the two positions of the bore of the inner ring (at 0° and 180°) have similar characteristics and match those that would be expected from the formation of FeOOH in a damp environment.

The third conclusion, which states '$Fe_2O_3.2H_2O$ would have a dominant oxide component of the O1s spectrum but cannot be completely ruled out', has been stated by the University of Surrey as there is a small possibility that the oxide is $Fe_2O_3.2H_2O$ rather than FeOOH. However, as is implied by the formula, $Fe_2O_3.2H_2O$ is also formed in a damp environment. Therefore, the main conclusion remains that the oxide species found in the two positions in the bore were formed in a damp environment.

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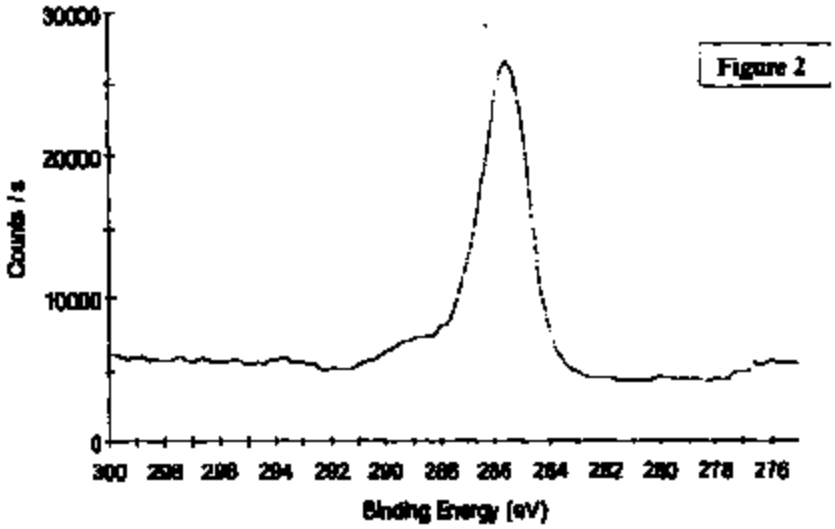
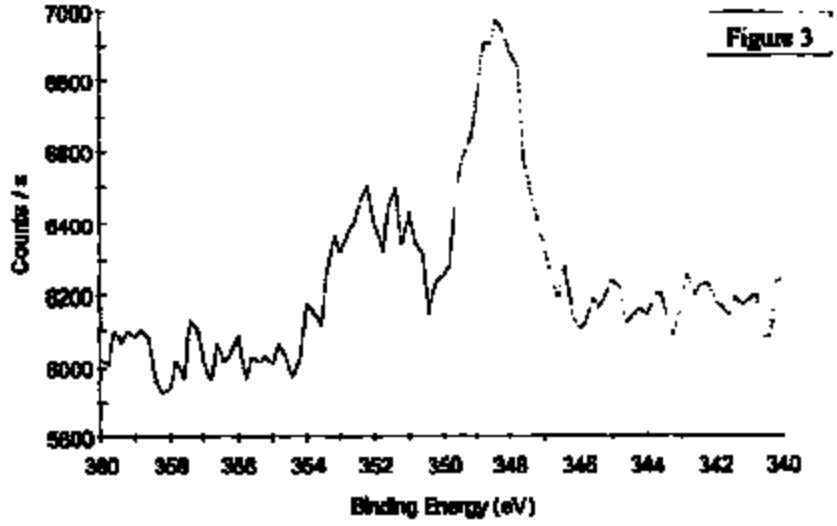
SKF01 Darkened red area in bore

C1s



Co2p



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F1s

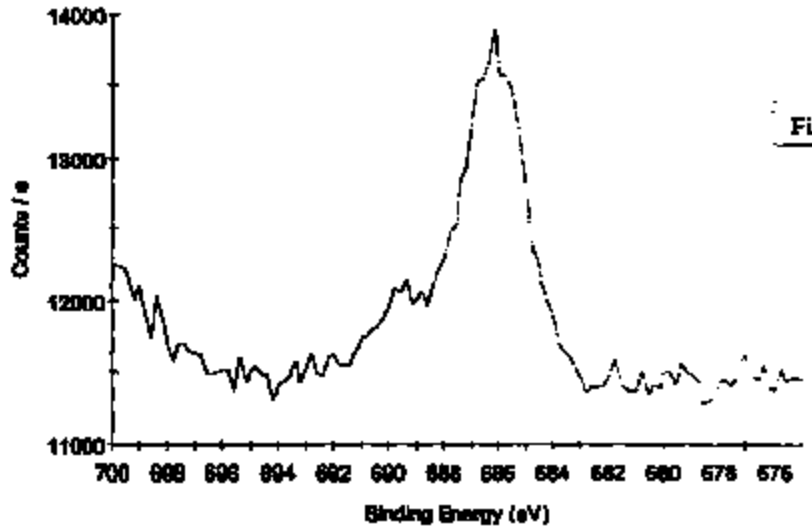

Figure 4

Fe2p

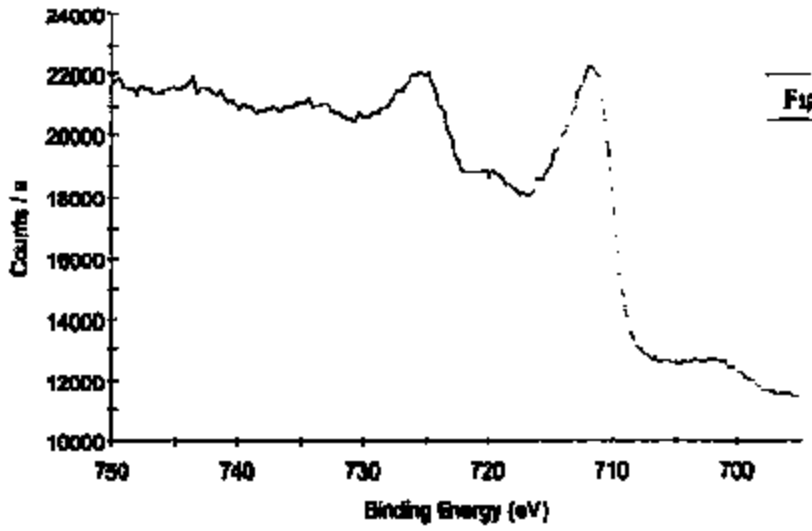

Figure 5

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N1s

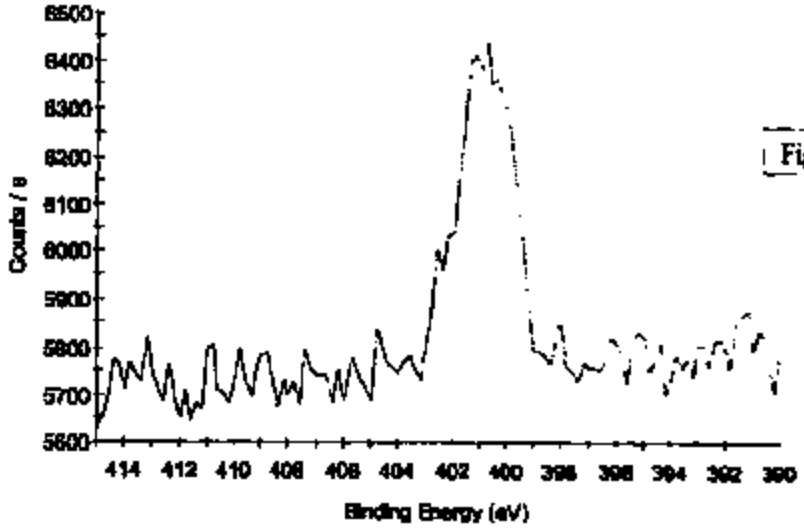

Figure 6

Na1s

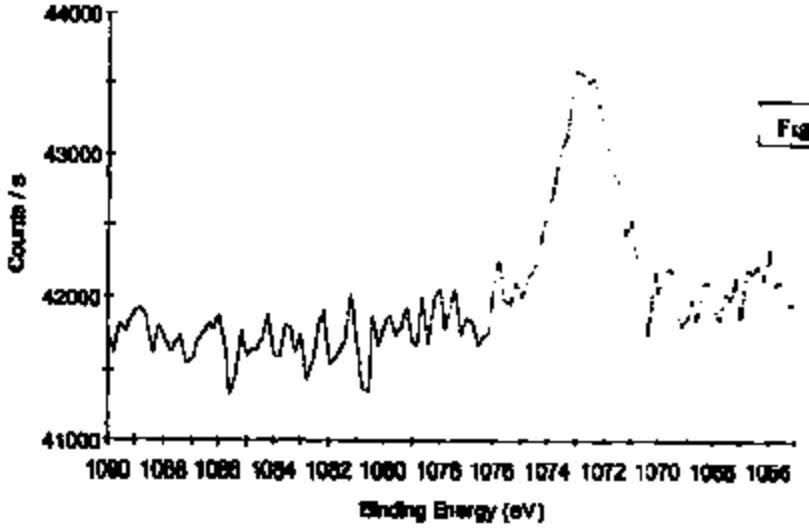

Figure 7

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O1s

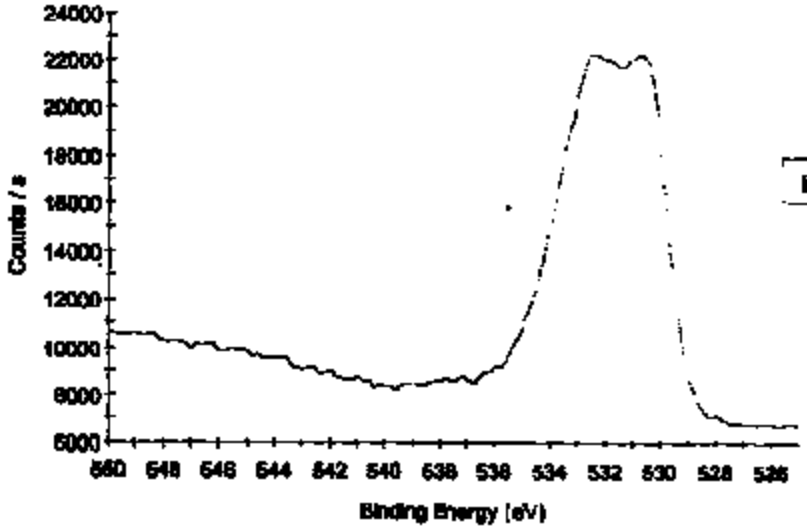

Figure 8

Survey

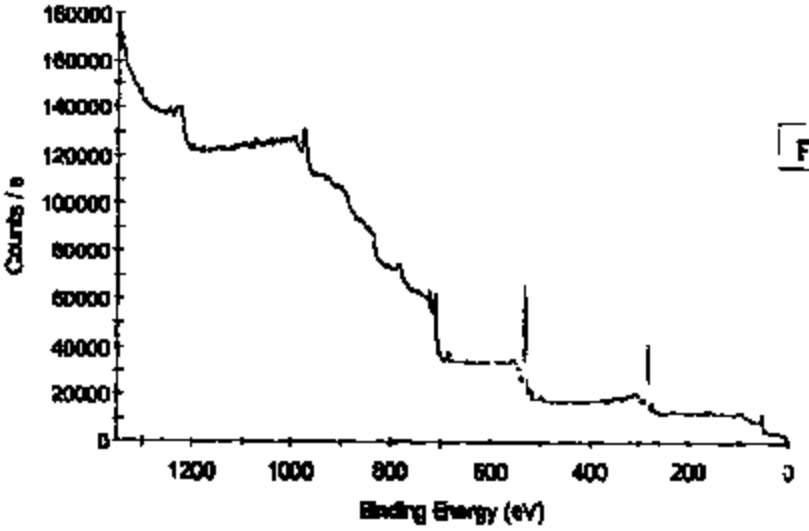

Figure 9

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SKF 02 Light red area in bore

C1s

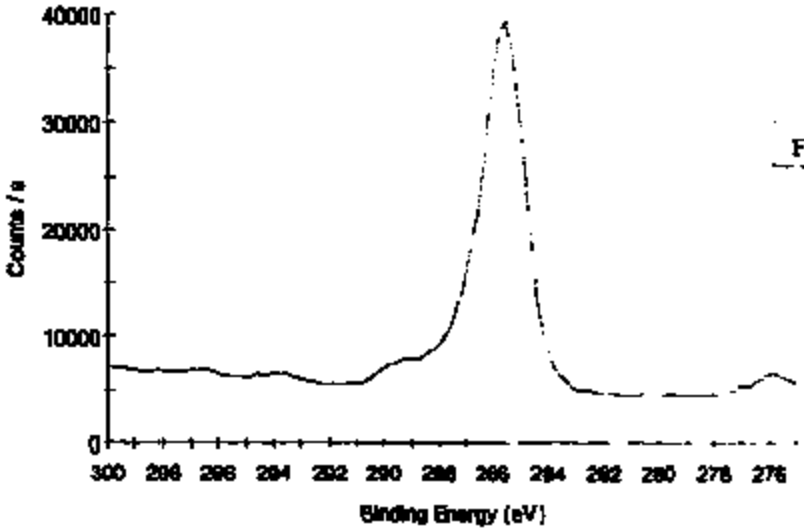

Figure 10

Ca2p

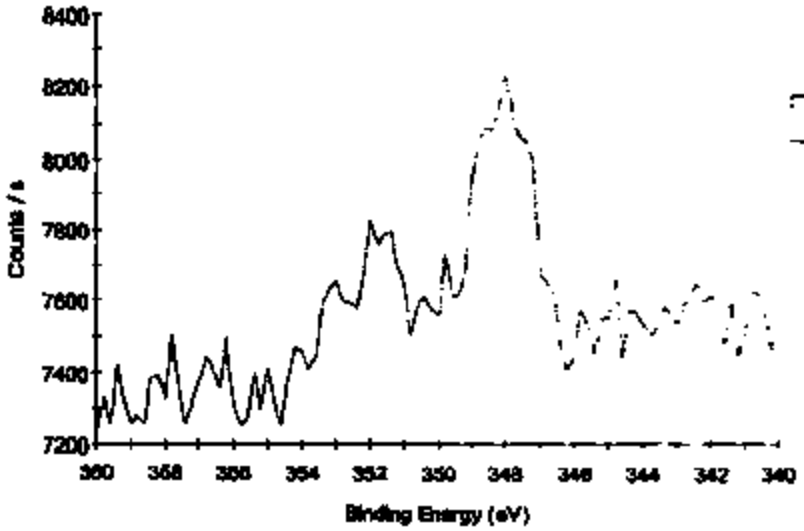

Figure 11

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F1s

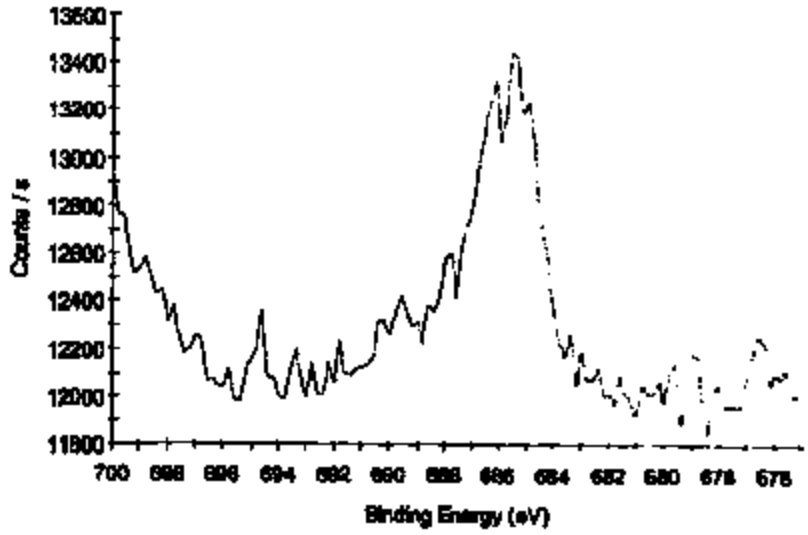

Figure 12

Fe2p

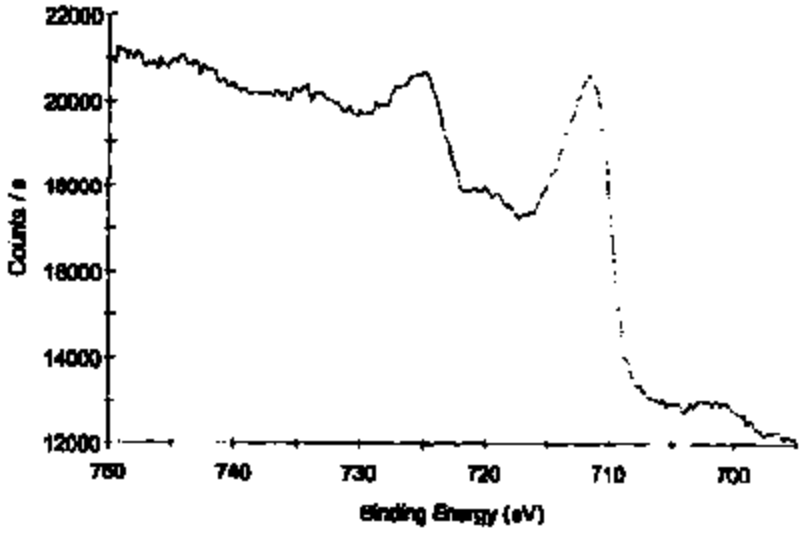

Figure 13

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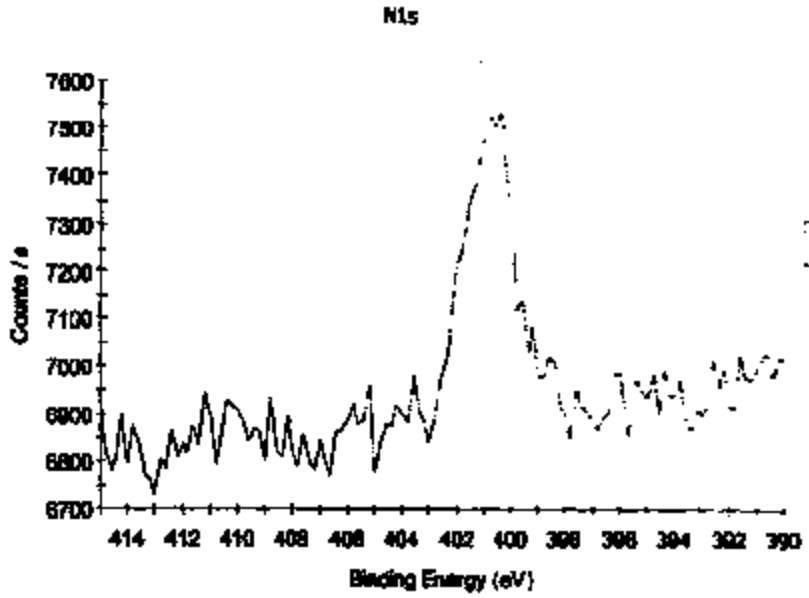

Figure 14

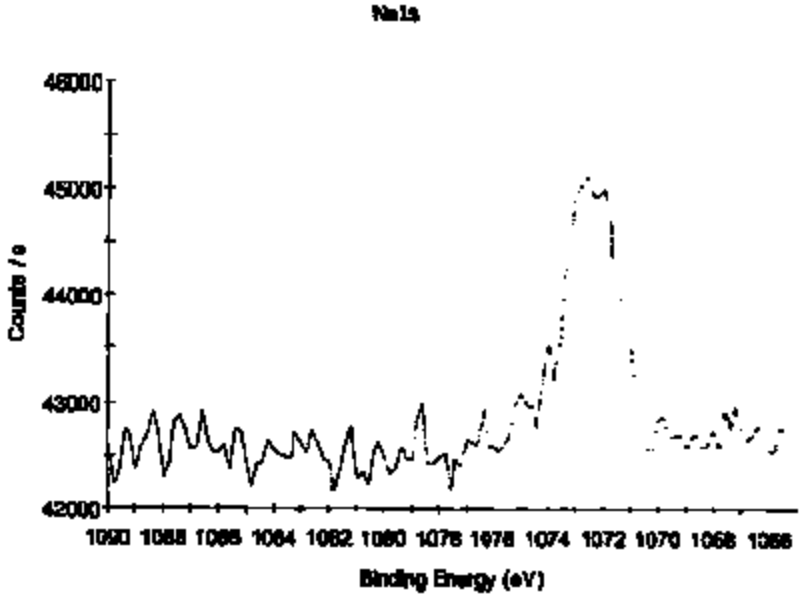

Figure 15

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O1s

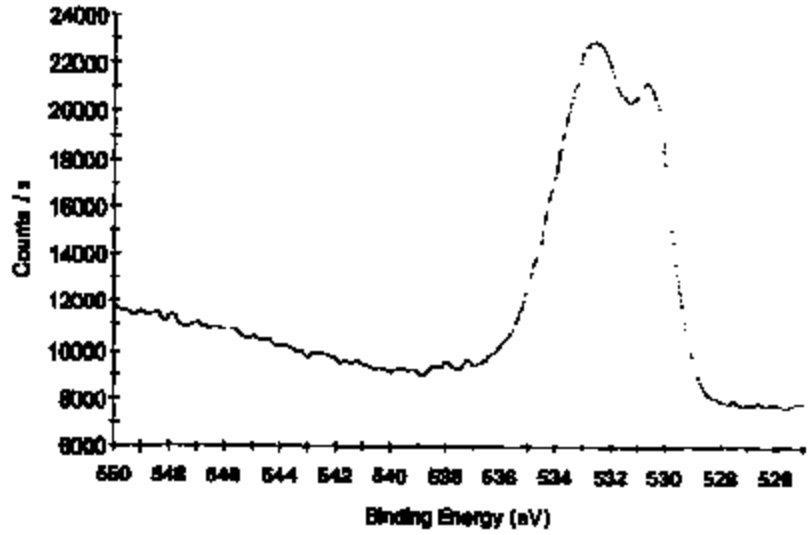

Figure 16

Survey

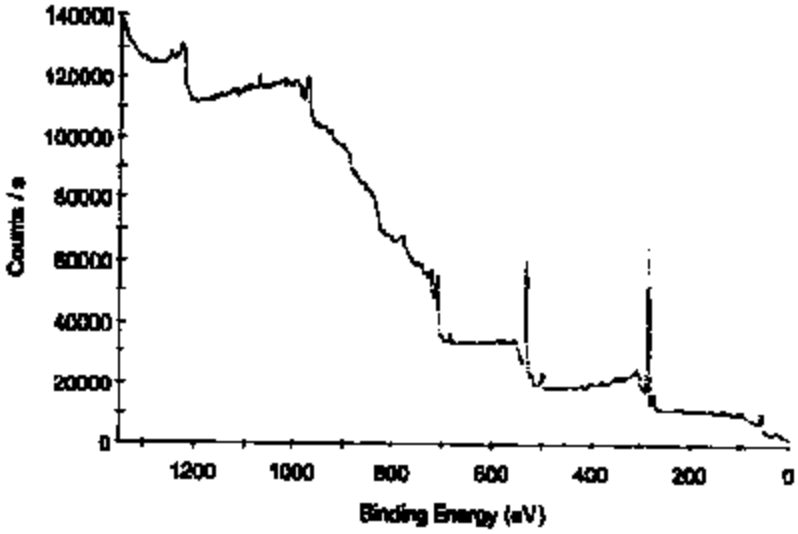

Figure 17

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SKF 03 Free-standing red area on chamfer

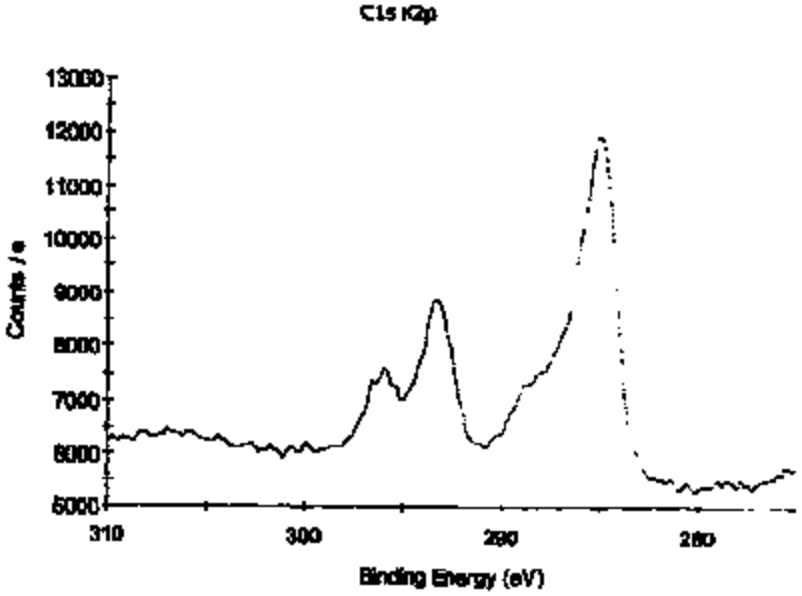

Figure 15

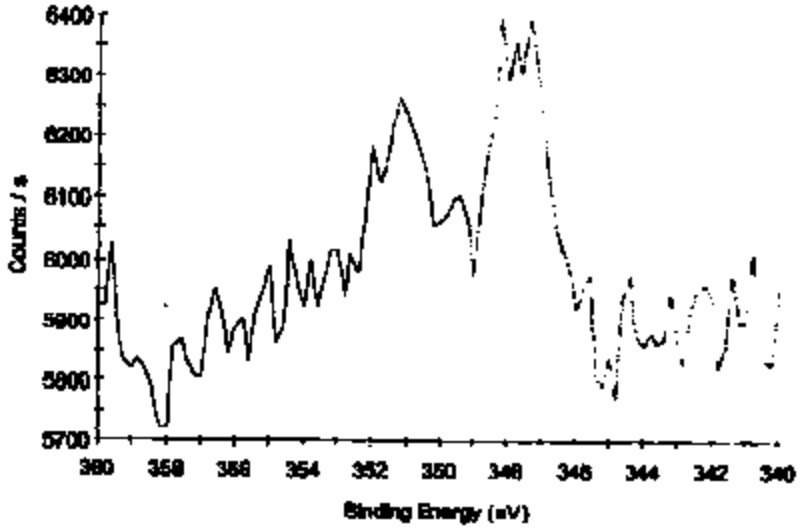

Figure 19

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F1s

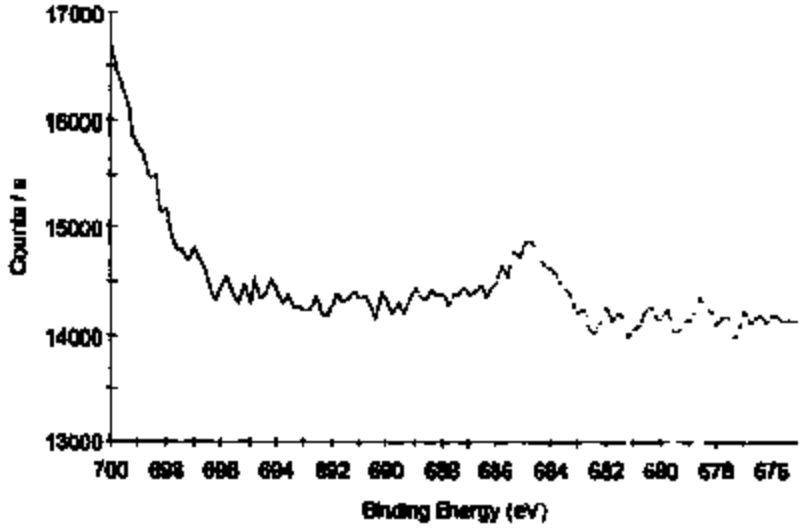

Figure 20

Fe2p

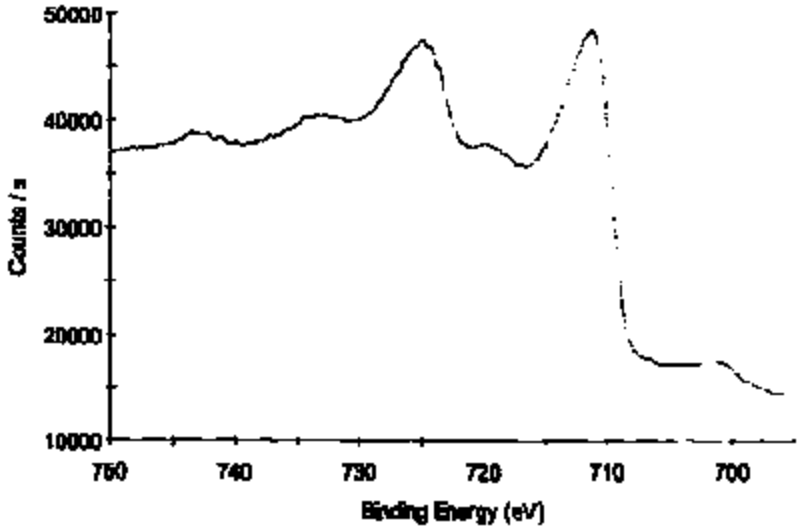

Figure 21

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N1s

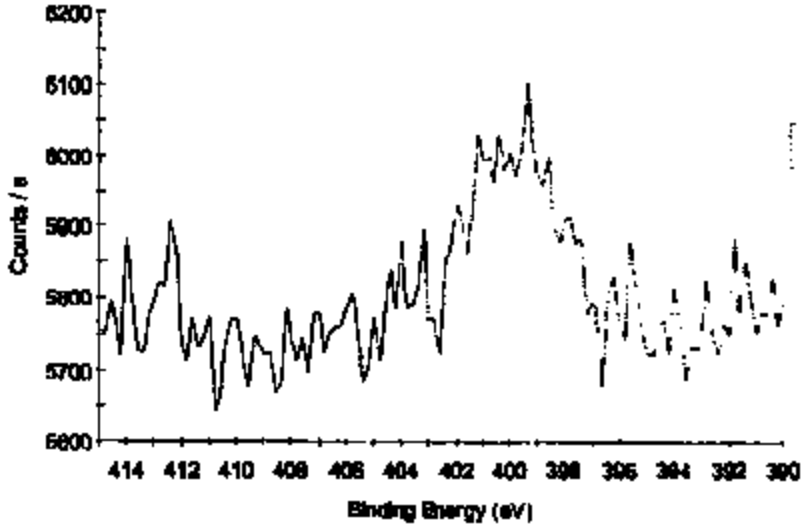

Figure 22

Na1s

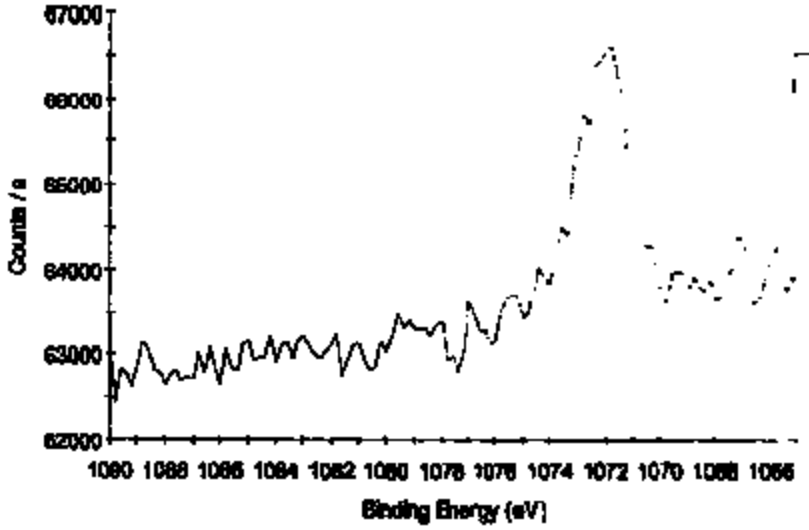

Figure 23

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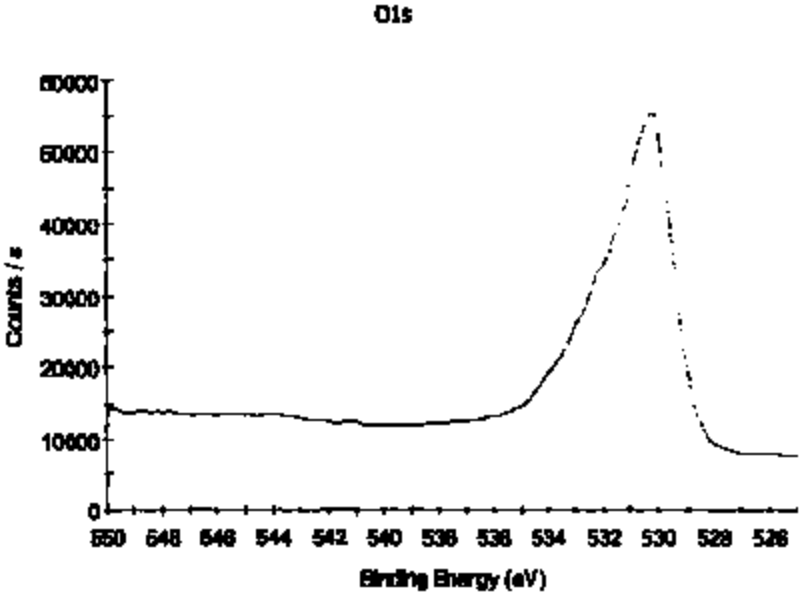

Figure 24

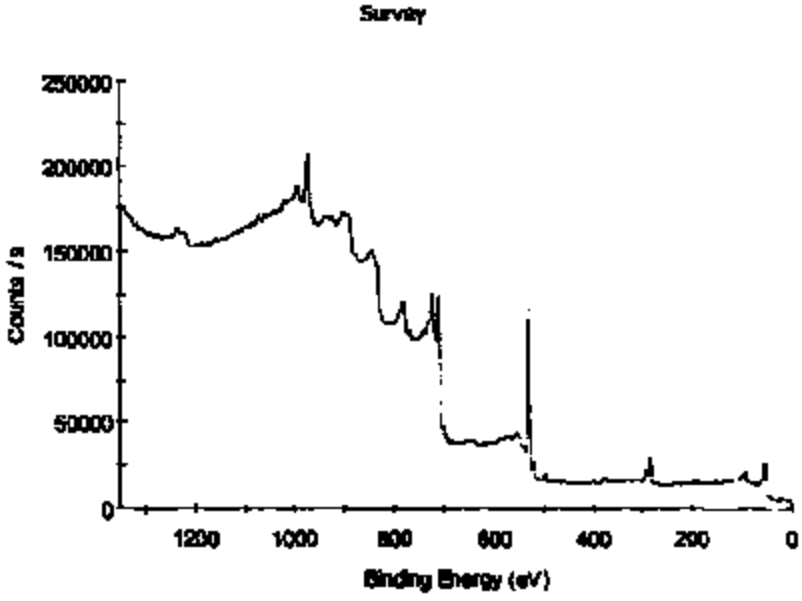

Figure 25

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SKF 000822

SKF04 Non-discoloured area on chamfer

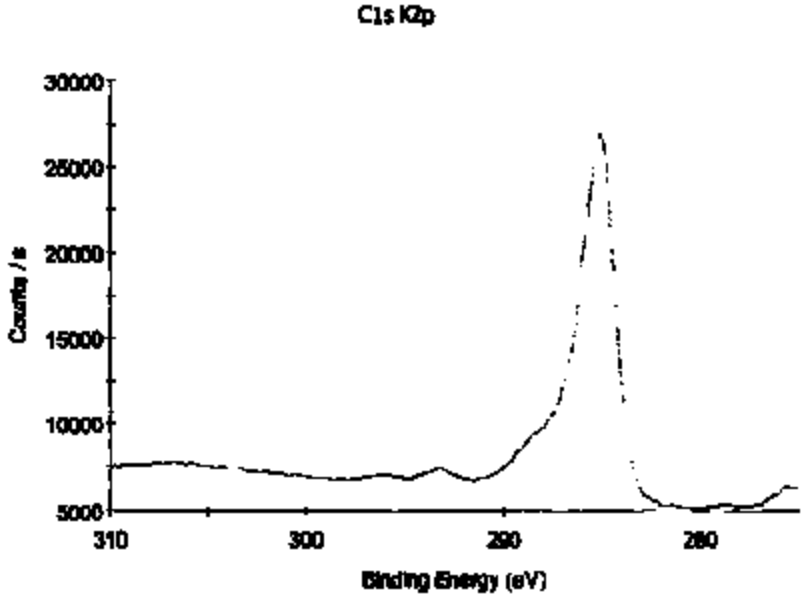

Figure 26

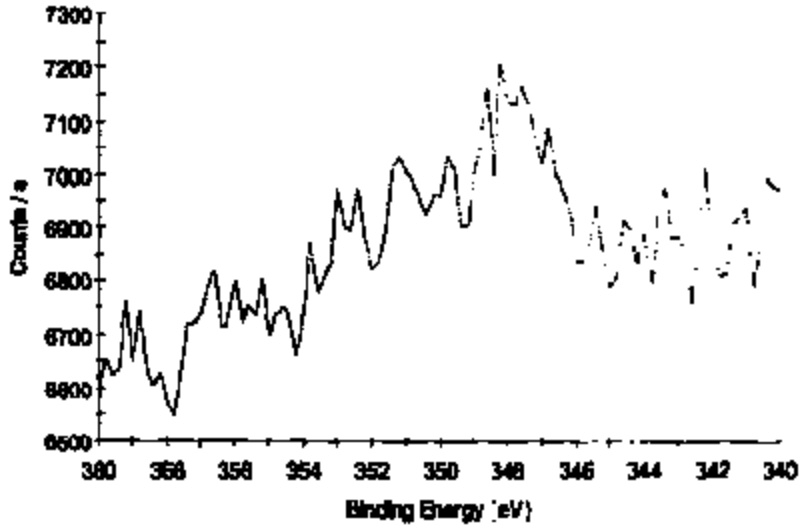

Figure 27

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F1s

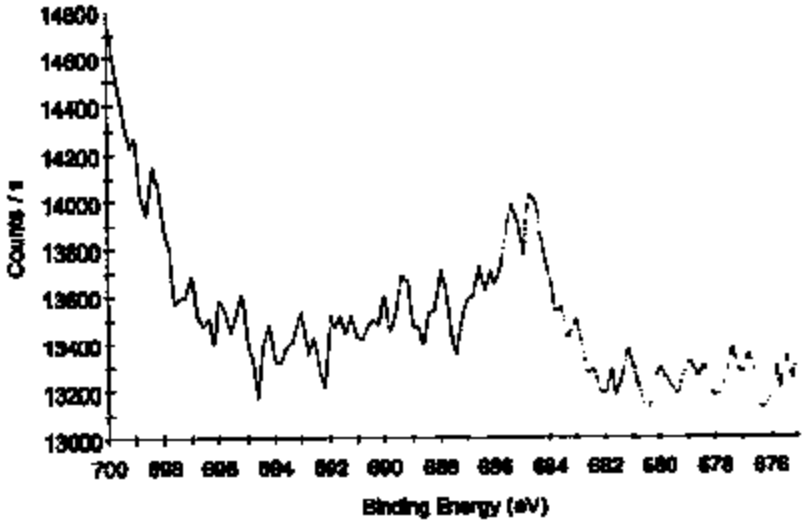

Figure 28

Fe2p

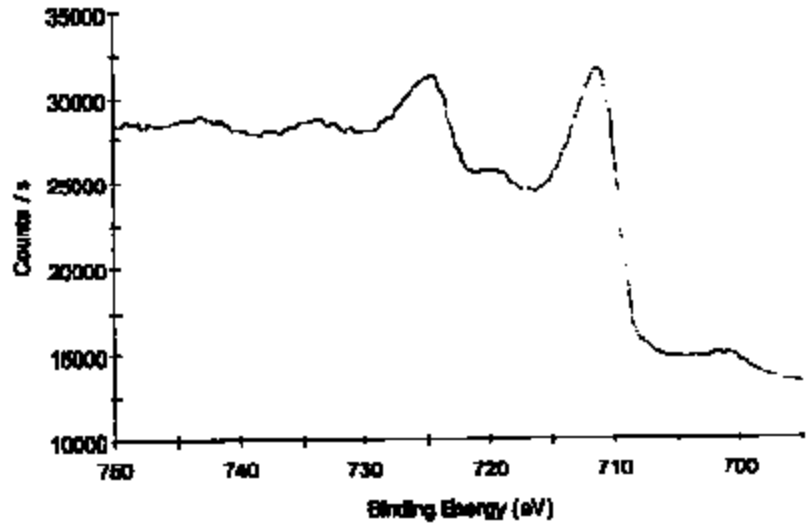

Figure 29

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N1s

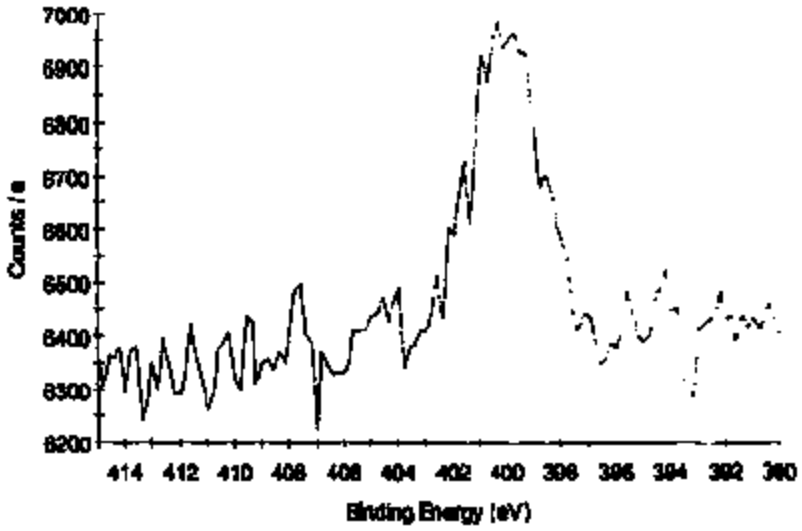

Figure 30

Na1s

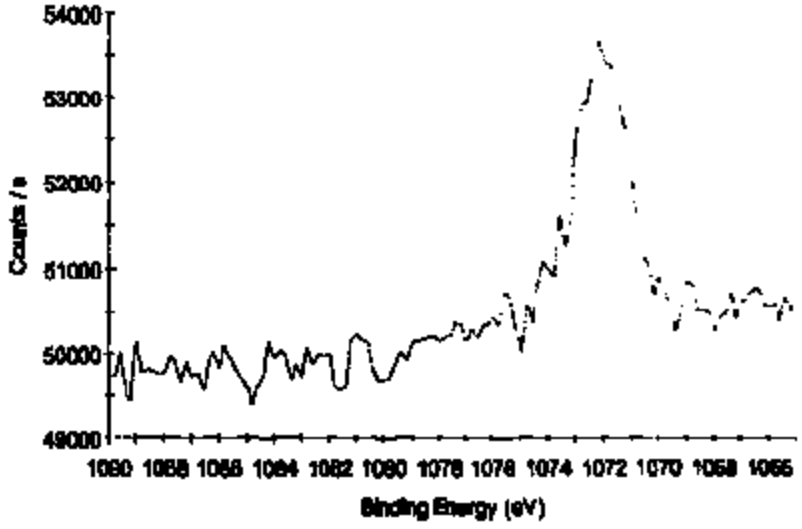

Figure 31

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O1s

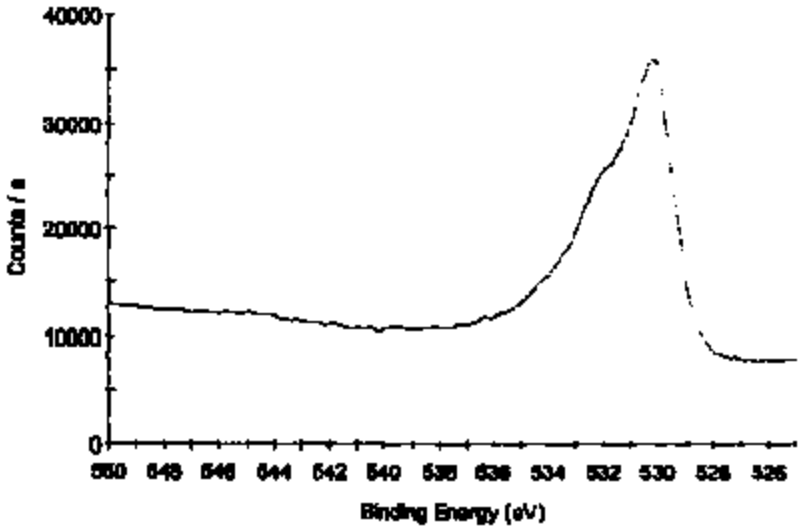

Figure 32

Survey

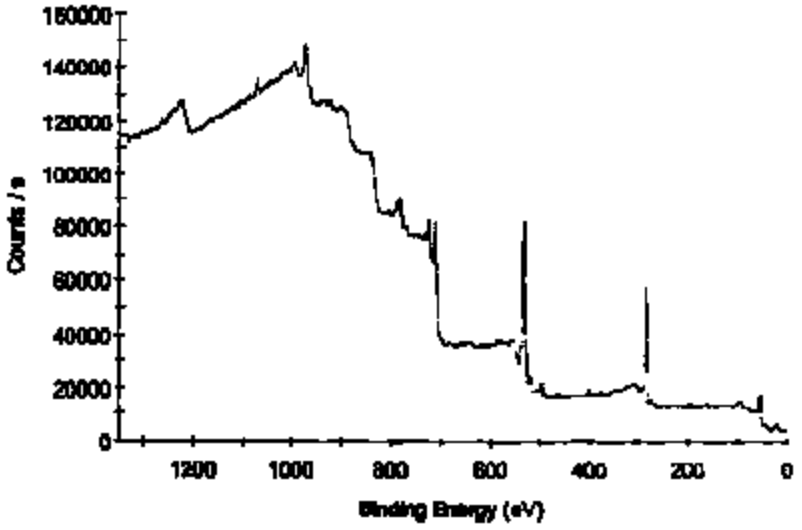

Figure 33

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Supplementary Information for Interim Report NL02M7903e
2002-07-31

ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis

Aidan Kerrigan

Materials Theory & Testing

EXTERNAL CUSTOMER
Report Supplement on Project No. N02 184

Supplementary Information on:

16,02wT903e
2002-07-5*

ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis

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Key Words: University of Surrey, x-ray photoelectron spectroscopy, iron oxide, corrosion, aqueous, humid

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ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis

Abstract The inner ring of a THU from the field was supplied to the University of Surrey, UK, for analysis using x-ray photoelectron spectroscopy. The objective was to determine the chemical species of various areas of the bore, which were different in appearance.

Project background

There have been incidents with THUs in the field in the USA. Examples of THUs from the field were supplied to ERC for investigation. One specific question was regarding the corrosion products seen on the bore of the outer rings. In the bore, at the highest loaded position (mentioned as 0°), there was a darkened red area, which would normally be classed as fretting corrosion. However, there was also a light red area at the 180° position, which was regarded as unusual. In general, the chamfer was not discoloured but there was a free-standing red area on the chamfer i.e. in a non-contacting location.

In order to classify these products, an inner ring was supplied to the University of Surrey, UK, for analysis using x-ray photoelectron spectroscopy (XPS). This technique is used to determine the chemical species by measurement of the chemical bonding energies.

It is important to state that the University of Surrey were not given any information other than that the part supplied was a taper roller bearing inner ring and given clear instructions of the areas to analyse. No manufacturing, application or customer information was given. As a result, the investigation and report from the University (incorporated into this report in its entirety) covers more than just the oxide species.

Objectives

To determine the chemical species present in the bore of a THU inner ring returned from the field.

Main results

According to the results and interpretation from the University of Surrey, the products in the bore of the THU inner ring at the 0° and 180° positions were an Fe(III) compound, most probably FeOOH, which were formed in a humid environment i.e. in the presence of water.

It should be noted that at the 0° position, the finish machining marks were not apparent but that at 180°, the finish machining marks were still visible.

On the (non-contacting) chamfer, the non-discoloured surface had an Fe_2O_3 type of deposit. This was stated to have been formed in a dry environment, at a 'slightly elevated' temperature, probably during heat treatment.

The free-standing red area on the chamfer was analysed and also found to be an Fe_2O_3 type of deposit, again formed in a dry environment.

The remarks about carbon for the areas on the chamfer are possibly explained by the fact that the general surface will have an oxide which formed during austenitising and was then oil quenched, picking up carbon. The other area may have formed after the quenching treatment, giving a lower carbon content. Note that this is very speculative.

The results at the 0° and 180° positions in the bore, as compared to the results from the chamfer, indicate that the technique can differentiate between different oxide species.

Main conclusions and recommendations

The products in the bore of the THU inner ring at the 0° and 180° positions were an Fe(III) compound, most probably FeOOH, which were formed in a humid environment i.e. in the presence of water.

Additional comments

For clarity, the codes used by the University of Surrey will be explained here in relation to the ERC description of the products in the bore.

	ERC	University
0° in bore :	Darkened red area	SKF 01
180° in bore :	Light red area	SKF 02
Chamfer :	Free-standing red area	SKF 03
Chamfer :	Non-discoloured area	SKF 04

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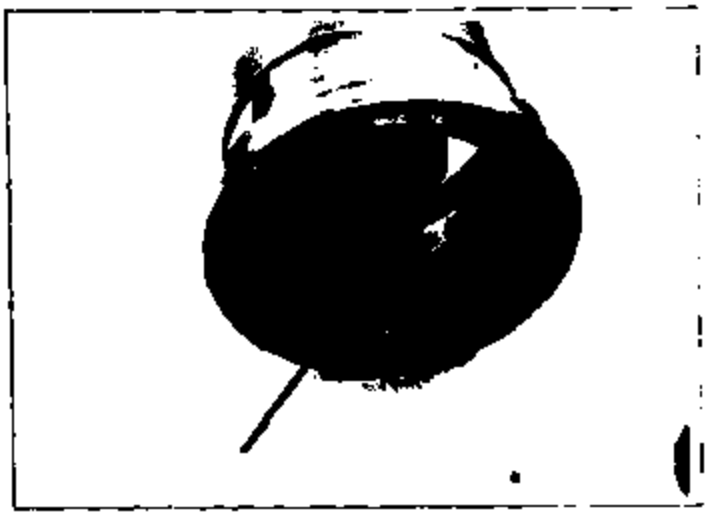
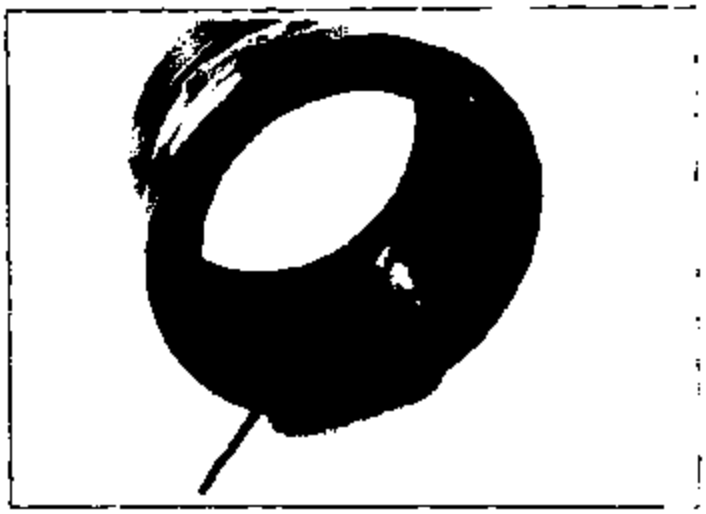
Photographs supplied to the University of Surrey



Darkened red area on bore (0°)



Light red area on bore (180°)

Free-standing red area on chamfer

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UniS

XPS Analysis of Discolouration on Bearing Inner Ring #11

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July 2002

Prepared for:
SKF Engineering & Research Centre BV

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XPS Analysis of Discolouration on Bearing Inner Ring #11

J F Watts, S J Greaves

Executive Summary

Surface chemical analysis of "Bearing Inner Ring #11" was carried out by X-ray photoelectron spectroscopy (XPS). XPS is a surface chemical analytical technique with an analysis depth of approximately 8 nm. Samples were cut from the bore and the chamfer of "Bearing Inner Ring #11". these were identified (by the customer) as darkened red area in bore (SKF01), light red area in bore (SKF02), free-standing red area on chamfer (SKF03). In addition an analysis from an unblemished region of the chamfer (SKF04) was also required.

Analyses from specimens within the bore indicate both the darkened red and the light red discolouration (SKF's descriptions) to arise from an Fe(III) compound, most probably FeOOH, which has been formed in a humid environment.

Both analyses indicate significant surface concentrations of surface carbon contamination which is predominantly hydrocarbon in nature with the presence of some C=O organic functionalities.

The analyses from the chamfer are both of an Fe_2O_3 type of deposit. The one identified as a free-standing red area on the chamfer is a voluminous (high surface area) form whilst that from the unblemished region of the chamfer is a thin passive film of the same composition probably resulting from a heat treatment procedure at some point in the ring's thermal history.

Minor elements (Ca, Na, F, K and N) are detected in low concentrations at all analysis positions but it is not possible to relate these, either qualitatively or quantitatively, to the performance of the bearing ring in service on the information supplied.

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XPS Analysis of Discolouration on Bearing Inner Ring

J F Watts, S J Greaves

Preamble

A bearing shell identified as "Inner Bearing Ring #11" was supplied complete by the customer along with a series of digital photographs that identified regions of concern regarding the physical appearance on both the bore of the bearing and the region identified as the chamfer. The descriptions of these regions of discolouration, and those that are used in the following reports are as follows:

Darkened red area in bore
Light red area in bore
Free-standing red area on chamfer

In addition we were also instructed to carry out analysis on a region of the "chamfer" that was not discoloured, this is identified as:

Non-discoloured area on chamfer

In the attached spectra these analysis zones are given the following codes:

SKF01
SKF02
SKF03
SKF04

The bearing shell was sectioned in University of Surrey workshops to provide relatively large pieces of the bearing ring for analysis, with the regions of interest identified in the customers photographs. Large specimens were used in order to avoid thermal effects that will be present near the machined surfaces, no cutting fluid was used to avoid the possibility of the modification of the surface chemistry of the regions of interest by the use of such reagents. A series of views of the sectioned bearing ring is shown in Figure 1.

XPS Analysis

The sectioned specimens were mounted for analysis on the platen of our Thermo VG Scientific Sigma Probe spectrometer. Analysis was carried out using AlKα radiation, and a survey spectrum over the region 0 – 1340 eV (binding energy) was first recorded from each region at a channel width of 0.4 eV. High resolution spectra were recorded on the basis of the elements identified in the survey spectrum. These were typically C1s, O1s, N1s, F1s, Ca2p, Fe2p, Na1s, depending on the specimen. All survey spectra and high resolution spectra acquired are appended to this report. The binding energies of the principal photoelectron core levels observed are listed in Table 1.

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Carbon 1s Data

The concentrations of carbon observed on these specimens are, in three cases, at a level to be expected from samples that have been exposed to the ambient environment in a relatively uncontrolled manner. with perhaps the presence of residual carbonaceous material from previous processes. In the case of the spectra recorded from the free-standing red area on the chamfer (SKF03) this value is much lower at 15 at %. This is unusual and provides significant clues to the form of the visually identified deposit. it is of a high surface area type and has formed within a relatively recent timescale, as it has not been contaminated in the manner the other regions have experienced.

Minor Elements

Small surface concentrations of Ca, Na, F, K and N are detected on all specimens. Ca is often associated with tap water and is slightly higher on analyses recorded from the bore than the chamfer regions. F is significantly higher on analyses from the bore than the chamfer and it is not possible at this stage to speculate on the source of this element. Na is a common contaminant from physiological media and does not vary significantly between the different specimens. Likewise the N levels seem fairly consistent from one to another. K is significantly higher on the specimen SKF03 and this most likely indicates it is intimately associated with the corrosion product In other samples the higher surface concentration of carbon attenuating the K2p signal.

Chemical State Information

Although most of the high resolution spectra contain little information of spectroscopic significance the Fe2p, O1s and C1s spectra are particularly informative.

Iron 2p Spectra

The 2p region recorded shows both the Fe2p3/2 and Fe2p1/2 components resulting from the spin orbit splitting of the Fe2p electrons. The binding energy is consistant with the Fe(III) state and this is confirmed by the presence of Fe2p3/2 satellite structure on the higher binding energy side of the valley between the Fe2p3/2 and Fe2p1/2. Thus the outer regions of the deposit (at the depth analysed by XPS, ca. 8 nm) is Fe(III) state in all cases. Fe(III) is the equilibrium phase likely to be formed in an excess of corrodent (oxygen or water), in a reduced partial pressure of oxygen Fe(II) is more likely to form.

Oxygen 1s Spectra

In the case of spectra SKF01 and SKF02, the O1s spectra [figures 8 and 16] have two well defined components at approximately 530 and 533 eV. Such observations are consistent with oxide and hydroxide components, indicating that the terminal phase is most probably FeOOH. This is the reaction product associated with the corrosion of iron in an aqueous (damp) environment. Indeed the exposure of pure iron to water vapour in clean, UHV conditions gives rise to a thin film this compound as does the exposure of mild steel to the ambient environment for short times of a few days

The other spectra, SKF03 and SKF04 have an altogether different form of O1s line [figures 24 and 32]. In these cases the oxide component at 530 eV is dominant and the hydroxide contribution is merely observed as a broadening on the higher binding energy side. This is consistent with an oxide formed in a dry environment, possible at a slightly elevated temperature. The Fe2p and O1s data taken together indicate that the non-discoloured region (Specimen SKF04) is probably a thin (passive) film of Fe_2O_3 formed during the production process. The corrosion product (SKF03) is of similar chemical composition (Fe_2O_3) but of a more voluminous physical form.

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Carbon 1s Spectra

In all cases the spectrum is centred at a binding energy of ca. 285 eV as expected. This is the position typical of adventitious carbon and for charge referencing purposes this can be set to exactly 285.0 eV if required. All spectra have a higher binding energy component centred at approximately 288 eV which is attributed to carbon bonded to oxygen in the form C=O. In the case of the low carbon concentration (SKF03) this is associated with polar carbon adsorbed from the atmosphere but in the case of higher carbon concentrations such those observed on specimens SKF01, 02, 04, such polar contributions would be swamped by the apolar carbon. This leads to the conclusion that the source of carbon on these samples is something other than the usual adventitious material, i.e. a specific source which includes a carbonyl functionality.

Conclusions

The analysis by XPS of four regions of "Inner Bearing Ring #11" enable the following conclusions to be drawn:

- The characteristics of the analyses taken from the two regions within the bore ("darkened red area" and "light red area") are very similar.
- These two analyses (SKF01 and 02) show iron in the Fe(III) state and equivalent contributions of oxide and hydroxide which would arise from the formation of a FeOOH phase in a damp environment:

$$Fe + H_2O \rightarrow FeOOH$$

- $Fe_2O_3.2H_2O$ would have a dominant oxide component of the O1s spectrum but cannot be completely ruled out.
- The surface concentration of F is significantly higher for the SKF01 and 02 specimens than for SKF03 and 04.
- Analyses taken from the chamfer region (SKF03 and SKF04) both yield O1s spectra dominated by an oxide component, consistent with the corrosion product (SK03) and passive film (SK04) having formed in a dry environment, possible at elevated temperature.
- The corrosion product on the chamfer (SKF03) is of a high surface area and has not been exposed to gross hydrocarbon contamination (e.g. oil) since its formation.
- The surface concentration of potassium is higher in analyses taken from the chamfer than the bore.

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SKF Comment - by Aidan Kerrigan

The first and second conclusions in the report from the University of Surrey state that the species in the two positions of the bore of the inner ring (at 0° and 180°) have similar characteristics and match those that would be expected from the formation of FeOOH in a damp environment.

The third conclusion, which states '$Fe_2O_3.2H_2O$ would have a dominant oxide component of the O1s spectrum but cannot be completely ruled out', has been stated by the University of Surrey as there is a small possibility that the oxide is $Fe_2O_3.2H_2O$ rather than FeOOH. However, as is implied by the formula, $Fe_2O_3.2H_2O$ is also formed in a damp environment. Therefore, the main conclusion remains that the oxide species found in the two positions in the bore were formed in a damp environment.

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SKF01 Darkened red area in bore

C1s

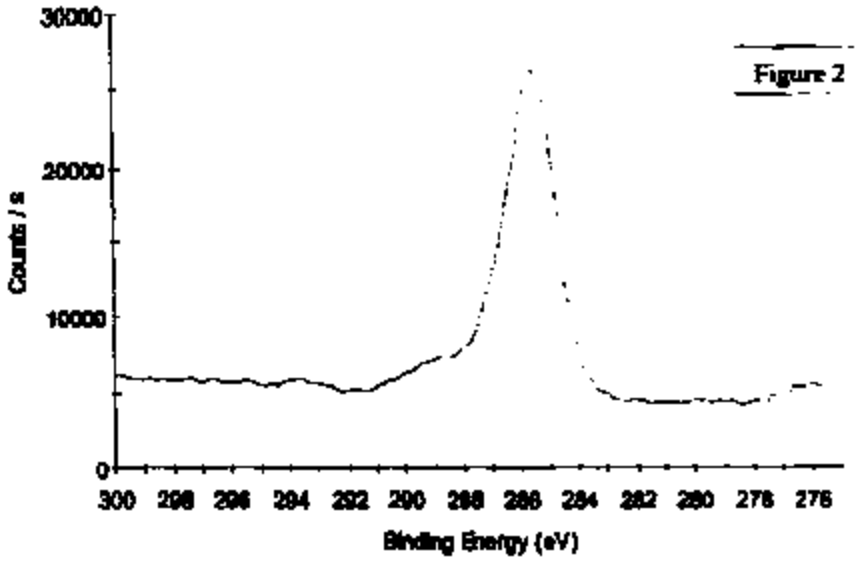

Figure 2

Ca2p

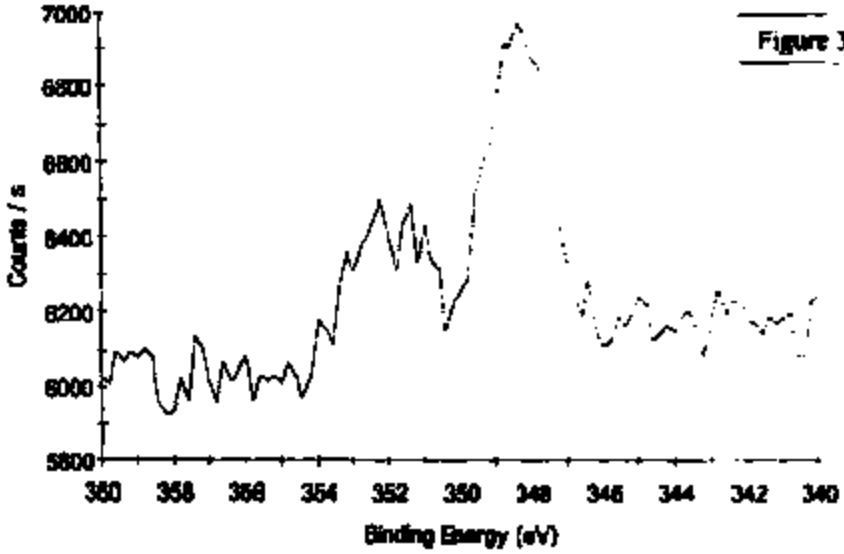

Figure 3

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F1s

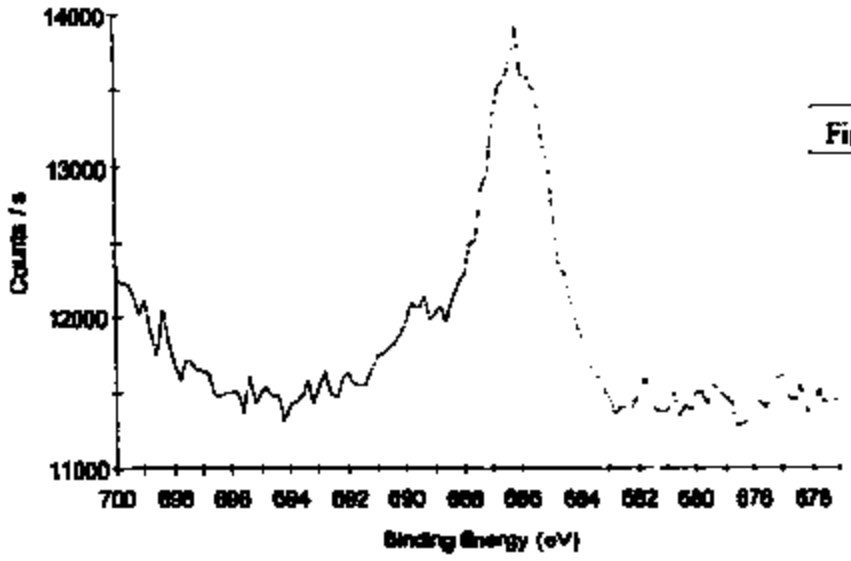

Figure 4

Fe2p

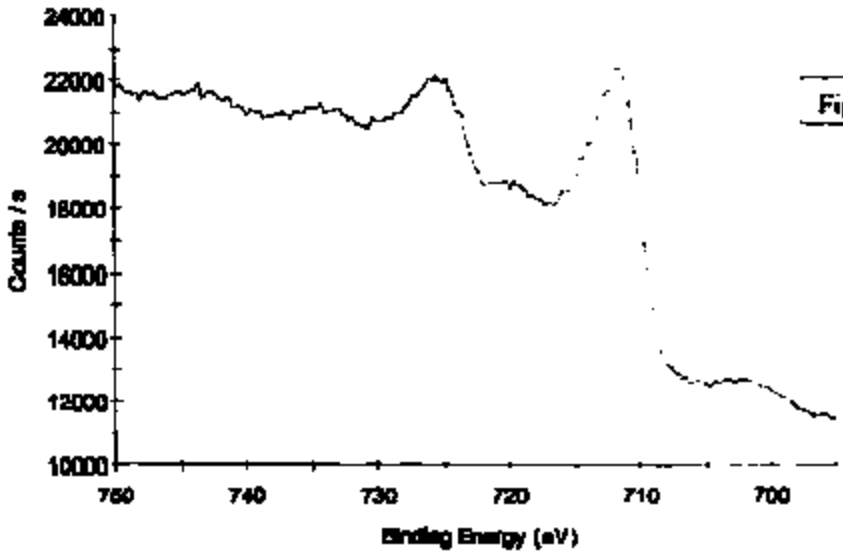

Figure 5

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N1s

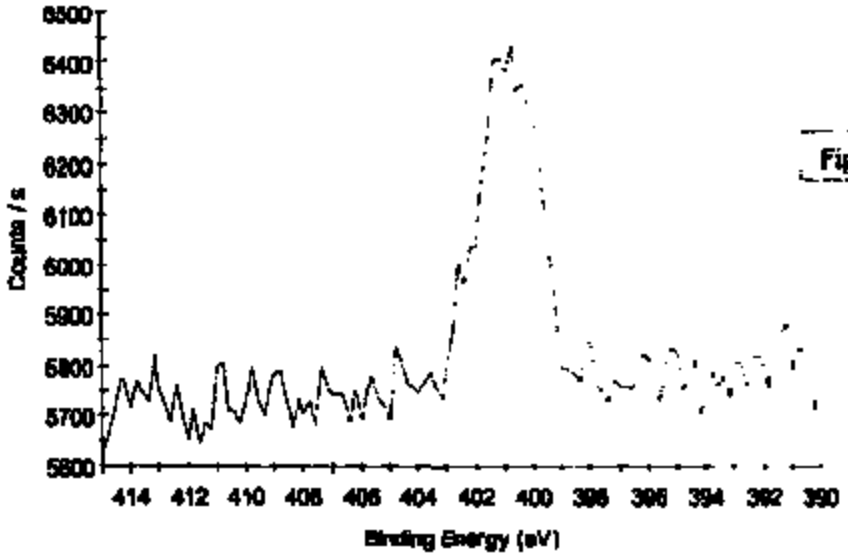

Figure 6

Na1s

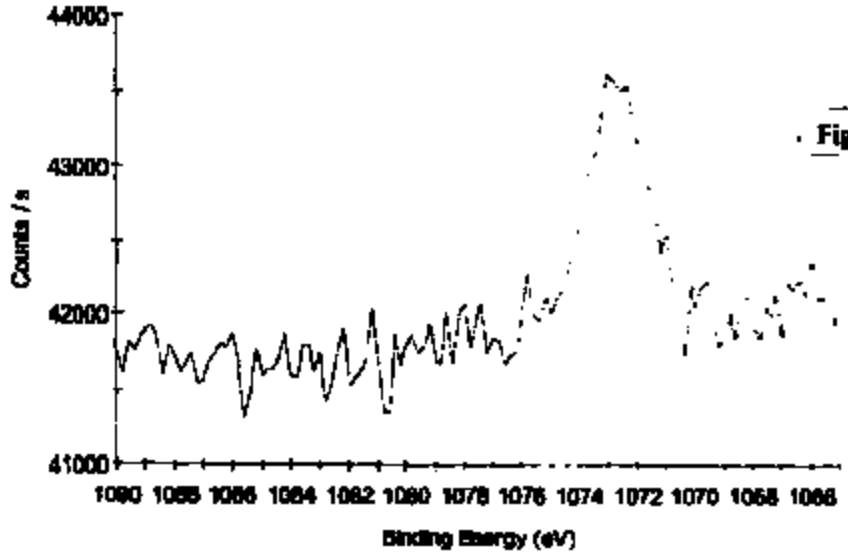

Figure 7

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O1s

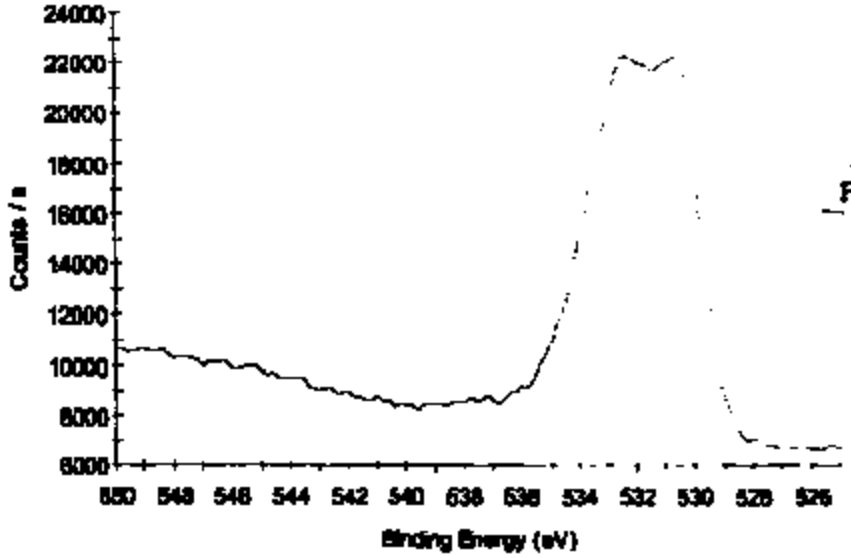

Figure 8

Survey

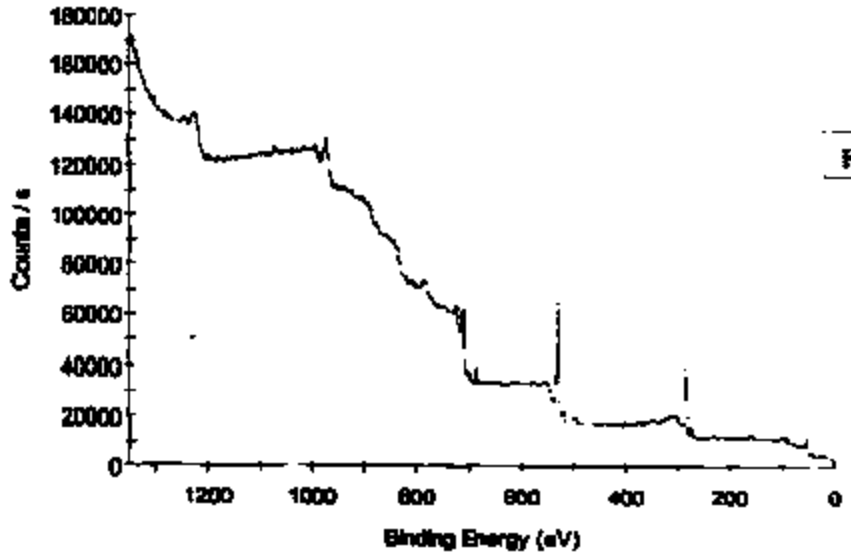

Figure 9

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SKF 02 Light red area in bore

C1s

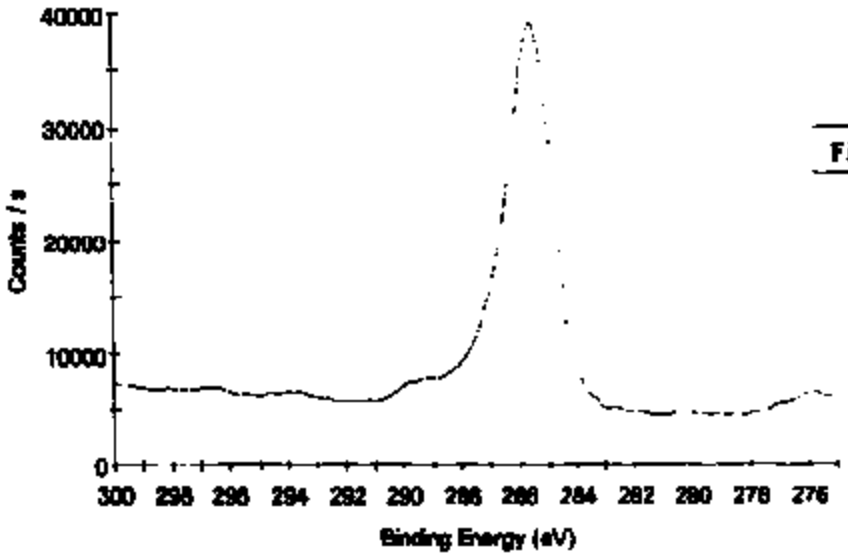

Figure 10

Ca2p

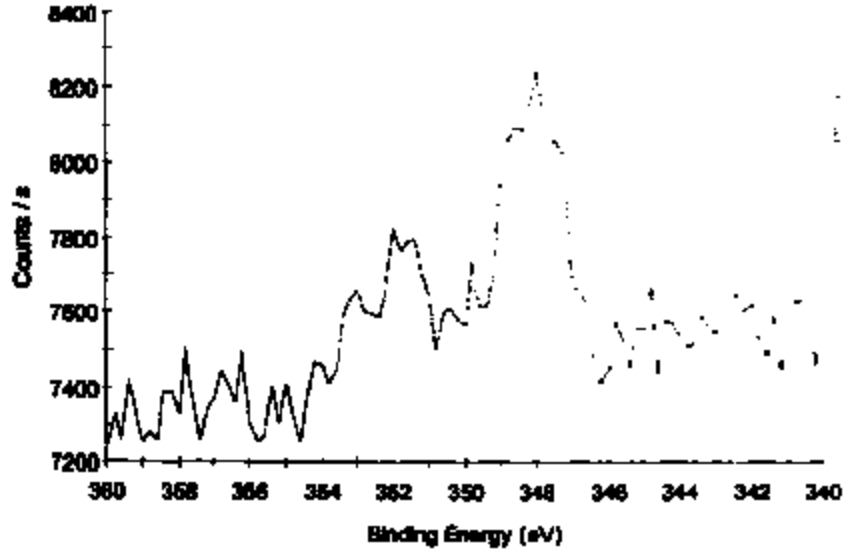

Figure 11

© SKF Engineering & Research Centre B.V.

F1s

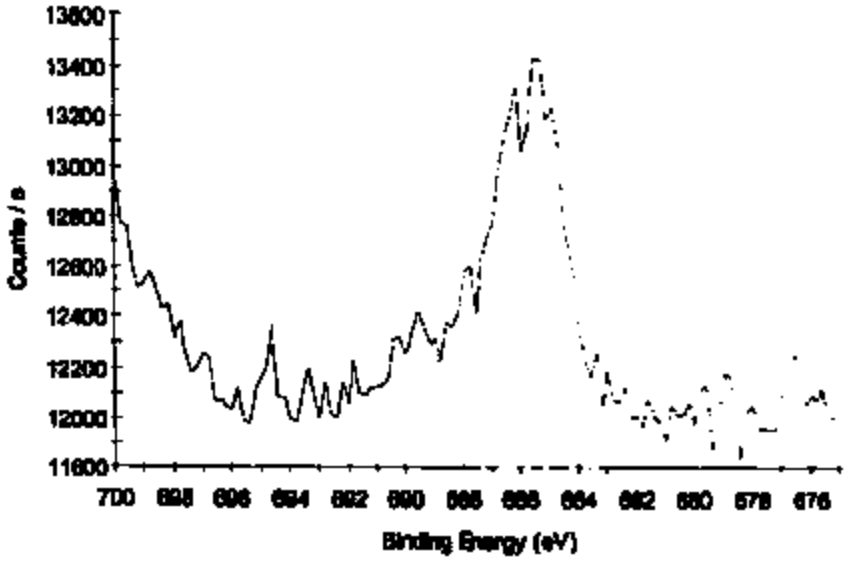

Figure 12

Fe2p

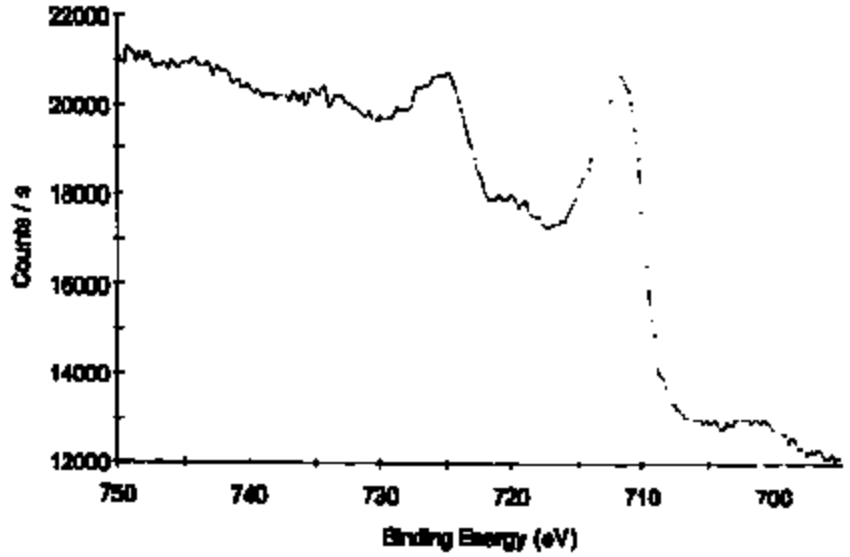

Figure 13

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N1s

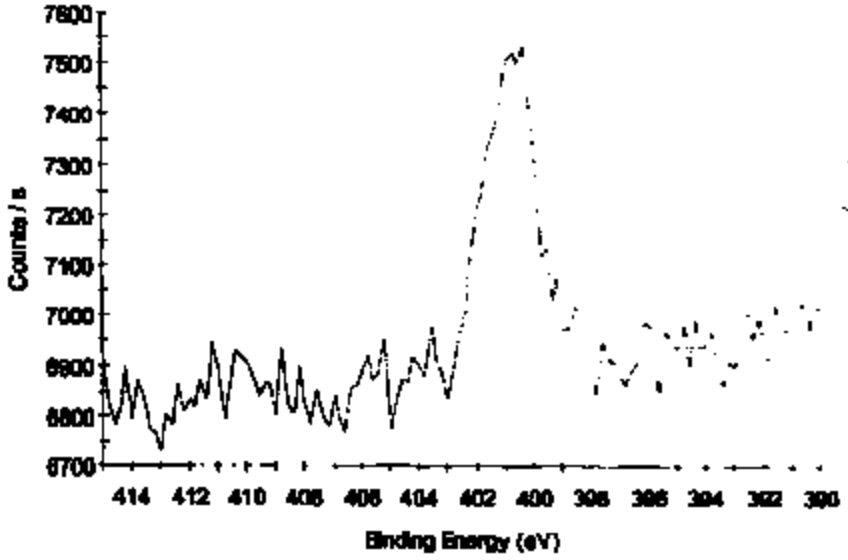

Figure 14

Na1s

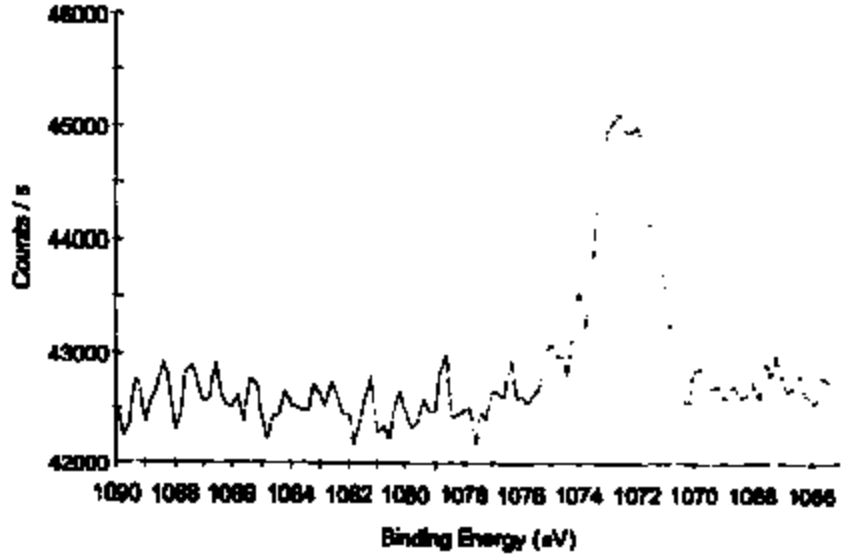

Figure 15

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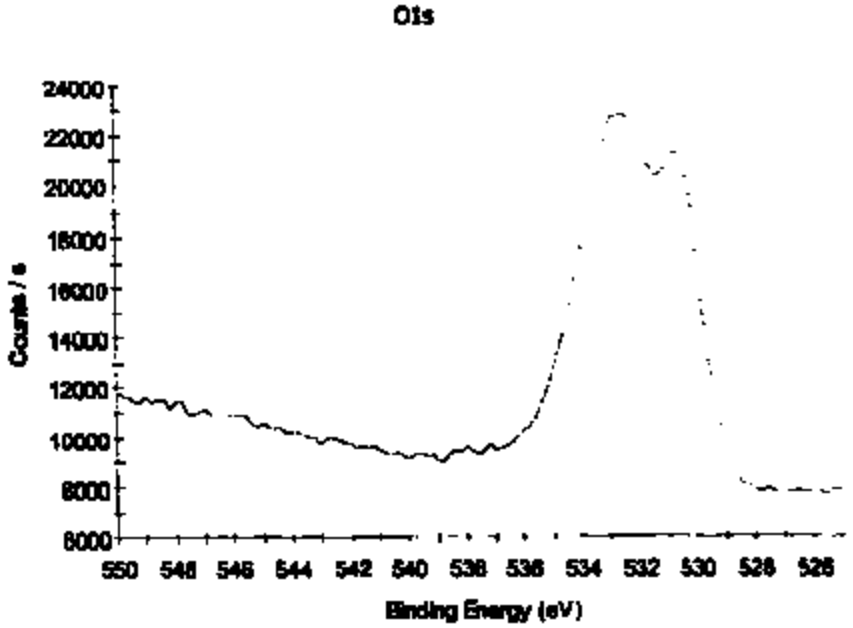

Figure 16

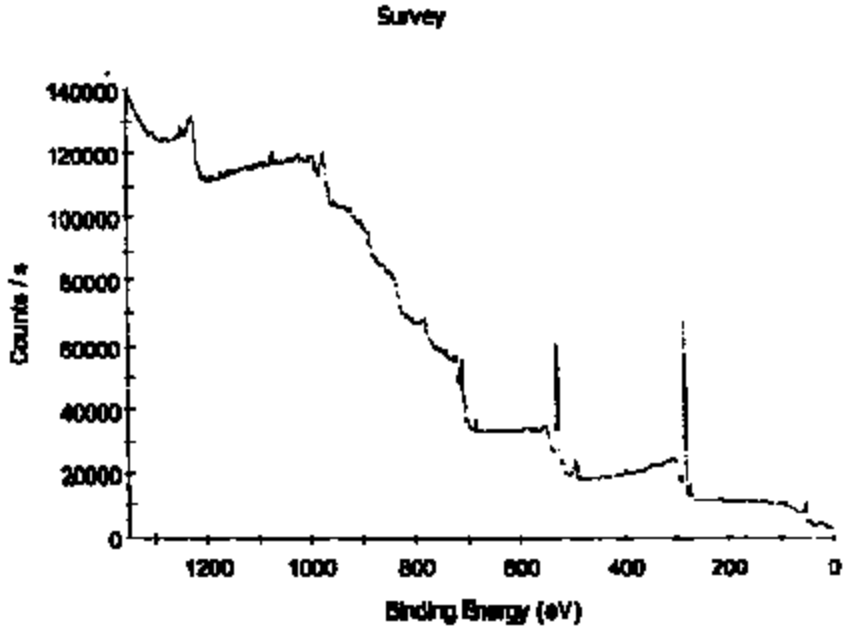

Figure 17

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SKF 03 Free-standing red area on chamfer

C1s K2p

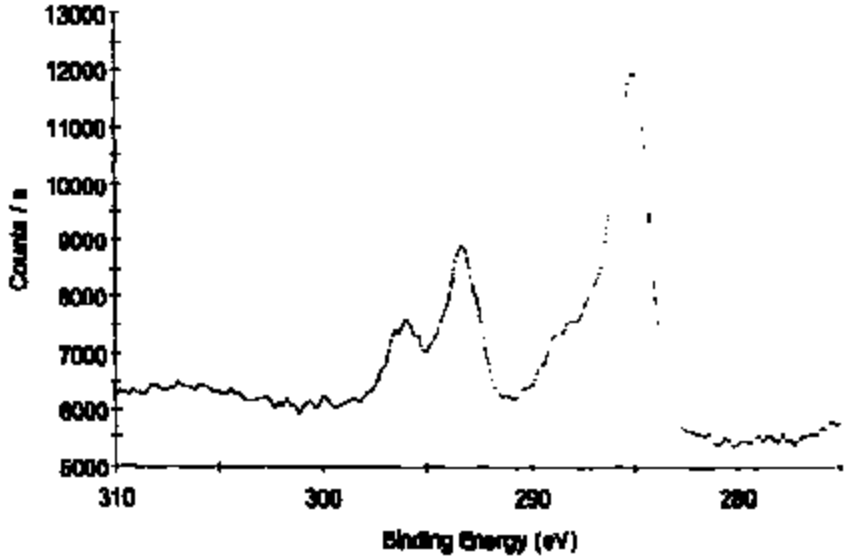

Figure 18

Ca2p

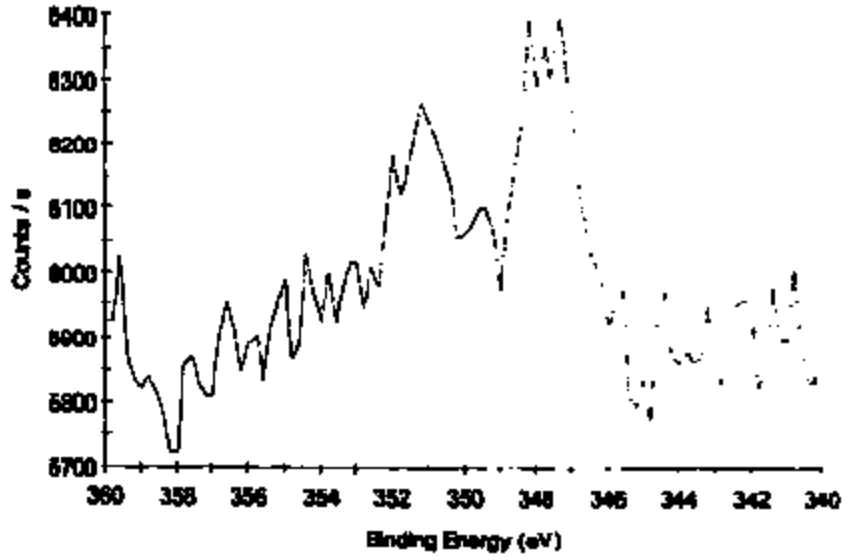

Figure 19

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F1s

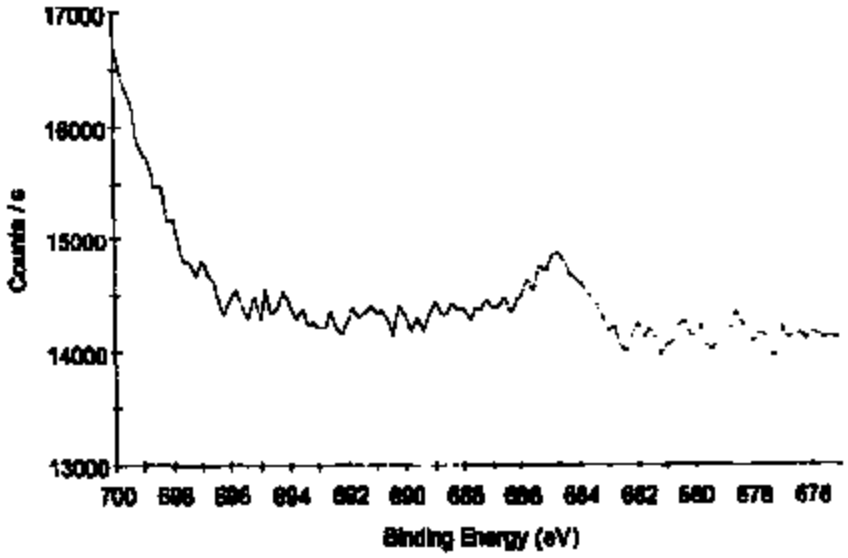

Figure 20

Fe2p

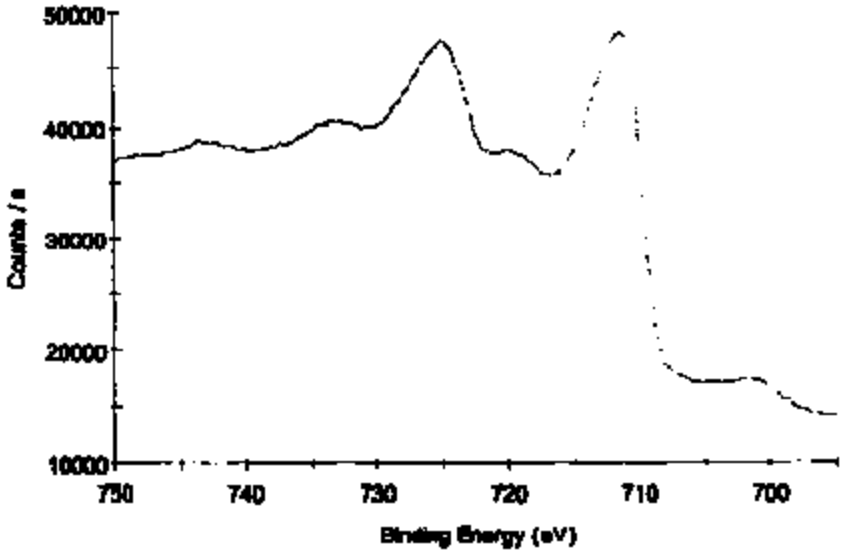

Figure 21

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N1s

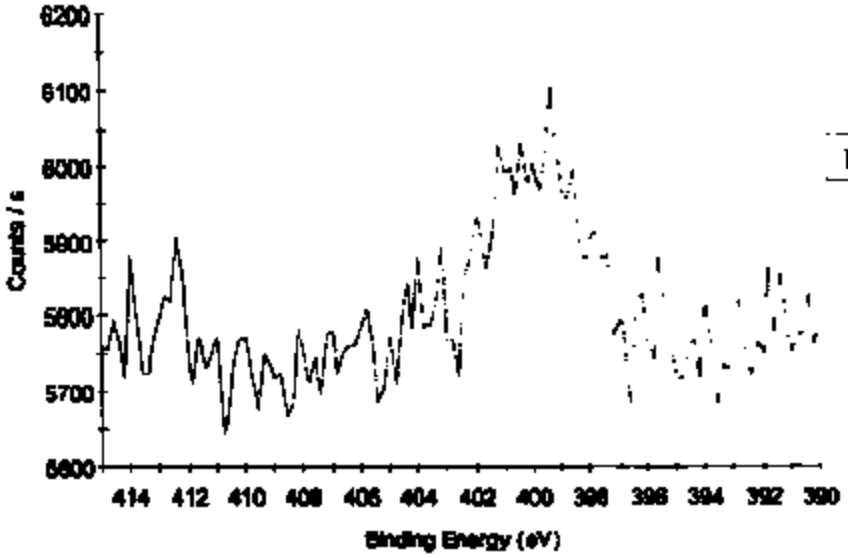

Figure 22

Na1s

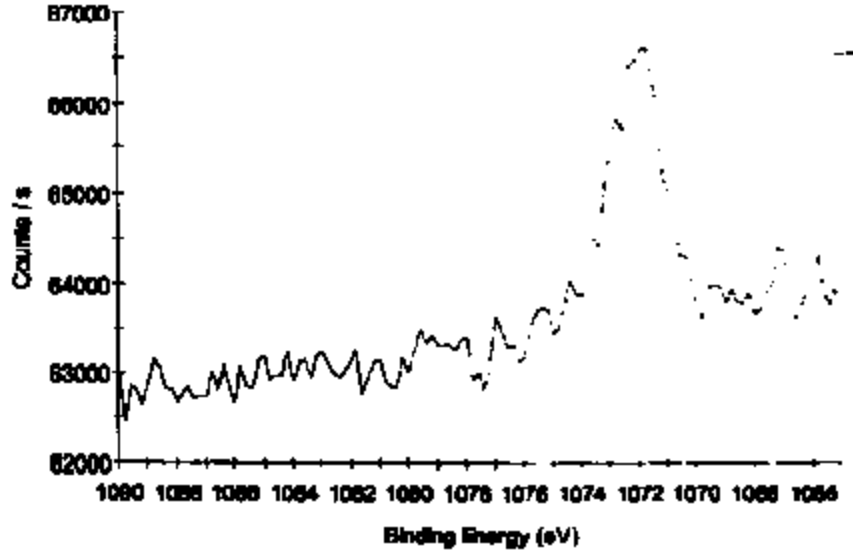

Figure 23

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O1s

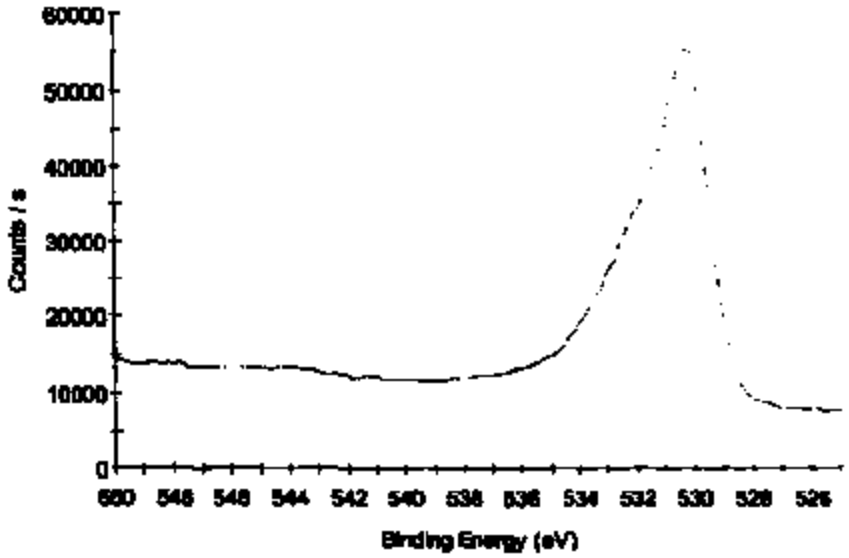

Figure 24

Survey

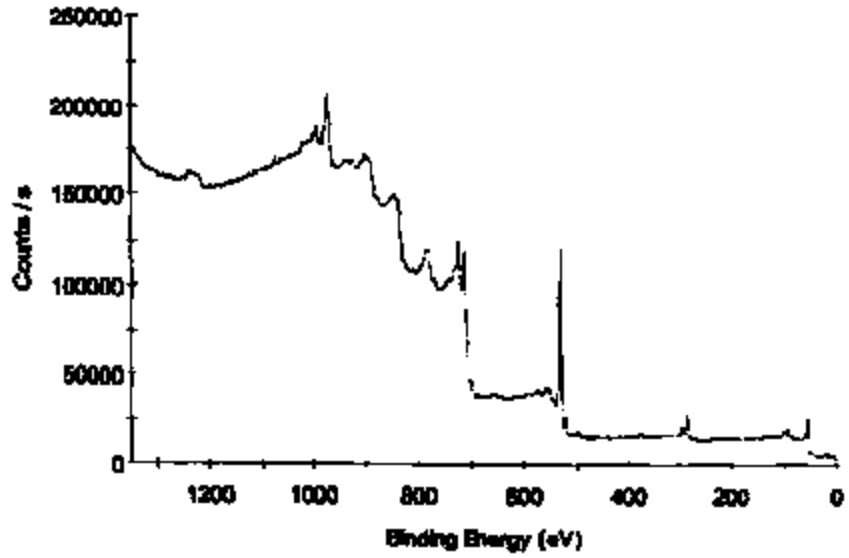

Figure 25

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SKF04 Non-discoloured area on chamfer

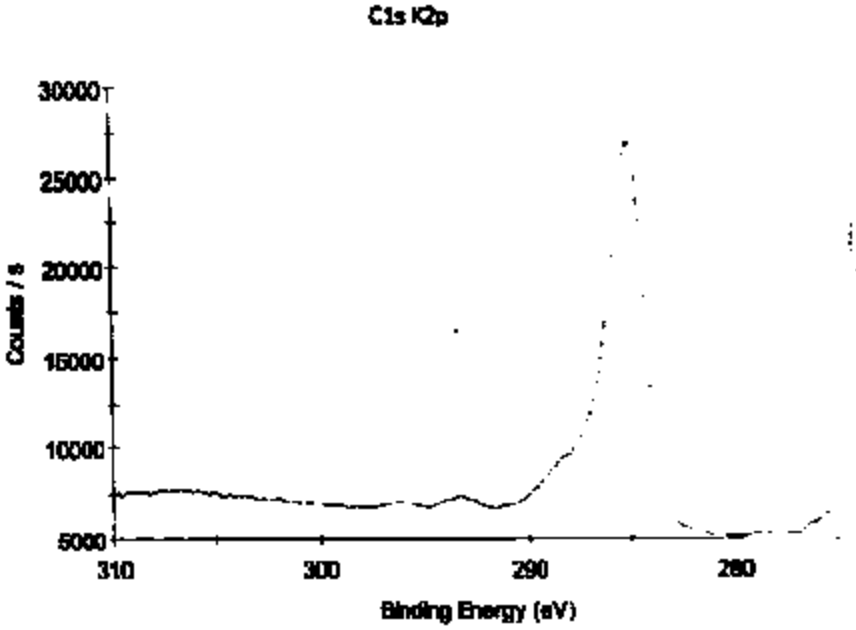

Figure 26

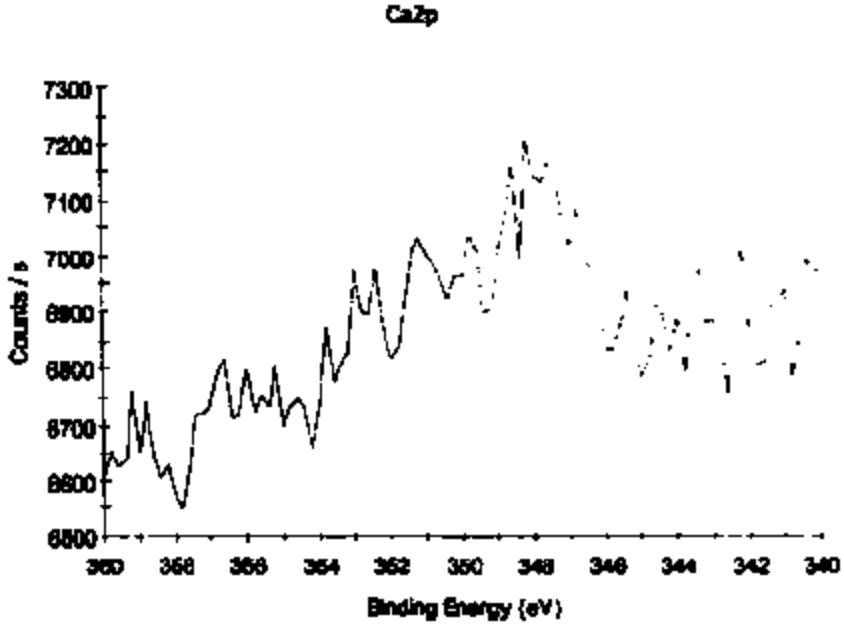

Figure 27

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F1s

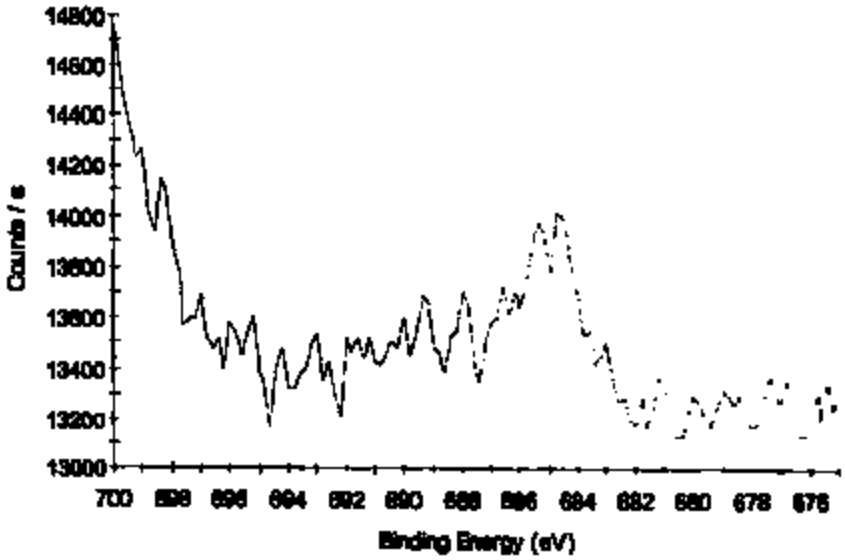

Figure 28

Fe2p

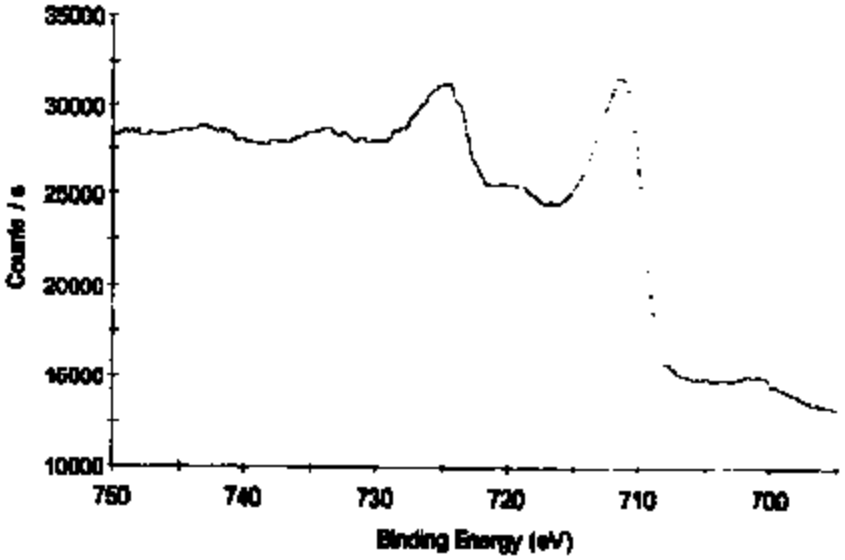

Figure 29

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N1s

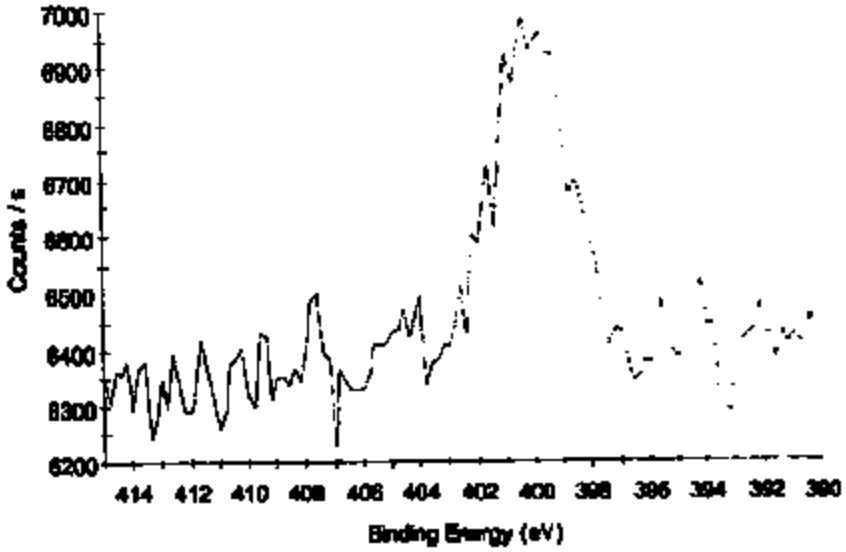

Figure 30

Mo1s

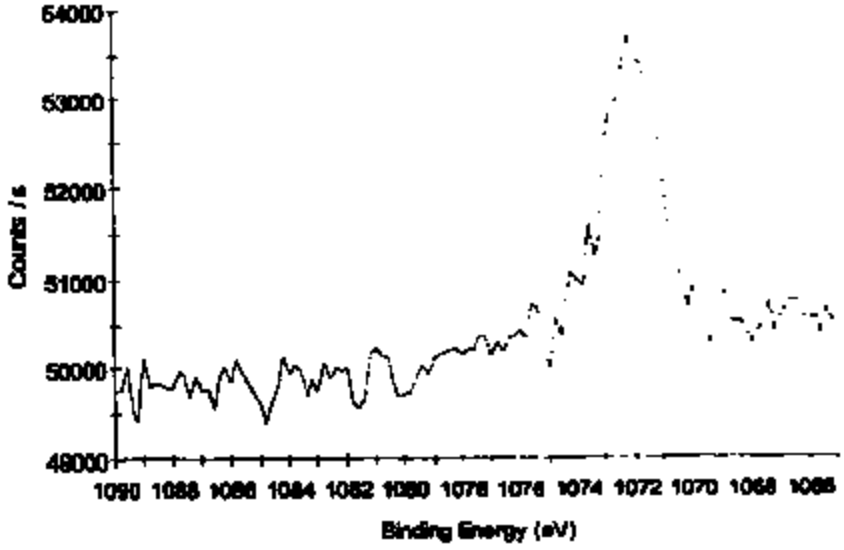

Figure 31

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O1s

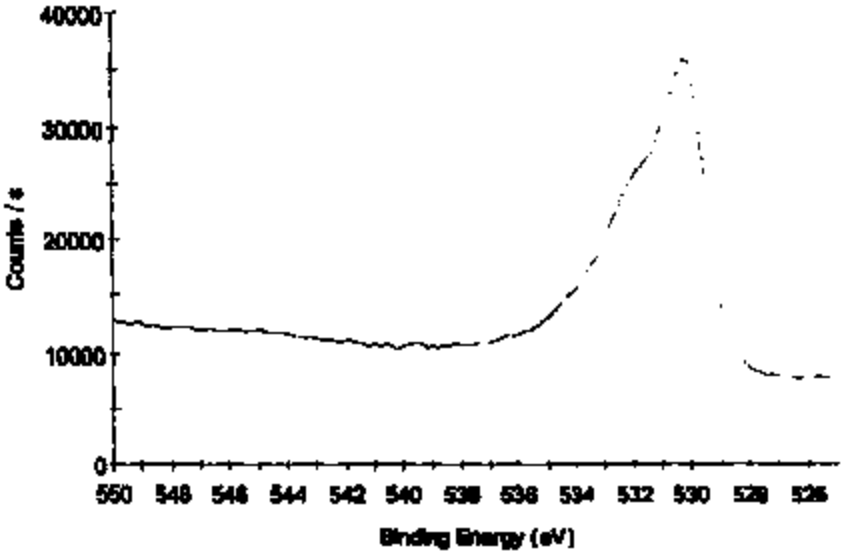

Figure 32

Survey

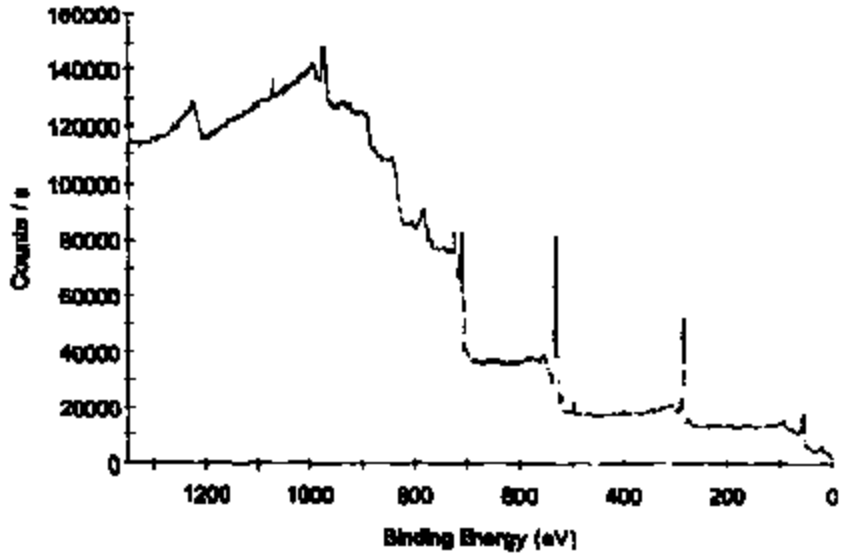

Figure 33

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STEEL AXLE PROJECT MIAMI

SKF 000855

MEST printout for:	Msgname:	Ref:	Received/Sent:
MAASSEN, ERIK C.	H1600141	*DISOSS*	95-06-08 21:29

From:	Company, Country:	Addr:
	ADDR: IBMX400.51940	HSNADS
To:		
MAASSEN, ERIK C.	SKF USA, DETROIT (AUTOM.), US	UDETECH

Subject:
SKF THUII Meeting

Date:
95-06-09

A meeting was held in Asheville on June 8 to discuss the THUII project. Attendees were:
Jerry Krug
Jack McKenzie
JP Pan
Ken Chalfin
Mike Barnett
Erik Maassen-SKF
Peter Lindholm-SKF
Steve Brown-SKF
Uwe Brockmuller-SKF Germany
Hans-Jurgen Dau-SKF Germany
The following items were discussed:

SKF has completed the validation testing for the hub. Hub testing was suspended when a 15-20mm crack was detected. The hub cycles are

530,000
670,000
810,000
837,000
970,000

SKF had misunderstood Rockwell's TP-926 test procedure and was under the impression that the one hub that had to run to 1,000,000 could not have a crack. J. Grant clarified the procedure to say that one hub must run one million cycles without a thru crack. SKF will place the hub that ran 970,000 cycles back on their test rig and run until 1 million cycles. Test was run at 13.2K rating.

Asheville will send two wheel nuts to J. Jennings so that Troy can run TP-926 on two SKF hubs. J. Krug to follow up.

SKF was asked to supply a free body diagram of their test procedure and compare it to the TP-926 loading.

SKF has proposed eliminating the undercut at the base of the drum pilot. This would increase the section size at their primary failure mode. RI must verify drum ID chamfers. Trailer Product's hub has no undercut and has a 2.3 mm radius. SKF will supply J. Krug the tolerance of the radius. 2.5 +.03 mm

Pages: 0 1 2 Msgname: H1600141

SKF has agreed to provide a chamfer on the OD of the hub flange to accommodate the reduce envelope brake drum. RI must supply the maximum diameter that can be allowed.

SKF has asked if the long stud can be used for steel wheel vocations (short stud vocations). RI will address issue with Freightliner.

SKF must have a decision on what seal design to use for production. Currently a Freudenburg design is being used. SKF has converted RVI to a CR design back in August of 1994. SKF is proposing the use of the CR design on RI product. RI has requested a design review meeting be held in Troy on July 6 at 1:00 pm to discuss this issue. Dale Bell and Bruce Murden have been asked to provide technical support. LAE will have a representative present. SKF has asked for RI to create a list of questions in advance of the meeting. B. Murden will be asked to help with formulating a list.

The decision has been made to introduce the screw in hub cap for production. Modifications to the hub design will be required. SKF is in the process of changing forging sources and moving to a larger capacity press. A new forging die is required and will contain the modifications to allow the screw in design. The changes will add approximately .5 kg of weight per hub and cost approximately 2.90 more. Regular production validation testing will be run on this design version. Ri is requesting that the new die be expidited due to the small quantity of hubs currently available from the last forging run. 150 hubs remain in Germany but approximately 25% of them contain forging laps. RI has requested SKF to hold non-conforming hubs for emergency use.

SKF has proposed changing the stud boss design to a continuous surface. This would make the forging axi-symatrical and result in a cost savings. This design change would be implemented after production has begun. Approximate timing is April of 96. Full validation testing would be run at that time. There is a potential for a weight increase of approximately 3 grams worst case.

SKF has requested an increase in the tolerance from the inner bearing seat to the drum/hub integrate. Current tolerance is +.2 mm. RI feels that +/- .4 mm would be acceptable. RI will verify this number with trailer products.

3009

Pages: 3 4. Msgname: H1600141

SKF is concerned about the lead in chamfer on the spindle. RI to review. SKF to provide proposal of chamfer angle and dimensions.

Hub identification information will be stamped on the OD of the flange. SKF is requesting information on Rockwell's requirement (julian date, logo, part number, etc). SKF has indicated that they can not put the Rockwell logo on the hub. SKF has indicated that they will provide a julian date plus several other serial numbers that will have to be tracked. Total numbers to be logged in will be 7 or 8.

If their are any corrections or additions to the meeting minutes please contact me ASAP. Thanks to all the people who were involved for their time, especially Uwe and Hans-Jurgen who travel from Europe to be here.

Jerry Krug Jr.

Extra X400 information begins:

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Sent by
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Domain Attrib: ID:AONA.GMKRUG
Node.Userid: IBMX400.51940
Subject: SKF THUII Meeting
Recipients
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Pages: 5 6 Msgname: H1600141

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Free Fmt Name: AONA -JWGRANT *JWGRANT

STOCK WARRANTY REVIEW 22-23 May 02

SKF 0000869

Bruce Weeks
10/30/2002 11:15 AM

To: Michael D Lewis/DE1/SKF@SKF
cc:

Subject: INFO: Warranty Root Cause Verification Parts

Mike,

These are summaries for the parts that are under further investigation for confirmation of root causes. Not all of these parts are out back. Those that are, have a '*' next to the claim number.

* E1800388 - Tentative determination - Oil Separation -
Oil in hubcap bowl, OB row VG but dry looking, IB VG but dry at small end, seal appears functional, does not appear to have ingress
ACTIONS TAKEN: Chem lab looking at grease samples for oil content
ACTIONS REQ'D: Assess after receipt of Chem Lab reports

* E1800672 2/2 - OPEN (Could be water ingress along spindle?)
Wet rusty bores, OB row VG with rust appearance in grease at small end, IB row VG with rust in grease at small end, IB seal appears functional, no corrosion on IB seal shoulder.
ACTIONS TAKEN: Chem lab looking at source of water, 5 grease samples supplied for contaminant determination to see if rust is coming from IR joint.
ACTIONS REQ'D: Assess after receipt of Chem Lab reports

* E1797640 1/2 - OPEN (could be IB seal ingress?)
OB Seal purge slightly excessive, IB row VG b ut a little dry, IB metallic debris - line spalls OR RW - IR RW slight spalling & shiny, IB seal appears functional.
ACTIONS TAKEN: Chem Lab lookin at grease samples to determination if this a contamination issue. IB seal was lost in shipment and cannot be examined. IB seal shoulder has slight corrosion under dust lip, four IB IR RW small shallow spalls with debris denting. GF has cyclolds
ACTIONS REQ'D: Assess after receipt of Chem Lab reports

* E1795181 - OPEN (could be hubcap or water along spindle)
OB seal gross leakage, OB row burnt-cage melted-IR & rollers shallow spalls 360 degrees at large end, OB OR RW shallow spalling at large end broken through to end of RW in spots (metallurgy?). IB row slight debris denting, IB IR RW one shallow spall with debris denting, IB seal appears functional- dust lip groove VG, main lip ~1.0 mm, seal shoulder VG.
ACTIONS TAKEN: Chem lab looking to determine if this is a contamination issue.
ACTIONS REQ'D: Consider metallurgy on OB OR RW for broken portion.

* E1776234 - Tentative determination - IB Seal Leak - Ingress
OB Seal off separation leak, OB row good, IB row rusty appearance, IB OR RW line spall, IB seal completely dry of grease & badly worn, IB IR GF blued with axial cracking 360 degrees, gross smearing especially in loaded zone to point of wearing away chamfer, roller end badly smeared and corners knocked off, IB seal dut lip worn out , main lip ~3.0 mm
ACTIONS TAKEN: None beyond visual inspection

* E1814675 - OPEN (could be hubcap or water along spindle? Or runout of IB seal?)
Wet rusty bores, bowl oil wetted, OB row rusty appearance-OR RW roller spaced spalls appear corrosion initiated, OB IR RW shallow spalling at small end, IB row honing structure still visable with very small rounded debris denting-GF shows cyclolds , IB seal dust lip worn out, main lip ~4.0 mm, no corrosion on seal shoulder, wear on IR under dust lip very slight at 180 to loadest zone, some

wear at load zone.
ACTIONS TAKEN: Chem lab looking at grease samples to determine direction of contamination flow.
ACTIONS REQ'D: Assess after receipt of chem lab report.

* E1812883 - OPEN (could be result of anti-seize compound through IR joint?) 12499 part
Silver anti-seize on OB seal &IR at OB side & bore, OB row VG - some anti-seize in grease at IR joint, IB row metallic debris, IB IR line spalls at roller spacing, grease at bearing center is ivory in color but is wrong date code for GWZ.
ACTION TAKEN: Chem lab looking at grease to determine if anti-seize is the problem, or was this unit re-greased.

* John Chamberlin, 35799-007094 - OPEN
Endplay 0.062", OB row VG, IB seal purge >2.0g, IB row burnt but only slight debris denting for large endplay, clip ring seems OK, IB seal dust lip worn out.
ACTIONS TAKEN: Chem lib determining if there is external contamination
ACTIONS REQ'D: Reassemble unit with new cages and re-check endplay, assess after receipt of chem lab reports.

11599-0135644 - OPEN
OB row VG, IB row rusty appearance with metallic debris, IB seal appears functional
ACTIONS TAKEN: Chem lab looking for external contamination in grease.

E1814599 - No Problem Found
Rusty bores, OB row VG, IB row VG, IB seal appears functional, grease pack appears uncontaminated, no internal distress.
ACTIONS TAKEN: Chem lab looking for contamination

E1806379 - Tentative determination - IB Seal Leak - Ingress
OB row rusty appearing grease but good condition, IB row burnt, IB seal lips worn out.
ACTIONS TAKEN: Chem lab looking at direction of contaminant flow to ensure that seal failed first.

E1803274 - OPEN - 12699 part
Dry rusty bores, OB row good with slight grease oxidation at center of RW, IB row rusty appearance-IB OR RW line spalls-metallic debris and denting, IB seal appears functional
ACTIONS TAKEN: Chem lab looking at grease to determine contaminant and flow direction
ACTIONS REQ'D: Assess after receipt of chem lab report.

E1800361 - Insignificant Leak
OB row VG, IB row VG, IB seal appears functional, no evidence of contamination apparent, no internal distress.
ACTIONS TAKEN: Chem lab looking at grease to insure no contamination has occured

E1797888 - Hubcap Lost
Rusty bores, hubcap threads rusty, OB row rusty appearance with metallic debris, IB row good with clean appearing grease, IB seal appear functional, no evidence of contamination in IB row
ACTIONS TAKEN: Chem lab looking at grease to determine contamination flow direction.

23 any further investigations 15 Oct 02

— E1800355 - Oil Sep? - Seal functional? - no ingress?
⊕ Chem lab looking at oil content

— E1800672 2/2 - Rust in grease at big row small ends - otherwise G.
⊕ Chem lab looking at source of water - spindle?

✓ E1797840 1/2 OB rowdry, 1B OR line pulls, seal looks OK - lubricant?
⊕ Chem lab looking to see if contam issue -
⇒ Micro exam of seal & seal shoulder

✓ E1795181 (1099.) OB row burnt, 1B row shallow pulls, seal OK?
⊕ Chem lab looking at if this is contam issue
⇒ Micro exam RW's, seal & shoulder

✓ E1796234 - 1B seal completely dry, 1B row OR line pulls
⇒ Exam seal & shoulder, 1B row RW's

✓ E1814575 - corrosion line pulls both rows, 1B seal worn, no rust shoulder
⇒ Micro exam of RW's, seal & shoulder

— E1812663 - Silver anti sieze - wrong grease?
⊕ Chem lab investigating

— John Chamberlin #5798-007094 - 1B row burnt - 0.062" EP w/ litter distress
⇒ ⊕ Microscopic exam ⊕ Chem lab verifying no ext contam.

8/23/02
further investigations

Root Cause
investigate & Detail

within 11099-13899

MNL: Truck Country 11699

~~E1812462 12399~~

E1800479 12399

E1803274 12699

E1800338 ~ 12799

Walmart 012217 11199

E1755899 12499

Sonal 7907 11199

11299

207,854 miles 0036033 13299

CB400804 11199

Walmart 2169 ~ 11199

E1741080 ~ 12399

~~E1800066 3~~

E1812466

~~E1741087 ?~~

~~E1741263 ?~~

E1809666

E1812663 (12499?)

John Chamberlin

E1800355

1372758 Aikan end play

E1800672½

~~E1800958?~~

~~E1799551?~~

E1797840½

E1795181 (11099?)

E1776234

E1814575 OB OR corrosion spall (11999?)

~~E1741011?~~

~~E1785105?~~

35798-0010894

17 Oct 02

E1776234

IB IR GF blood w/ axial cracking 360°
gross smearing - especially in loaded zone
to point of eliminating chamfer
Roller ends badly smeared & corner knocked off
IB seal dust lip worn out, main lip 3mm.

E1814575

IB Seal dust lip completely worn through
main lip 4.0mm
IB IR RW ~~excellent~~ - herring structure visible
but with rounded dessin of entry
GF shows cycloids
Seal shoulder very little wear at dust lip
at 180 to load zone - some wear at load zone

cont'd.

LE781[illegible]575 (cont'd)

~~E[illegible]~~

IB Seal VG - dust lip grooves bg
main lap ≈1.0mm
IB Seal shoulder VG w/little wear
IB OR RW G -
OB OR RW Roller spaced spalls - rusty
hubcap threads OK

E[illegible]1

IB Seal shoulder VG
IB Seal VG
OB IR 360° shallow spalls lg end
IB OR RW 1 spall shallow - debris denting
OB OR RW broken out at lg end

E1797840 1/2

Seal cost - cannot examine
IB IR Seal shoulder slight corrosion under dust lip
GF RW small shallow spalls + debris denting
GF cycloids

SKF Steer Hub Inspection

453,864

Customer: [illegible] Freightliner Claim #: E1800657 Mileage: 730,267 K.Y.

VIN #: 1FUYDDZ86WP898874 Hub Serial #: M879510

Customer Complaint: Hub Bearing loose

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads down: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >5 grams: yes no Endplay: no yes If no: .006"

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on lower BRG cone front: yes no In service date: 07/01/97 Failed: 04/17/02

Comments: wet rusty bores, IB IR to side face very rusty, OB row VG, IB row rusty - debris denting - shallow spall by end, IB seal lips worn out.

Disposition: VALID Sent to SKF 07/15/02 Bar 2

Root cause: IB SEAL LEAK - INGRESS

Customer: John Chamberlin Claim #: N/A Mileage: 207711

VIN #: 2HSFMAHR47C038090 Hub Serial #: 35798-0070094

Customer Complaint: Hub Bearing loose

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads down: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >5 grams: yes no Endplay: no yes If no: .062"

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on lower BRG cone front: yes no In service date: 02/18/00 Failed: 01/17/03

Comments: OB row VG, IB seal purge >2.0g, IB row burnt but only slight debris denting for 0.062" endplay IB seal dust lip worn out

Disposition: OPEN Sent to SKF 07/15/02

Root cause:

SKF	NATC SERVICE REQUEST	Service Number	Issue Number

Service Requested By	Department Number	Service Request Date	Required Completion Date
J. Bruce Weeks	711	6/26/2002	9/6/2002
Service to be Paid By	**Department Number**	**Approval Signature (Payer)**	**Approval Date**
711	711	J. Bruce Weeks	9/6/2002

Type of Service (A project specification is required for projects and Market laboratory services)

[X] Task A (<40 hours) [ ] Task B (<40 hours) [ ] Project (Field requirements/field contract) [ ] Development (Changing requirements and measures) [ ] Laboratory

Item Description	Steer THU	Customer	ArvinMeritor
Source or Factory	Aiken	Application	FF-98X Steer Axle
SKF Part Number	BTF-0052	Customer Part Number	HFFU-OOTS-32
Critical Safety Item	[ ] Yes [X] No	Special Characteristics	

A critical safety item is a part, assembly, or production system with one or more specified characteristics, that if not conforming to the design data or quality requirements, would result in an unsafe condition that could cause loss of serious damage to the end item or major components, loss of utilities, or serious injury.

Disposition of Samples [ ] (2) Years [ ] (1) Year [ ] (6) Months [X] Return [ ] Discard [ ] Specify

Customer Request, Service Objective, Reason for Service (This section is specified by the customer)

One grease sample supplied - Is there any evidence of external contamination?

IB large end

Background, Item History, Application Data, Test Conditions (This section is specified by the customer)
(Note: All drawings, test specifications, and application parameters are required with this request.)

Warranty Claim Julian date 35798 Serial #0070094 - Unknown miles - any evidence of external contamination?

John Chamberlin

NATC Service Recommendation and Deliverables (including pre- and post test inspections/evaluations)

Specification Numbers (ASTM, SKF, etc.)

NATC Use Only

Capability [ ] Yes [ ] No Resources Available [ ] Yes [ ] No Subcontract [ ] Yes [ ] No

Estimated Cost Estimated Completion Date [ ] Specification to be Developed

Activity Title Assigned To

Revision Description

Service Request Form (v5a) 03-20-2002

SKF C06869

John Chamberlin

1B seal dust lip completely worn out
main lip ~ 4.0mm
(A IR GF cycloids & smearing but little wear
rust stains on seal shoulder
1 shallow spall at SM End -
roller ends scored but little wear
Clip ring ok - no nose deformities

SKF Steer Hub Inspection

Customer: Burke : Freightliner Corp. Claim #: E1783280 ✓ Mileage: 221,463

Vehicle: 1FUYSSZR84LF59797 Hub Serial #: 20699 - 0167469

Customer Complaint: Mr. Bearing Bonds Sticks.

Complete hub rebuilt: yes no Highly progressive backlash: yes no Hammer work: yes no

Hub cap threads clean: yes no Wheel silt: yes no

IB seal purge >5 grams: yes no O/B seal purge >2 grams: yes no Endplay: yes no If no ____

Smooth rotation: yes no and drag acceptable: yes no Clip ring generally: yes no

Grender witness marks on lower RRS cone faces: yes no In service date: 12/27/99 Rebuilt: 01/26/00

Comments: OB ROW VG, IB ROW VG, IB Seal functional, no internal distress.

Disposition: INVALID ~~Sent to SKF~~ 07/03/02

Root cause: NPF

Box 2

Customer: Dorsa Hahn : Freightliner Claim #: E1747888 Mileage: 580,181

Vehicle: 1FUYSSER84LB65874 Hub Serial #: Rusty N/A Aiken

Customer Complaint: Mr. Bearing Noisy Rattles

Complete hub rebuilt: yes no Highly progressive backlash: yes no Hammer work: yes no

Hub cap threads clean: yes no Wheel silt: yes no

IB seal purge >5 grams: yes no O/B seal purge >2 grams: yes no Endplay: yes no If no ____

Smooth rotation: yes no and drag acceptable: yes no Clip ring generally: yes no

Grender witness marks on lower RRS cone faces: yes no In service date: 07/01/99 Rebuilt: 07/12/02

Comments: rusty bores & hubcap Thread, OB row rusty & dust debris, IB ROW G, grease clean, IB Seal VG & functional - no evidence of contamination

GREASE SAMPLES TAKEN

Disposition: INVALID Sent to SKF 07/03/02

Root cause: HUBCAP LOST

Box 2

SKF	NATC SERVICE REQUEST	Service Number	Issue Number

Service Requested By	Department Number	Service Request Date	Required Completion Date
J. Bruce Weeks	711	8/28/2002	9/6/2002
Service to be Paid By	**Department Number**	**Approval Signature (Payer)**	**Approval Date**
711	711	J. Bruce Weeks	9/6/2002

Type of Service (A project specification is required for projects and blanket laboratory services)

[X] Task A (< 40 Hours) [ ] Task B (>40 Hours) [ ] Project (Fixed requirements/fixed contract) [ ] Development (Changing requirements/fixed contract) [ ] Laboratory

Item Description	Steer THU	Customer	ArvinMeritor
Source or Factory	Aiken	Application	FF-98X Steer Axle
SKF Part Number	BTF-0062	Customer Part Number	HFFU-OOTS-32
Critical Safety Item	[ ] Yes [X] No	Special Characteristics	

A critical safety item is a part, assembly, or production system with one or more essential characteristics, that if not conformed to the design data or quality requirements, would result in an unsafe condition that could cause loss or serious damage to the end item or major components, loss of control, or serious injury.

Disposition of Samples [ ] (2) Years [ ] (1) Year [ ] (0) Months [X] Return [ ] Discard [ ] Specify

Customer Request, Service Objective, Reason for Service (This section is specified by the customer)

Four grease samples supplied - What is level of external contamination in these samples
Where is the contamination coming from? Which end of bearing?
IB large end, IB small end, OB small End, OB large end

Background, Item History, Application Data, Test Conditions (This section is specified by the customer)
(Note: All drawings, test specifications, and application parameters are required with this request.)

Warranty Claims E1797868 580161 miles - Appears contamination is coming from hubcap
Is this true?

NATC Service Recommendation and Deliverables (including pre- and post test inspections/evaluations)

Specification Numbers (ASTM, SKF, etc.)

NATC Use Only

Capability [ ] Yes [ ] No Resources Available [ ] Yes [ ] No Subcontract [ ] Yes [ ] No

Estimated Cost Estimated Completion Date [ ] Specification to be Developed

Activity Title Assigned To

Revision Description

Service Request Form (nfs) 03-20-2002

SKF Steer Hub Inspection

Customer: Hegarthal - Freightline Claim #: E1800360 Mileage: 252,118

VIN: 1FUYSA4B6YLB91892 Hub Serial #: 23199 - 0187013

Customer Complaint: Hub Roaring Leak

Complete hub rotation: yes no Highly progressive incident: yes no Hammer work: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >4 grams: yes no Endplay: no yes If no .028"

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on lower RRG cone forces: yes no In service date: 12/16/98 Failure: 04/17/02

Comments: rusty bores, OB row slightly rusty very minor debris denting, IB row Burnt - roller ends worn down to shoulders, IB seal completely worn out.

Disposition: VALID ~~Sent to SKF~~ 07/02/02

Root cause: IB Seal Leak - Ingress

Customer: Ryan S. Inc. Freightline Claim #: E1800361 Mileage: 349,004

VIN: 1FUYSSEB3YLF08241 Hub Serial #: 17497 - 0154900

Customer Complaint: Hub Roaring Leaks

Complete hub rotation: yes no Highly progressive incident: yes no Hammer work: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >4 grams: yes no Endplay: yes If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on lower RRG cone forces: yes no In service date: 12/07/99 Failure: 04/15/02

Comments: OB row VG, IB row VG, IB Seal functional, no evidence of contamination, no internal debris

Disposition: INVALID ~~Sent to SKF~~ 07/02/02

Root cause: INSIGNIFICANT LEAK

SKF	NATC SERVICE REQUEST	Service Number	Issue Number

Service Requested By	Department Number	Service Request Date	Required Completion Date
J. Bruce Weeks	711	8/26/2002	9/6/2002
Service to be Paid By	**Department Number**	**Approval Signature (Payer)**	**Approval Date**
711	711	J. Bruce Weeks	9/6/2002

Type of Service (A project specification is required for projects and market laboratory services)

[X] Task A (< 45 Hours) [ ] Task B (> 45 Hours) [ ] Project (Plant requirements/cost scenario) [ ] Development (Changing requirements and suppliers) [ ] Laboratory

Item Description	Steer THU	Customer	ArvinMeritor
Source or Factory	Aiken	Application	FF-96X Steer Axle
SKF Part Number	BTF-0052	Customer Part Number	HFFU-OOTS-32
Critical Safety Item	[ ] Yes [X] No	Special Characteristics	

A critical safety item is a part, assembly, or production system with one or more especial characteristics, that if not conforming to the design data or quality requirements, would result in an unsafe condition that could cause loss or injury through to the end loss or major components, risk or damage, to serious injury.

Disposition of Samples [ ] (2) Years [ ] (1) Year [ ] (6) Months [X] Return [ ] Discard [ ] Specify

Customer Request, Service Objective, Reason for Service (This section is specified by the customer)

Two grease supplies supplied - Is there external contamination present?

Between IB seal lips, IB row at large end

Background, Item History, Application Data, Test Conditions (This section is specified by the customer)
(Note: All drawings, test specifications, and application parameters are required with this request.)

Warranty Claim E1800361 - 349004 miles - Want to confirm that contaminant ingress has not occurred

NATC Service Recommendation and Deliverables (including pre- and post test inspections/evaluations)

Specification Numbers (ASTM, SKF, etc.)

NATC Use Only

Capability [ ] Yes [ ] No Resources Available [ ] Yes [ ] No Subcontract [ ] Yes [ ] No

Estimated Cost Estimated Completion Date [ ] Specification to be Developed

Activity Title Assigned To

Revision Description

Service Request Form (v5a) 03-20-2002

Customer: _____ Claim #: E1803274 Mileage: N/A

Vinfo: N/A Hub Serial #: 17699 0130413

Customer Complaint: N/A

Complete hub received: yes no Highly progressive incident: yes no Hammer seed: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >1 grams: yes no Endplay: no yes If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: N/A failed: N/A

Comments: dry rusty bris, OBrowG w/ slight oxidation at ch of RW, IB raw rusty - OR RW fine spalls - not debris & denting, seal appears OK

GREASE SAMPLES TAKEN

Disposition: OPEN Sent to SKF

Root cause: _____

Customer: _____ Claim #: _____ Mileage: _____

Vinfo: _____ Hub Serial #: _____

Customer Complaint: _____

Complete hub received: yes no Highly progressive incident: yes no Hammer seed: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >1 grams: yes no Endplay: no yes If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: _____ failed: _____

Comments: _____

Disposition: _____

Root cause: _____

SKF	NATC SERVICE REQUEST	Service Number	Issue Number

Service Requested By	Department Number	Service Request Date	Requested Completion Date
J. Bruce Weeks	711	8/28/2002	9/6/2002
Service to be Paid By	**Department Number**	**Approval Signature (Payer)**	**Approval Date**
711	711	J. Bruce Weeks	9/6/2002

Type of Service (A project specification is required for projects and Minitat laboratory services)

[X] Task A (1-40 Hours) [ ] Task B (>40 Hours) [ ] Project (With implementation/post contact) [ ] Development (Design/equipment modification and evaluation) [ ] Laboratory

Item Description	Steer THU	Customer	ArvinMeritor
Source or Factory	Allan	Application	FF-9BX Steer Axle
SKF Part Number	BTF-0052	Customer Part Number	HFFU-OOTS-32
Critical Safety Item	[ ] Yes [X] No	Special Characteristics	

A critical safety item is a part, assembly, or production system with one or more operational characteristics, that if not conforming to the design data or quality requirements, could result in an unsafe condition that could affect form or assembly compatibility, type of vehicle, or vehicle style.

Disposition of Samples [ ] (2) Years [ ] (1) Year [ ] (6) Months [X] Return [ ] Discard [ ] Specify

Customer Request, Service Objective, Reason for Service (This section is specified by the customer)

Three grease samples supplied - Appears that contamination is not coming through IB seal
Need contaminant content and type.
IB seal between lips, IB large end, IB small end

Background, Item History, Application Data, Test Conditions (This section is specified by the customer)
(Note: All drawings, test specifications, and application parameters are applied with this request.)

Warranty Claim E1603274 - Unknown miles - Is contamination coming through seal?

NATC Service Recommendation and Deliverables (including pre- and post test inspections/audits/surveys)

Specification Number (ASTM, SKF, etc.)

NATC Use Only

Capability [ ] Yes [ ] No Resources Available [ ] Yes [ ] No Subcontract [ ] Yes [ ] No

Estimated Cost Estimated Completion Date [ ] Specification to be Developed

Activity Title Assigned To

Revision Description

SKF Steer Hub Inspection

349,169

Customer: Freightliner Corp. Claim #: E1808379 Mileage: 561,813 Kilo

Vehicle: 1FUYNWDB3YLF40552 Hub Serial #: N/A Rusty Axlen

Customer Complaint: Hub Bearing Broken

Complete hub received: yes no Highly progressive incident: yes no Measurement: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >1 grams: yes no Bodyplay: yes no If no ___

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on lower BRG cone forms: yes no In service date: [illegible] Date: 05/01/02

Comments: OB [illegible] rusty grease but Good cond. IB [illegible] IB Seal [illegible]

Disposition: VALID ~~Sent to SKF~~ 07/[illegible]/02

Root cause: IB Seal LEAK - INGRESS

349,457

Customer: Freightliner Corp. Claim #: E1800672 2/L Mileage: 546,186 Kilo

Vehicle: 2FUYNWDB0WA701401 Hub Serial #: N/A Lunchbowl Rusty

Customer Complaint: Hub Bearing Broke; Stick

Complete hub received: yes no Highly progressive incident: yes no Measurement: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >1 grams: yes no Bodyplay: yes no If no ___

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on lower BRG cone forms: yes no In service date: 07/23/[illegible] Date: 05/01/02

Comments: wet rusty bores, OB [illegible] VG rust in grease @ small end, IB VG rust in grease at small end, IB Seal functional, [illegible] on IB IB Seal shoulder

GREASE SAMPLES TAKEN

Disposition: OPEN Sent to SKF 07/11/02

Root cause: [illegible]

SKF 000877

SKF	NATC SERVICE REQUEST	Service Number	Issue Number

Service Requested By	Department Number	Service Request Date	Required Completion Date
J. Bruce Weeks	711	8/29/2002	9/6/2002
Service to be Paid By	**Department Number**	**Approval Signature (Payer)**	**Approval Date**
711	711	J. Bruce Weeks	9/6/2002

Type of Service (A project specification is required for projects and Market laboratory services)

[X] Task A (< 40 Hours) [ ] Task B (> 40 Hours) [ ] Project (First requirements/fixed contract) [ ] Development (Changing requirements/fixed contract) [ ] Laboratory

Item Description	Steer THU	Customer	ArvinMeritor
Source or Factory	Alrea	Application	FF-96X Steer Axle
SKF Part Number	BTF-0052	Customer Part Number	HFFU-OOTS-32
Critical Safety Item	[ ] Yes [X] No	Special Characteristics	

A critical safety item is equal, assembly, or production system with one or more essential characteristics, that if not conforming to the design state or quality requirements, would result in an unsafe condition that could cause loss or serious damage to the end item or major components, loss of control, or serious injury.

Disposition of Samples [ ] (2) Years [ ] (1) Year [ ] (6) Months [X] Return [ ] Discard [ ] Specify

Customer Request, Service Objective, Reason for Service (This section is specified by the customer)

Five grease samples supplied - Appears that water is ingressing at joint between inner rings.
Need contaminant content and type.
IB small end, IB large end, OB large end, OB small end, OR at bearing center

Background, Item History, Application Data, Test Conditions (This section is specified by the customer)
(Note: All drawings, test specifications, and application parameters are required with this request.)

Warranty Claim E1600672 2 of 2 - 339457 miles - Is the rust coming from the joint between inner rings?

NATC Service Recommendation and Deliverables (including pre- and post test inspections/evaluations)

Specification Numbers (ASTM, SKF, etc.)

NATC Use Only

Capability [ ] Yes [ ] No Resources Available [ ] Yes [ ] No Subcontract [ ] Yes [ ] No

Estimated Cost Estimated Completion Date [ ] Specification to be Developed

Activity Title Assigned To

Revision Description

Service Request Form (v5a) 03-20-2002

SKF	NATC SERVICE REQUEST	Service Number	Issue Number

Service Requested By	Department Number	Service Request Date	Required Completion Date
J. Bruce Weeks	711	8/26/2002	9/6/2002
Service to be Paid By	**Department Number**	**Approval Signature (Payer)**	**Approval Date**
711	711	J. Bruce Weeks	9/6/2002

Type of Service (A project specification is required for projects and blanket laboratory services)

[X] Task A (1-40 Hours) [ ] Task B (1-80 Hours) [ ] Project (Field requirements/test contract) [ ] Development (Changing requirements/test and reference) [ ] Laboratory

Item Description	Steer THU	Customer	ArvinMeritor
Source or Factory	Aiken	Application	FF-98X Steer Axle
SKF Part Number	BTF-0052	Customer Part Number	HFFU-OOTS-32
Critical Safety Item	[ ] Yes [X] No	Special Characteristics	

A critical safety item is a part, assembly, or production system with one or more selected characteristics, that if not conforming to the design data or quality requirements, would result in an unsafe condition that could cause loss or serious damage to the end item or major components, loss of service, or serious injury.

Disposition of Samples [ ] (2) Years [ ] (1) Year [ ] (6) Months [X] Return [ ] Discard [ ] Specify

Customer Request, Service Objective, Reason for Service (This section is specified by the customer)

Four grease samples supplied - Appears that seal failed
Need contaminant content and type.
OB small end, OB large end, IB small end, IB large end

Background, Item History, Application Data, Test Conditions (This section is specified by the customer)
(Note: All drawings, test specifications, and application parameters are required with this request.)

Warranty Claim E1808379 - 349169 miles - From what direction is contamination coming?

NATC Service Recommendation and Deliverables (Including pre- and post test inspections/evaluations)

Specification Number (ASTM, SKF, etc.)

NATC Use Only

Capability [ ] Yes [ ] No Resources Available [ ] Yes [ ] No Subcontract [ ] Yes [ ] No

Estimated Cost Estimated Completion Date [ ] Specification to be Developed

Activity Title Assigned To

Revision Description

Service Request Form (v6a) 03-20-2002

SKF C00879

SKF Star Hub Inspection

Customer: Freightliner Corp. Claim #: E18083187 X Mileage: 196,433 11

VIN: 1FUYSSZB3XLA63806 Hub Serial #: 04999 - 0092566

Customer Complaint: Hub Bearing Brake; Shirks

Complete hub rendrek (yes) no Highly progressive incident yes (no) Hammer mark yes (no)

Hub cap thrust clean: yes (no) Wheel off yes (no)

IB seal purge >5 grams (yes) no OB seal purge >4 grams yes (no) Endplay (no) yes If no ___

Smooth rotation (yes) no seal drag acceptable (yes) no Clip ring grooves yes (no) - noses pulled

Circular witness marks on inner RRG case faces yes (no) In service date 04/11/99 Initials 07/05/02

Comments: bowl oil wetted, OB row VG, clip ring noses pulled, IB row VG, IB Seal VG, no evidence of contamination, no internal dishess

Disposition: INVALID Sent to SKF 07/24/02

Designation: ~~NPF~~ REMOVAL DAMAGE Box 3

Customer: Arrow: Freightliner Claim #: E18145977 X Mileage: 207,120

VIN: 1FUYSSEBOVDB35187 Hub Serial #: 11879 - 0126227

Customer Complaint: Hub Bearing loose

Complete hub rendrek (yes) no Highly progressive incident yes (no) Hammer mark yes (no)

Hub cap thrust clean: yes (no) Wheel off yes (no)

IB seal purge >5 grams (yes) no OB seal purge >4 grams yes (no) Endplay (no) yes If no ___

Smooth rotation (yes) no seal drag acceptable (yes) no Clip ring grooves yes no

Circular witness marks on inner RRG case faces yes no In service date 07/02/99 Initials 05/21/02

Comments: mid plane, OB row G, IB row VG, IB Seal functional - grease pack not contaminated - no internal dishess

GREASE SAMPLES TAKEN

Disposition: 1 of 2 INVALID Sent to SKF 07/24/02 Box 3

Root cause: NPF

SKF 000880

SKF	NATC SERVICE REQUEST	Service Number	Issue Number

Service Requested By	Department Number	Service Request Date	Required Completion Date
J. Bruce Weeks	711	8/26/2002	9/6/2002
Service to be Paid By	**Department Number**	**Approval Signature (Paper)**	**Approval Date**
711	711	J. Bruce Weeks	9/6/2002

Type of Service (A project specification is required for projects and blanket laboratory services)

[X] Task A (< 40 Hours) [ ] Task B (> 40 Hours) [ ] Project (Fixed requirements/fixed contract) [ ] Development (Changing requirements/fixed contract) [ ] Laboratory

Item Description	Steer THU	Customer	Arvin/Meritor
Source of Factory	Aiken	Application	FF-98X Steer Axle
SKF Part Number	BTF-0052	Customer Part Number	HFFU-ODTS-32
Critical Safety Item	[ ] Yes [X] No	Special Characteristics	

A critical safety item is a part, assembly, or production system with one or more material characteristics, that if not conforming to the design data or quality requirements, would result in an unsafe condition that would cause loss or serious damage to the end item or major components, loss of mission, or serious injury.

Disposition of Samples [ ] (2) Years [ ] (1) Year [ ] (6) Months [X] Return [ ] Discard [ ] Specify

Customer Request, Service Objective, Reason for Service (This section is specified by the customer)

Four grease samples supplied - Is there any evidence of external contamination?

OB small end, OB large end, IB large end, IB small end

Background, Item History, Application Data, Test Conditions (This section is specified by the customer)
(Note: All drawings, test specifications, and application parameters are required with this request.)

Warranty Claim E1814599 - 207120 miles - any evidence of contamination?

NATC Service Recommendation and Deliverables (including pre- and post test inspections/evaluations)

Specification Numbers (ASTM, SKF, etc.)

NATC Use Only

Capability [ ] Yes [ ] No Resources Available [ ] Yes [ ] No Subcontract [ ] Yes [ ] No

Estimated Cost Estimated Completion Date [ ] Specification to be Developed

Activity Title Assigned To

Revision Description

Service Request Form (v6a) 03-20-2002

SKF Steer Hub Inspection

Customer: SKB: Freightliner Corp Claim #: E1800564 X Mileage: 262660

Vehicle: 1FUJAPBD01PF73062 Hub Serial #: 07000 - A253341

Customer Complaint: Hub Bearing Brake; Sticks

Complete hub received: (yes) no Highly progressive incident: yes (no) Hammer used: yes (no)

Hub cap threads done: yes (no) Wheel bolt: yes (no)

I/B seal purge >5 grams: yes (no) O/B seal purge >8 grams: yes (no) Redeploy: (no) yes If no ____

Smooth rotation: (yes) no seal drag acceptable: (yes) no Clip ring grooved: yes (no)

Circular witness marks on inner RRG cone faces: yes (no) In service date: 04/08/02 Initials: 03/08/02

Comments: OB Row VG Slightly dry, IB Row VG, IB Seal excellent, no internal contress

Disposition: ~~to AVAILD Sent to SKF~~ 07/08/02 Box 2

Root cause: NPF

Customer: MNL: Track Country Claim #: N/A Mileage: N/A X

Vehicle: N/A Hub Serial #: 11699 - 035544

Customer Complaint: N/A

Complete hub received: (yes) no Highly progressive incident: yes (no) Hammer used: yes no

Hub cap threads done: (yes) no Wheel bolt: yes (no)

I/B seal purge >5 grams: (yes) no O/B seal purge >8 grams: yes (no) Redeploy: (no) yes If no ____

Smooth rotation: yes (no) seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner RRG cone faces: yes no In service date: N/A Initials: N/A

Comments: OB Row VG, IB Row nearly w/ rust debris, IB Seal excellent

GREASE SAMPLES TAKEN

Disposition: OPEN SENT TO SKF 07/08/02

Root cause: ____

SKF	NATC SERVICE REQUEST	Service Number	Issue Number

Service Requested By	Department Number	Service Request Date	Required Completion Date
J. Bruce Weeks	711	8/26/2002	9/6/2002
Service to be Paid By	**Department Number**	**Approval Signature (Paper)**	**Approval Date**
711	711	J. Bruce Weeks	9/6/2002

Type of Service (A project specification is required for projects and Market laboratory services)

[X] Task A (2-40 Hours) [ ] Task B (40 Hours) [ ] Project (Field requirements/field service) [ ] Development (Changing requirements and concepts) [ ] Laboratory

Item Description	Steer THU	Customer	ArvinMeritor
Source or Factory	Aiken	Application	FF-98X Steer Axle
SKF Part Number	BTF-0052	Customer Part Number	HFFU-OOTS-32
Critical Safety Item	[ ] Yes [X] No	Special Characteristics	

A critical safety item is a part, assembly, or production system with one or more essential characteristics, that if not conforming to the design area or quality requirements, would result in an unsafe condition that would cause fire or serious damage in the end use or major components, loss of control, or pollution rates.

Disposition of Samples [ ] (2) Years [ ] (1) Year [ ] (6) Months [X] Return [ ] Discard [ ] Specify

Customer Request, Service Objective, Reason for Service (This section is specified by the customer)

Two grease samples supplied - Is there any evidence of external contamination?

IB large end, IB small end

Background, Item History, Application Data, Test Conditions (This section is specified by the customer)
(Note: All drawings, test specifications, and application parameters are required with this request.)

Warranty Claim Julian date 11699 Serial #0135544 - Unknown miles - any evidence of external contamination?

NATC Service Recommendation and Deliverables (including pre- and post test inspections/evaluations)

Specification Numbers (ASTM, SKF, etc.)

NATC Use Only

Capability [ ] Yes [ ] No Resources Available [ ] Yes [ ] No Subcontract [ ] Yes [ ] No

Estimated Cost Estimated Completion Date [ ] Specification to be Developed

Activity Title Assigned To

Revision Description

Service Request Form (ofa) 03-20-2002

SKF Stow Hub Inspection

Customer: Freightliner Corp. Claim #: E18109666 X Mileage: 346,050

Vin #: 1FUYSSZ8Y1PA83326 Hub Serial #: 15299-0142790

Customer Complaint: Hub Assembly Corroded

Complete hub received: (yes) no Highly progressive incident: yes (no) Hammer work: yes (no)

Hub cap threads clean: yes (no) Wheel off: yes (no)

I/B seal purge >.5 grease: yes (no) O/B seal purge >.5 grease: yes (no) Bodyplay: (yes) yes If no ____

Smooth rotation: (yes) no and drag acceptable: (yes) no Clip ring grooves: yes no

Circular witness marks on inner BRG cone front: yes no In service date: 3/11/99 Initials: 05/16/02

Comments: OB Row VG, IB Row VG, IB Seal Excellent, no external dolines

Disposition: 2 of 2 INVALID sent to SKF 07/17/02 / Sep 2

Root cause: NPF

Customer: Wheelmart Inc. Freightliner Claim #: E1812667 X Mileage: 624,430

Vin #: 1FUYDXYR2WP8[illegible]704 Hub Serial #: 09600-0264979

Customer Complaint: Hub Bearing Noisy

Complete hub received: (yes) no Highly progressive incident: yes (no) Hammer work: yes (no)

Hub cap threads clean: yes (no) Wheel off: yes (no)

I/B seal purge >.5 grease: yes (no) O/B seal purge >.5 grease: yes (no) Bodyplay: (yes) yes If no ____

Smooth rotation: yes (no) and drag acceptable: yes (no) Clip ring grooves: yes no

Circular witness marks on inner BRG cone front: yes no In service date: 07/07/98 Initials: 05/06/02

Comments: Silver anti-siege on OB Seal & IR at OB side & bore, OB Row VG - some anti-siege in grease at IR joint, IB Row [illegible] - IR line spalls @ [illegible] spacing - grease at bearing center [illegible] - NOT GWZ? (wrong date code for GWZ)
Lots of grease samples

Disposition: OPEN sent to SKF 07/17/02

Root cause: ____

SKF	NATC SERVICE REQUEST	Service Number	Issue Number

Service Requested By	Department Number	Service Request Date	Required Completion Date
J. Bruce Weeks	711	8/26/2002	9/6/2002
Service to be Paid By	**Department Number**	**Approval Signature (Payer)**	**Approval Date**
711	711	J. Bruce Weeks	9/6/2002

Type of Service (A project specification is required for projects and blanket laboratory services)

[X] Task A (1-20 Hours) [ ] Task B (>20 Hours) [ ] Project (Field requirements/Test comments) [ ] Development (Changing requirements and deliverable) [ ] Laboratory

Item Description	Steer THU	Customer	ArvinMeritor
Source or Factory	Aiken	Application	FF-98X Steer Axle
SKF Part Number	BTF-0052	Customer Part Number	HFFU-OOTS-32
Critical Safety Item	[ ] Yes [X] No	Special Characteristics	

A critical safety item is a part, assembly, or production system with one or more essential characteristics. Test if not conforming to the design data or quality requirements, would result in an unsafe condition that would cause loss or serious damage to the end item or major components, data of critical, or critical query.

Disposition of Samples [ ] (2) Years [ ] (1) Year [ ] (6) Months [X] Return [ ] Discard [ ] Specify

Customer Request, Service Objective, Reason for Service (This section is specified by the customer)

Six grease samples supplied - Appears anti-seize compound got into bearing at inner ring joint.
Is grease degraded by anti-seize compound?
OB small end, OB large end, IB small end, IB large end, between seal lips, OR at bearing center

Background, Item History, Application Data, Test Conditions (This section is specified by the customer)
(Note: All drawings, test specifications, and application parameters are required with this request.)

Warranty Claim E1812683 - 624436 miles - Did anti-seize compound cause this failure?

Grease appears very in color - what grease is this?

NATC Service Recommendation and Deliverables (including pre- and post test inspections/evaluations)

Specification Numbers (ASTM, SKF, etc.)

NATC Use Only

Capability [ ] Yes [ ] No Resources Available [ ] Yes [ ] No Subcontract [ ] Yes [ ] No

Estimated Cost Estimated Completion Date [ ] Specification to be Developed

Activity Title Assigned To

Revision Description

Service Request Form (v6a) 03-20-2002

SKF 000885

SKF Steer Hub Inspection

Customer: GIF : Freightliner Claim #: E1814525 ✓ Mileage: 463,276

VIN#: 1FUBSDZBSXP783252 Hub Serial #: 21998-0011572

Customer Complaint: Hub Rotation Bearing Shields

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads done: yes no Wheel off: yes no

I/B seal purge >5 grease: yes no O/B seal purge >8 grease: yes no Endplay: yes if no

Smooth rotation: yes no and drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on lower BRG cone forest: yes no In service date: 10/03/99 Failure: 04/30/02

Comments: Wet rusty bres, Dual oil wetted, OB row rusty OR RW roller spaced spalls corrosion initiated IR RW shallow spalls small end, IB row G, IB seal dual lip worn out - no rust on IB seal shoulder

Disposition: OPEN Sent to SKF 07/02/02

Root cause:

Customer: Sanford : Freightliner Claim #: E1781277 ✓ Mileage: 306,828 ~~[illegible]~~

VIN#: 1FUYSXYBXYLB[illegible] Hub Serial #: [illegible]

Customer Complaint: Hub Rotation Bearing

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads done: yes no Wheel off: yes no

I/B seal purge >5 grease: yes no O/B seal purge >8 grease: yes no Endplay: no if no -.021"

Smooth rotation: yes no and drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on lower BRG cone forest: yes no In service date: 10/[illegible] Failure: 05/[illegible]

Comments: Hub looks like it has been setting in 3" of water after removal, OB row rusty but no corrosion spalls, grease at bag on clear, IB row burnt & rusty - debris denting - IB IR RW shallow spalls, IB seal worn out - IR shoulder completely rusted - bore & lip seal face completely rusted

Disposition: VALID Sent to SKF 07/22/02

Root cause: IB Seal Leak - ingress

Box 3

SKF	NATC SERVICE REQUEST	Service Number	Issue Number

Service Requested By	Department Number	Service Request Date	Request Completion Date
J. Bruce Weeks	711	8/28/2002	9/6/2002
Service to be Paid By	**Department Number**	**Approval Signature (Payer)**	**Approval Date**
711	711	J. Bruce Weeks	9/6/2002

Type of Service (A project specification is required for projects and started laboratory services)

[X] Task A (40 Hours) [ ] Task B (>40 Hours) [ ] Project (Fixed requirements/test method) [ ] Development (Changing requirements/test method) [ ] Laboratory

Item Description	Steer THU	Customer	Arvinmeritor
Source or Factory	Alton	Application	FF-98X Steer Axle
SKF Part Number	BTF-0052	Customer Part Number	HFFU-OOTS-32
Critical Safety Item	[ ] Yes [X] No	Special Characteristics	

A critical safety item is a part, assembly, or production system without one or more essential characteristics that if not conforming to the design data or quality requirements, would result in an unsafe condition that could cause loss or serious damage to the end item or major components, loss of control, or serious injury.

Disposition of Samples [ ] (2) Years [ ] (1) Year [ ] (6) Months [X] Return [ ] Discard [ ] Specify

Customer Request, Service Objective, Reason for Service (This section is specified by the customer)

Three grease samples supplied - Appears contamination is coming from somewhere other than seal. What is contamination content and type?
OB small end, OB large end, IB large end

Background, Item History, Application Data, Test Conditions (This section is specified by the customer)
(Note: All drawings, test specifications, and application parameters are required with the request.)

Warranty Claim E1614575 - 463276 miles - From what direction did contamination come?

NATC Service Recommendation and Deliverables (including pre- and post test inspections/evaluations)

Specification Numbers (ASTM, SKF, etc.)

NATC Use Only

Capability [ ] Yes [ ] No Resources Available [ ] Yes [ ] No Subcontract [ ] Yes [ ] No

Estimated Cost Estimated Completion Date [ ] Specification to be Developed

Activity Title Assigned To

Revision Description

Service Request Form (.doc) 03-20-2002

SKF Steer Hub Inspection

Customer: Prime Trucking Claim #: E1998211 ✓ Mileage: 360,467

VIN#: 1FUYDSZ B5XLA01494 Hub Serial #: 53499 - 0012495

Customer Complaint: Hub Bearing Beam; Strike

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >2 grams: yes no Redisplay: no yes If no .045"

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BRG cone front: yes no In service date: 11/1/98 Failed: 04/03/02

Comments: OB raw grease Burnt - brg Good - IB raw burnt - melted cage - GF & rollers and severely worn; IB seal worn out

Disposition: VALID Ship to SKF 04/05/02

Reason: IB Seal Leak - INGRESS Box 3

Customer: Prime Inc. Claim #: E1776234 ✓ Mileage: 570,981

VIN#: 1FUYDSZ B0XPA64317 Hub Serial #: Axkm : N/A : Rusty

Customer Complaint: Hub Bearing Noisy Rattles

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >2 grams: yes no Redisplay: no yes If no .035"

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BRG cone front: yes no In service date: 04/10/97 Failed: 03/12/02

Comments: OB seal oil separation leak - OB raw Good, IB raw Rusty OR CW line spill - IB seal completely dry of grease & badly worn

Disposition: VALID Ship to SKF 06/13/02

Reason: IB SEAL LEAK - INGRESS

SKF Steer Hub Inspection

Customer: Barney's Freightliner Claim #: E1799670 Mileage: 870,355

Vin #: 1FUPDDYB 8YPF 70312 Hub Serial #: 19999-0140132

Customer Complaint: Hub Assembly Inoperative

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >6 grams: yes no Endplay: no no If no .015"

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BMG cone faces: yes no In service date: 08/05/99 Initials: 07/10/02

Comments: OB row slightly rusty, nest rusty bores, slight debris dusting, IB row dust rusty - case melting, IB seal [illegible] spring & dusting completely worn out

Disposition: VALID Sent to SKF 07/16/02 [illegible]

Root cause: IB SEAL LEAK-INGRESS

Customer: Freightliner Corp. Claim #: E1800855 Mileage: 521,116

Vin #: 1FUYSSCRBBXLA42840 Hub Serial #: 26598-0071728

Customer Complaint: Hub Bearing leaks

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >6 grams: yes no Endplay: yes no If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BMG cone faces: yes no In service date: 08/06/99 Initials: 02/13/07

Comments: Oil sep in hubcap area, bowl oil wetted, OB row VG but a little dry looking, IB row VG but dry at small end, IB seal functional w/ evidence of ingress

GREASE SAMPLES TAKEN

Disposition: VALID Sent to SKF 07/16/02 [illegible]

Root cause: OIL SEPARATION

SKF 000889

SKF	NATC SERVICE REQUEST	Service Number	Issue Number

Service Requested By	Department Number	Service Request Date	Required Completion Date
J. Bruce Weeks	711	8/26/2002	9/6/2002
Service to be Paid By	**Department Number**	**Approval Signature (Payer)**	**Approval Date**
711	711	J. Bruce Weeks	9/6/2002

Type of Service (A project specification is required for projects and blanket laboratory services)

[X] Task A (1-10 Hours) [ ] Task B (10 Hours) [ ] Project (Final requirements/time sensitive) [ ] Development (Changing requirements/time sensitive) [ ] Laboratory

Item Description	Steer THU	Customer	ArvinMeritor
Source or Factory	Aiken	Application	FF-98X Steer Axle
SKF Part Number	BTF-0052	Customer Part Number	HFFU-OOTS-32
Critical Safety Item	[ ] Yes [X] No	Special Characteristics	

A critical safety item is a part, assembly, or production system with one or more customer characteristics. Not if not conforming to the design data or quality requirements, would result in an unsafe condition that could cause loss or serious damage to the end user or major components, loss of control, or serious injury.

Disposition of Samples [ ] (2) Years [ ] (1) Year [ ] (6) Months [X] Return [ ] Discard [ ] Specify

Customer Request, Service Objective, Reason for Service (This section is specified by the customer)

Five grease samples supplied - is this simply an oil separation issue?
What is oil content of samples compared to new Calithia?
IB large end, IB small end, OB small End, OB large end, OR at bearing center

Background, Item History, Application Data, Test Conditions (This section is specified by the customer)
(Note: All drawings, test specifications, and application parameters are required with this request.)

Warranty Claim E1600335 - 521116 miles - Appears that oil separation has occurred causing leakage from hub unit.

NATC Service Recommendation and Deliverables (including pre- and post test inspections/evaluations)

Specification Numbers (ASTM, SKF, etc.)

NATC Use Only

Capability [ ] Yes [ ] No Resources Available [ ] Yes [ ] No Subcontract [ ] Yes [ ] No

Estimated Cost Estimated Completion Date [ ] Specification to be Developed

Activity Title Assigned To

Revision Description

Service Request Form (vdo) 03-30-2002

SKF 0C0890

SKF Star Hub Inspection

Customer: PFI & Freightliner Order #: E1797840 1/2 Mileage: 290,380

VIN#: 1FUYSCYB32C092284 Hub Serial #: 22292 - 0011808 .8(?) matches V's data (?)

Customer Complaint: Hub Bearing Leaks

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grease: yes no O/B seal purge >.5 grease: yes no Endplay: yes no If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring present: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: 09/05/98 Sold: 03/16/02

Comments: ~~[illegible]~~ OB seal purge slightly excessive, OB raw VG but slightly dry, IB not detailed - line spalls OR raw - IB raw slight spalls & shiny, IB seal appears OK

GLENSE SAMPLES TAKEN

Disposition: OPEN Sent to SKF 06/28/02

Root cause: ____

Customer: Freightliner Corp. Order #: E1800338 Mileage: 376,679 (3)

VIN#: 1FUYSDYB3XLPA18959 Hub Serial #: 12799 - 081327

Customer Complaint: Hub Bearing Worn

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grease: yes no O/B seal purge >.5 grease: yes no Endplay: no yes If no .024"

Smooth rotation: yes no seal drag acceptable: yes no Clip ring present: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: 8/12/97 Sold: 5/03/02

Comments: OB raw VG, IB raw burnt - OR raw line spalls at roller spacing, IB seal worn out

Disposition: VALID ~~Sent to SKF~~ 06/28/02

Root cause: IB SEAL LEAK - INGRESS

SKF	NATC SERVICE REQUEST	Service Number	Issue Number

Service Requested By	Department Number	Service Request Date	Required Completion Date
J. Bruce Weeks	711	6/28/2002	9/6/2002
Service to be Paid By	**Department Number**	**Approval Signature (Payer)**	**Approval Date**
711	711	J. Bruce Weeks	9/6/2002

Type of Service (A project specification is required for projects and Market laboratory services)

[X] Task A (<40 Hours) [ ] Task B (<80 Hours) [ ] Project (Point requirements/fixed contract) [ ] Development (Changing requirements and contracts) [ ] Laboratory

Item Description	Steer THU	Customer	ArvinMeritor
Source or Factory	Aiken	Application	FF-98X Steer Axle
SKF Part Number	BTF-0052	Customer Part Number	HFFU-OOTS-32
Critical Safety Item	[ ] Yes [X] No	Special Characteristics	

A critical safety item is a part, assembly, or production system with one or more essential characteristics, that if not conforming to the design data or quality requirements, should result in an unsafe condition that could cause loss or serious damage to harvest men or major components, loss of control, or injury others.

Disposition of Samples [ ] (2) Years [ ] (1) Year [ ] (6) Months [X] Return [ ] Discard [ ] Specify

Customer Request, Service Objective, Reason for Service (This section is specified by the customer)

Two grease samples supplied - Between seal lips and IB row large end of taper
Is there external contamination?

Background, Item History, Application Data, Test Conditions (This section is specified by the customer)
(Note: All drawings, test specifications, and applicable parameters are required with this request.)

Warranty Claim E1797640 1/2 - 290308 miles - IB row appears contaminated but IB seal appears to be functional. Is there an ingress of contaminants through seal?

NATC Service Recommendation and Deliverables (including pre- and post test inspections/evaluations)

Specification Numbers (ASTM, SKF, etc.)

NATC Use Only

Capability [ ] Yes [ ] No Resources Available [ ] Yes [ ] No Subcontract [ ] Yes [ ] No

Estimated Cost Estimated Completion Date [ ] Specification to be Developed

Activity Title Assigned To

Revision Description

Service Request Form (v6a) 03-20-2002

SKF Steer Hub Inspection

Customer: Freightliner Claim #: E18005430 Mileage: 576,094

Vin #: 1FUPSSRB9WLB52925 Hub Serial #: 006520 A M776332

Customer Complaint: Hub Bearing Bonds; Sticks

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel silk yes no

I/B seal purge >5 grams: yes no O/B seal purge >5 grams: yes no Sudplays: no yes If no .038"

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner RRG cone faces: yes no In service date: 05/21/01 Failed: 04/30/02

Comments: IB Seal purge 7 1.0g, wet rusty bones, OB rusty w/wet debris, IB rubbed gage - Dunt, IB Seal completely worn out.

Disposition: VALID Sent to SKF 06/28/02 Box 2

Root cause: IB Seal Leak - INGRESS

Customer: Knight Transport: Freightliner Claim #: E1795181 Mileage: 106,392

Vin #: 1FUPSSRB9WLB49205 Hub Serial #: 07500 - 0255752

Customer Complaint: Front assembly leaks

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel silk yes no

I/B seal purge >5 grams: yes no O/B seal purge >5 grams: yes no Sudplays: yes no If no

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner RRG cone faces: yes no In service date: 4/09/01 Failed: 03/25/02

Comments: OB seal grease leakage, OB row Dunt - cage melted - rt rollers shallow spalls 360° at lg end, OB OR RW spalled shallow at large end, IB row slight debris denting - OB OR RW & spall, IB Seal OR

Disposition: OPEN Sent to SKF 07/02/02

Root cause:

SKF 000893

SKF	NATC SERVICE REQUEST	Service Number	Issue Number

Service Requested By	Department Number	Service Request Date	Required Completion Date
J. Bruce Weeks	711	8/26/2002	9/6/2002
Service to be Paid By	**Department Number**	**Approval Signature (Payer)**	**Approval Date**
711	711	J. Bruce Weeks	9/6/2002

Type of Service (A project specification is required for projects and blanket laboratory services)

[X] Task A (< 40 Hours) [ ] Task B (> 40 Hours) [ ] Project (Field requirements/data services) [ ] Development (Changing requirements/data services) [ ] Laboratory

Item Description	Steer THU	Customer	Arvin Meritor
Source or Factory	Aiken	Application	FF-96X Steer Axle
SKF Part Number	BTF-0052	Customer Part Number	HFFU-OOTS-32
Critical Safety Item	[ ] Yes [X] No	Special Characteristics	

A critical safety item is a part, assembly, or production system with one or more essential characteristics, that if not conforming to the design data or quality requirements, could result in an unsafe condition that could cause loss or serious damage to the end item or major component, use of service, or serious injury.

Disposition of Samples [ ] (2) Years [ ] (1) Year [ ] (6) Months [X] Return [ ] Discard [ ] Specify

Customer Request, Service Objective, Reason for Service (This section is specified by the customer)

Three grease samples supplied - Is there external contamination present?

Background, Item History, Application Data, Test Conditions (This section is specified by the customer)
(Note: All drawings, test specifications, and application parameters are required with this request.)

Warranty Claim E1795181 - 106392 miles - Outboard bearing row has 360 degree spalling on both inner and outer rings. Suspect dimensional problem, but could this be result of ingress of contaminants through hubcap or spindle?

NATC Service Recommendation and Deliverables (including pre- and post test inspections/evaluations)

Specification Numbers (ASTM, SKF, etc.)

NATC Use Only

Capability [ ] Yes [ ] No Resources Available [ ] Yes [ ] No Subcontract [ ] Yes [ ] No

Estimated Cost Estimated Completion Date [ ] Specification to be Developed

Activity Title Assigned To

Revision Description

Service Request Form (v5d) 03-20-2002

SEER WARRANTY REVIEW OF ARM 02

CONFIDENTIAL SKF 000896

Entire Assy

SKF Steer Hub Inspection

Customer: Salem: Freightliner Claim #: E1800555 Mileage: 203,882

VIN#: 1FUJA6CG92LK06021 Hub Serial #: 08001 - 0331305

Customer Complaint: Hub Bearing Broken

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >2 grams: yes no Endplay: yes no If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: 07/05/01 failed: 04/15/02

Comments: OB brg ran VG - grease VG, IB ran OR RON spall w/common

SENT TO SKF Elgin Elkin

Disposition: OPEN 07/16/02

Root cause: ____

Customer: ____ Claim #: ____ Mileage: ____

VIN#: ____ Hub Serial #: ____

Customer Complaint: 1

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >2 grams: yes no Endplay: no yes If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: ____ failed: ____

Comments: ____

Disposition: ____

Root cause: ____

1 records were found

Report Selection Criteria:

Division: ALL
Product Class: ALL
Product Model: ALL
Sub-Assembly: ALL
System: ALL
Claim Type: ALL
Payee: ALL
Paid Fiscal Year: ALL
Build Fiscal Year: ALL
Serial Number: ALL
Paid From Date: ALL Paid To Date: ALL
Build From Date: ALL Build To Date: ALL
Comment Key Words: - - - -
Pay Action: ALL

ArvinMeritor Claim Number: E1800555 (Approved)

Customer Information

Name: FREIGHTLINER CORP. (C708ET)

Claim/Batch: MTFD0052F187T FRT-MAY 13 2002

Work Order Number: 9106449

VIN: 1FUJA6CG92LK06421

Vehicle Age: 10. Month(s) Vehicle OEM: FREIGHTLINER CORPORATION

Amount Requested	Amount Paid
Parts: 420.13	420.13

SKF 000899

Labor: 62.10	62.10
Other: .00	.00
Freight: .00	.00
Policy:	.00
Total: 482.22	**482.22**

Product Information	Claim Information
Product Model: FF961	Claim Type: OEM ON-HWY
Sub Assembly: HUB	Service Claim: No
Failed Part Code Desc:	In-Service Date: 07/05/2001
Problem Code Desc: BRKN/CHIP/CRACKED/RUPTRD	Failed Date: 04/15/2002
Serial Number: AVF01855524	Paid Date: 06/04/2002
Repl Serial Number:	Odometer Reading/Unit: 203,682 Miles
Failed Part:	Written By: SCOTT WOODY
Problem Location: Not Applicable	Authorized By: SCOTT WOODY
Plant: Asheville	
Material Inspected: No	Inspect By:

Parts Information

Qty	Part Number
1.00	MFFU00TS34

Claim Comments

OEM - DNG: FRONT AXLE BEARING BROKEN
OEM - RT FRONT BEARING EXCESSIVE PLAY, FOUND UNITIZED HUB BAD, R/R
OEM - HUB AND INSTALLED NEW HUB,

SKF 000900

SKF Steer Hub Inspection

Customer: Freightliner Corp. Claim #: E1812429 Mileage: 553,687

VIN#: 1FUWSSER1XP7BN605 Hub Serial #: 07401 0335177 replacement hub @ 413,000 miles

Customer Complaint: HUB BEARING BROKEN.

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >2 grams: yes no Endplay: no yes If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grounds: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: 05/29/02 Failed: 05/29/02

Comments: OB row VG - grease VG, IB row Met. debris & rudy grease - IR RW shallow spalling & shiny

SENT IB HR & seal to SKF - Elsa

Disposition: OPEN 07/18/02

Root cause: ____

Customer: ____ Claim #: ____ Mileage: ____

VIN#: ____ Hub Serial #: ____

Customer Complaint: ____

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >2 grams: yes no Endplay: no yes If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grounds: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: ____ Failed: ____

Comments: ____

Disposition: ____

Root cause: ____

2nd Claim This Week

1 records were found

Report Selection Criteria:

Division: ALL
Product Class: ALL
Product Model: ALL
Sub-Assembly: ALL
System: ALL
Claim Type: ALL
Payee: ALL
Paid Fiscal Year: ALL
Build Fiscal Year: ALL
Serial Number: ALL
Paid From Date: ALL Paid To Date: ALL
Build From Date: ALL Build To Date: ALL
Comment Key Words: - - - -
Pay Action: ALL

ArvinMeritor Claim Number: E1812429 (Approved)

Customer Information

Name: FREIGHTLINER CORP. (C708ST)

Claim/Batch: [illegible] FRT-JUN 17 2002

Work Order Number: 227384

VIN: [illegible]

Vehicle Age: 49. Month(s) Vehicle OEM: FREIGHTLINER CORPORATION

Amount Requested	Amount Paid
Parts: 465.40	465.40

SKF 000902

Labor: 62.10	62.10
Other: .00	.00
Freight: .00	.00
Policy:	.00
Total: 525.50	**525.50**

Product Information	Claim Information
Product Model: FF981	Claim Type: OEM ON-ENT
Sub Assembly: SUB	Service Claim: No
Failed Part Code Desc:	In-Service Date: 05/29/1998
Problem Code Desc: BRKN/CHIP/CRACKED/RUPTRD	Failed Date: 05/28/2002
Serial Number: AVF98085176	Paid Date: 07/15/2002
Repl Serial Number:	Odometer Reading/Unit: 553,697 Miles
Failed Part:	Written By: SCOTT WOODY
Problem Location: Not Applicable	Authorized By: SCOTT WOODY
Plant: Asheville	
Material Inspected: No	Inspect By:

Parts Information

Qty	Part Number
1.00	KIT1432

Claim Comments

OEM - DMG: FRONT AXLE HUB BEARING BROKEN
OEM - UNITIZED FRONT AXLE BEARINGS FAILED, R/R FRONT AXLE UNITIZED
OEM - SUB,

SNF 000903

SKF Steer Hub Inspection

Customer: Leladon ? Freight [illegible] Claim #: E1800395 Mileage: 181,603

VIN#: 1FUJA3AVB1L6-[illegible] Hub Serial #: 09800 - 0265977

Customer Complaint: Hub Bearing Warm

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >2 grams: yes no Endplay: no yes If no .005"

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: [illegible] Mileage: 04/16/03

Comments: OB bag row VG - grease VG, IB bag row debris dented - rollers ends badly scored - seal appears to be functioning

SENT TO SKF for FURTHER [illegible]

Disposition: OPEN 07/02/02

Root cause:

Customer: Claim #: Mileage:

VIN#: Hub Serial #:

Customer Complaint:

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >2 grams: yes no Endplay: no yes If no

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: Mileage:

Comments:

Disposition:

Root cause:

1 records were found

Report Selection Criteria:

Division: ALL
Product Class: ALL
Product Model: ALL
Sub-Assembly: ALL
System: ALL
Claim Type: ALL
Payee: ALL
Paid Fiscal Year: ALL
Build Fiscal Year: ALL
Serial Number: ALL
Paid From Date: ALL Paid To Date: ALL
Build From Date: ALL Build To Date: ALL
Comment Key Words: - - - -
Pay Action: ALL

ArvinMeritor Claim Number: E1800395 (Approved)

Customer Information

Name: FREIGHTLINER CORP. (C708KY)

Claim/Batch: MXFD00A00133T FRT-MAY 15 2002

Work Order Number: 66774

VIN: 1FUJA3AYB1LG96728

Vehicle Age: 21. Month(s) Vehicle OEM: FREIGHTLINER CORPORATION

Amount Requested	Amount Paid
Parts: 411.64	411.64

SKF 000905

Labor: 61.20	61.20
Other: .00	.00
Freight: .00	.00
Policy:	.00
Total: 472.84	**472.84**

Product Information	Claim Information
Product Model: FF881	Claim Type: OEM ON-ENT
Sub Assembly: HUB	Service Claim: No
Failed Part Code Desc:	In-Service Date: 08/10/2000
Problem Code Desc: INEFFECT/INOPER/WORN OUT	Failed Date: 04/16/2002
Serial Number: AVF00110437	Paid Date: 05/30/2002
Repl Serial Number:	Odometer Reading/Unit: 181,603 Miles
Failed Part:	Written By: SCOTT WOODY
Problem Location: Not Applicable	Authorized By: SCOTT WOODY
Plant: Asheville	
Material Inspected:	Inspect By:

Parts Information

Qty	Part Number
1.00	NFFU00T812

Claim Comments

OEM - DMG: FRONT AXLE,HUB BEARING WORN
OEM - LEFT FRONT STEER AXLE WHEEL LOOSE CHECKED & FOUND HUB BEARIN
OEM - GF TORQUED PROPERLY, FOUND PLAY IN HUB R/R HUB ASSEMBLY JR

SKF 000906

SKF Steer Hub Inspection

Customer: Freightliner Corp Claim #: E1741267 Mileage: 412,231

Vehicle: 1C11 4DC7 R1 YPB 62515 Hub Serial #: 00401-0325965

Customer Complaint: Hub Bearing leaks

Complete hub received: yes no Highly progressive incidents: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel stiff: yes no

I/B seal purge >5 grams: yes no O/B seal purge >4 grams: yes no Endplay: no yes If no: .008"

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: 07/28/01 Failed: 12/28/01

Comments: OB row VG, Grease VG - LB 10N slight net debris, roller ends brown, RING

Send to SKF Aiken
Why OB endplay?

Disposition: OPEN 07/28/02

Root cause:

Customer: Claim #: Mileage:

Vehicle: Hub Serial #:

Customer Complaint:

Complete hub received: yes no Highly progressive incidents: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel stiff: yes no

I/B seal purge >5 grams: yes no O/B seal purge >4 grams: yes no Endplay: no yes If no:

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: Failed:

Comments:

Disposition:

Root cause:

SKF 000907

1 records were found

Report Selection Criteria:

Division: ALL
Product Class: ALL
Product Model: ALL
Sub-Assembly: ALL
System: ALL
Claim Type: ALL
Payee: ALL
Paid Fiscal Year: ALL
Build Fiscal Year: ALL
Serial Number: ALL
Paid From Date: ALL Paid To Date: ALL
Build From Date: ALL Build To Date: ALL
Comment Key Words: - - - -
Pay Action: ALL

ArvinMeritor Claim Number: E1741267 (Approved)

Customer Information

Name: FREIGHTLINER CORP. (C708ST)

Claim/Batch: MSFD0001CM03T FRT-JAN 21 2002

Work Order Number: 39728-01

VIN: 1FVTDCEB1YPB67815

Vehicle Age: 33. Month(s) Vehicle OEM: FREIGHTLINER CORPORATION

Amount Requested	Amount Paid
Parts: 583.60	583.60

SKF 000908

Labor: 89.70	89.70
Other: .00	.00
Freight: .00	.00
Policy:	.00
Total: 673.30	**673.30**

Product Information	Claim Information
Product Model: FF981	Claim Type: OEM ON-HWY
Sub Assembly: HUB	Service Claim: No
Failed Part Code Desc:	In-Service Date: 04/28/1999
Problem Code Desc: SEIZED/LOCKED UP	Failed Date: 12/28/2001
Serial Number:	Paid Date: 02/04/2002
Repl Serial Number:	Odometer Reading/Unit: 417,231 Miles
Failed Part:	Written By: SCOTT WOODY
Problem Location: Not Applicable	Authorized By: SCOTT WOODY
Plant: Asheville	
Material Inspected: No	Inspect By:

Parts Information

Qty	Part Number
1.00	EFFU00T814

Claim Comments

OEM - DMG: FRONT AXLE HUB BEARING LEAKS
OEM - CHECK WHEEL BEARING LEFT SIDE STEER AXLE BEARING IN HUB FAIL
OEM - RD R & R HUB ASSEMBLY

SKF 000909

ArvinMeritor

Report No.: WFWB502

Customer Support Systems
OEM & EM Warranty Systems
VIN Image Copy Report

VIN Number: 1FUYDCXB1YPB67515

In-Service Date: 04/28/99

Claim #	Comp/ Retro	Claim Date	Failed Date	Odometer	Product Model	Prob Loc	Sub-Assy	Prob Code
E1860948		06/04/01	05/16/01	430,448 MILES	FF981	NA	BC	42
E1741267		01/21/02	12/28/01	417,231 MILES	FF981	NA	DA	14

----------V I N R E G I S T R A T I O N I N F O R M A T

In-Service Date: 04/12/99 Vocation:

Product	Coverage Code	Lube	Serial Number
ABS			
FF981			
QB165			
EEX016EA			
RT40145			

SKF Steer Hub Inspection Entire assy

Customer: FREIGHTLINER CORP Claim #: E1T78621 Mileage: 178,256 miles

Vin#: 1FUJA6CG12LK06600 Hub Serial #: 05101 - 0331502

Customer Complaint: Hub Bearing Broken

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >2 grams: yes no Endplay: no yes if no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: 04/20/01 failed: 03/04/02

Comments: OB row VG - grease slightly dark, IB row OK RW line cleaning spalls

Sent ~~[illegible]~~ to SKF Elgin

Disposition: OPEN 05/28/02

Root cause: ____

Customer: ____ Claim #: ____ Mileage: ____

Vin#: ____ Hub Serial #: ____

Customer Complaint: ____

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >2 grams: yes no Endplay: no yes if no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: ____ failed: ____

Comments: ____

Disposition: ____

Root cause: ____

ArvinMeritor

1 records were found

Report Selection Criteria:

Division: ALL
Product Class: ALL
Product Model: ALL
Sub-Assembly: ALL
System: ALL
Claim Type: ALL
Payee: ALL
Paid Fiscal Year: ALL
Build Fiscal Year: ALL
Serial Number: ALL
Paid From Date: ALL Paid To Date: ALL
Build From Date: ALL Build To Date: ALL
Comment Key Words: - - - -
Pay Action: ALL

ArvinMeritor Claim Number: E1778621 (Approved)

Customer Information

Name: FREIGHTLINER CORP. (C70625F)
Claim/Batch: ETFD0002P130T FRI-MAR 15 2002
Work Order Number: 9196307
VIN: 1FUJA6CG12LK06600
Vehicle Age: 9. Month(s) Vehicle OEM: FREIGHTLINER CORPORATION

Amount Requested **Amount Paid**

SKF 0009

Parts: 461.39	461.39
Labor: 117.30	117.30
Other: .00	.00
Freight: .00	.00
Policy:	.00
Total: 578.69	**578.69**

Product Information
Product Model: FF981
Sub Assembly: HUB
Failed Part Code Desc:
Problem Code Desc: BRKN/CHIP/CRACKED/RUPTED
Serial Number: AVF01053345
Repl Serial Number:
Failed Part:
Problem Location: Not Applicable
Plant: Asheville
Material Inspected: No

Claim Information
Claim Type: OEM ON-ENY
Service Claim: No
In-Service Date: 05/30/2001
Failed Date: 03/04/2002
Paid Date: 04/08/2002
Odometer Reading/Unit: 178,238 Miles
Written By: SCOTT WOODY
Authorized By: SCOTT WOODY

Inspect By:

Parts Information

Qty	Part Number
1.00	EFFU00TS34

Claim Comments

OEM - DNG: FRONT AXLE HUB BEARING BROKEN
OEM - CK TRUCK FOR RIGHT FRONT BEARING MAKING NOISE, FOUND EXCESSI
OEM - VE PLAY IN UNITIZED HUB BEARINGS, INSPECTED AND FOUND BEARIN
OEM - GS DAMAGED, EXTRA TIME DUE TO HUB FROZEN ON SPINDLE, REMOVED
OEM - HUB AND CLEAN UP SPINDLE, INSTALLED NEW HUB.

ArvinMeritor

Report No.: WFM8502

Customer Support Systems
OEM & RV Warranty Systems
VIN Image Copy Report

VIN Number: 1FUYSSEB1XP780605

In-Service Date: 05/29/98

Claim #	Comp/ Retro	Claim Date	Failed Date	Odometer	Product Model	Prob Loc	Sub-Assy	Prob Code
M1563718		09/13/00	08/12/00	308,891 MILES	LX500	HA	HC	14
M1576598		10/17/00	08/25/00	314,189 MILES	KM40145	HA	AH	13
M1589966		11/09/00	10/01/00	328,075 MILES	KM40145	HA	AH	13
M1591594		11/13/00	06/25/00	290,269 MILES	LX500	HA	HC	14
M1599424		11/28/00	11/01/00	341,158 MILES	KM40145	HA	AH	13
M1608929		01/01/01	12/17/00	342,266 MILES	RMX0155A	HA	HJ	13
M1629467		02/28/01	03/31/00	297,849 MILES	RMX0155A	HA	HH	11
M1633981		03/14/01	04/28/01	348,463 MILES	KM40145	HA	AH	13
M1699167		09/24/01	08/20/01	413,160 MILES	FF981	HA	DA	11
M1727781		12/17/01	06/22/01	381,993 MILES	RMX0155A	HA	HJ	11
M1813429		06/17/02	05/28/02	553,637 MILES	FF981	HA	DA	11

VIN REGISTRATION INFORMAT

In-Service Date: 05/29/98 Vocation:

Product	Coverage Code	Labs	Serial Number
FF981			AVF98605176
LX500			
QB165			
RMX0155A			LB98012132
KM40145			AVA98079880
E13DCF			

ENTIRE ASSY

PENDING

SKF Steer Hub Inspection

Customer: Freightliner Corp. Claim #: E1819364 Mileage: 149,008

Vin#: 1FUJACA872LK01606 Hub Serial #: 05101-0331487

Customer Complaint: Hub Roaring Noisy, Rattles

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel nut: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >1 grams: yes no Endplay: no yes if no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner RRG cone faces: yes no In service date: 5/28/01 Failed: 04/22/02

Comments: O/B RACE DISCOLORATION AROUND LOAD ZONE O/B CONE AND ROLLERS ARE IN GOOD CONDITION. I/B ONE SPALL AND LIGHT POLISHING IN CENTER. CLIP RING NO GROOVE

Disposition: INCONCLUSIVE 08/01/02

Root cause: SENT TO: SKF OPEN

Customer: ____ Claim #: ____ Mileage: ____

Vin#: ____ Hub Serial #: ____

Customer Complaint: ____

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel nut: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >1 grams: yes no Endplay: no yes if no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner RRG cone faces: yes no In service date: ____ Failed: ____

Comments: ____

Disposition: ____

Root cause: ____

E1812429 ~~[illegible]~~

IR & Seal only

1 records were found

Report Selection Criteria:

Division: ALL
Product Class: ALL
Product Model: ALL
Sub-Assembly: ALL
System: ALL
Claim Type: ALL
Payee: ALL
Paid Fiscal Year: ALL
Build Fiscal Year: ALL
Serial Number: ALL
Paid From Date: ALL Paid To Date: ALL
Build From Date: ALL Build To Date: ALL
Comment Key Words: - - - -
Pay Action: ALL

ArvinMeritor Claim Number: E1819364 (Pending)

Customer Information

Name: FREIGHTLINER CORP. (C708ET)

Claim/Batch: F4AA00A00836T FRT-JUL 08 2002

Work Order Number: 2282293

VIN: 1FUJACA872LN01606

Vehicle Age: 15. Month(s) Vehicle OEM: FREIGHTLINER CORPORATION

Amount Requested	Amount Paid
Parts: 435.66	.00

SKF 000916

Labor: 45.00	.00
Other: .00	.00
Freight: .00	.00
Policy:	.00
Total: 480.66	**.00**

Product Information	Claim Information
Product Model: FF981	Claim Type: OEM ON-ENT
Sub Assembly: HUB	Service Claim: No
Failed Part Code Desc:	In-Service Date: 05/28/2001
Problem Code Desc: CHATTER/NOISY/VIBRATION	Failed Date: 06/22/2002
Serial Number: AVF01853920	Paid Date:
Repl Serial Number:	Odometer Reading/Unit: 149,088 Miles
Failed Part:	Written By: GINA NIEDOLINKA
Problem Location: Not Applicable	Authorized By: GINA NIEDOLINKA
Plant: Newark	
Material Inspected: No	Inspect By:

Parts Information

Qty	Part Number
1.00	KIT1436

Claim Comments

OEM - DMG: FRONT AXLE HUB BEARING NOISY,RATTLES
OEM - R22452-RT119--THE RIGHT FRONT HUB BEARINGS WERE BAD REMOVED
OEM - THE HUB ASSY AND REPLACED WITH NEW

SKF 000917

SKF Steer Hub Inspection

Customer: WAL-MART Stores Claim #: N/A Mileage: 074661

VIN#: 2HSCEAMR52C023379 Hub Serial #: 05106 - 0331595

Customer Complaint: HUB BEARING NOISY.

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

NB seal purge >5 grams: yes no OB seal purge >8 grams: yes no Endplay: yes no If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Chrysler witness marks on inner BRG cone faces: yes no In service date: 06/04/01 Failed: 03/17/02

Comments: OB Row VG - grease VG - IB OR Row single linespall - corrosion

Sent Seal & IB bkg row to SKF - Elgin

Disposition: OPEN 07/15/02

Root cause: ____

Customer: ____ Claim #: ____ Mileage: ____

VIN#: ____ Hub Serial #: ____

Customer Complaint: ____

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

NB seal purge >5 grams: yes no OB seal purge >8 grams: yes no Endplay: no yes If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Chrysler witness marks on inner BRG cone faces: yes no In service date: ____ Failed: ____

Comments: ____

Disposition: ____

Root cause: ____

IR only

SKF Steer Hub Inspection

Customer: Freightliner Corp. Claim #: E1808416 Mileage: 62,010 miles 99,774 kb

VIN#: 1FUJA9AB72LJ47114 Hub Serial #: 05801 - 0332845 62,010 miles

Customer Complaint: Hub Assembly leaks RJ NONY

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >1 grams: yes no Endplay: yes no If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grounds: yes no

Circular witness marks on inner RRG cone faces: yes no In service date: 09/25/01 Initials: 05/07/02

Comments: OB raw VG, grease VG - IB raw rut, debris & denting, IR RW single spall

Send IR & Seal to Elgin - metallurgy on IR

Disposition: OPEN 07/24/02

Root cause: ____

Customer: ____ Claim #: ____ Mileage: ____

VIN#: ____ Hub Serial #: ____

Customer Complaint: ____

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >1 grams: yes no Endplay: yes no If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grounds: yes no

Circular witness marks on inner RRG cone faces: yes no In service date: ____ Initials: ____

Comments: ____

Disposition: ____

1 records were found

Report Selection Criteria:

Division: ALL
Product Class: ALL
Product Model: ALL
Sub-Assembly: ALL
System: ALL
Claim Type: ALL
Payee: ALL
Paid Fiscal Year: ALL
Build Fiscal Year: ALL
Serial Number: ALL
Paid From Date: ALL Paid To Date: ALL
Build From Date: ALL Build To Date: ALL
Comment Key Words: - - - -
Pay Action: ALL

ArvinMeritor Claim Number: E1808416 (Approved)

Customer Information

Name: FREIGHTLINER CORP. (C706ET)

Claim/Batch: KMCD00A00061T FRT-JUN 03 2002

Work Order Number: 18701A

VIN: 1FUJA9A972LJ47114

Vehicle Age: 6. Month(s) Vehicle OEM: FREIGHTLINER CORPORATION

Amount Requested	Amount Paid
Parts: 383.05	383.05

SKF 000920

Labor: 67.14	67.14
Other: .00	.00
Freight: .00	.00
Policy:	.00
Total: 450.19	**450.19**

Product Information	Claim Information
Product Model: FF981	Claim Type: OEM ON-ENY
Sub Assembly: HUB	Service Claim: No
Failed Part Code Desc:	In-Service Date: 05/25/2001
Problem Code Desc: LEAKING	Failed Date: 05/07/2002
Serial Number: AVF01079536	Paid Date: 06/08/2002
Repl Serial Number:	Odometer Reading/Unit: 99,774 Kilometers
Failed Part:	Written By: SCOTT WOODY
Problem Location: Not Applicable	Authorized By: SCOTT WOODY
Plant: Asheville	
Material Inspected:	Inspect By:

Parts Information

Qty	Part Number
1.00	HFF000T633

Claim Comments

OEM - DNG: FRONT AXLE,HUB ASSEMBLY LEAKS
OEM - NOISE COMMING OUT FROM FRONT AXLE FRONT R/E WHEEL FRONT AXLE
OEM - HUB IS LEAKING (NOT HOLDING GREASE) TROUBLESHOOT, R&R R/N W
OEM - WHEEL, DRUM, BRAKE COMPONENT & REPLACE R/E HUB ASST

SKF 00092

Do not have

SKF Star Hub Inspection

Customer: SALEM : Freightliner Claim #: E1810369 Mileage: 201,269

VIN#: 3FUJA6CG62LK066083 Hub Serial #: 05101 - C331511

Customer Complaint: HUB BEARING BROKEN.

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >1 grams: yes no Endplay: yes no if no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooves: yes no

Circular witness marks on inner RRG cone faces: yes no In service date: 07/01/01 Failed: 05/06/02

Comments: OB brg row VG, grease VG, IB non shallow spall IR RW, moly grease

Disposition: VALID 07/24/02

Root cause: IB Seal Leak - hygiene

Customer: ____ Claim #: ____ Mileage: ____

VIN#: ____ Hub Serial #: ____

Customer Complaint: ____

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >1 grams: yes no Endplay: no yes if no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooves: yes no

Circular witness marks on inner RRG cone faces: yes no In service date: ____ Failed: ____

Comments: ____

Disposition: ____

E1800395
E1741267
Entire assy

1 records were found

Report Selection Criteria:

Division: ALL
Product Class: ALL
Product Model: ALL
Sub-Assembly: ALL
System: ALL
Claim Type: ALL
Payee: ALL
Paid Fiscal Year: ALL
Build Fiscal Year: ALL
Serial Number: ALL
Paid From Date: ALL Paid To Date: ALL
Build From Date: ALL Build To Date: ALL
Comment Key Words: - - - -
Pay Action: ALL

ArvinMeritor Claim Number: E1810369 (Approved)

Customer Information

Name: FREIGHTLINER CORP. (C7088T)

Claim/Batch: MTFD0002P249T FRT-JUN 10 2002

Work Order Number: 9106544

VIN: 1FUJA5CG62LE06608

Vehicle Age: 11. Month(s) Vehicle OEM: FREIGHTLINER CORPORATION

Amount Requested	Amount Paid
Parts: 420.12	420.12

SKF 000923

Labor: 62.10	62.10
Other: .00	.00
Freight: .00	.00
Policy:	.00
Total: 482.22	**482.22**

Product Information	Claim Information
Product Model: FF981	Claim Type: OEM ON-HWY
Sub Assembly: HUB	Service Claim: No
Failed Part Code Desc:	In-Service Date: 07/01/2001
Problem Code Desc: BRKN/CHIP/CRACKED/RUPTRD	Failed Date: 05/06/2002
Serial Number: AVF01053607	Paid Date: 07/11/2002
Repl Serial Number:	Odometer Reading/Unit: 201,269 Miles
Failed Part:	Written By: SCOTT WOODY
Problem Location: Not Applicable	Authorized By: SCOTT WOODY
Plant: Asheville	
Material Inspected: No	Inspect By:

Parts Information

Qty	Part Number
1.00	EFFU007834

Claim Comments

OEM - DEC: FRONT AXLE,HUB BEARING BROKEN
OEM - LEFT FRONT HUB BEARING BROKEN RAR HUB ASSEMBLEY / / / /

SKF 000924

SKF Steer Hub Inspection

Customer: Freightliner Corp Claim #: EIR03144 Mileage: 218,273 Mile 351,201 Kilo

VIN#: 1FUJAHCG81LH92726 Hub Serial #: 00100 - 0771053

Customer Complaint: Hub Bearing loose.

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >2 grams: yes no Endplay: no yes If no .012"

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on lower BRG cone faces: yes no In service date: 12/12/00 Failed: 07/29/02

Comments: O/B Cone Race and Rollers are in good condition, IB Cowlings - wipe jar - Shiny Rails - Spalling Shallow - Seal - main lip badly worn & grooved, axial lip - moderate wear - could be metallic debris rolling

Disposition: VALID 07/15/02

Root cause: IB Seal Leak - Ingress

Customer: Claim #: Mileage:

VIN#: Hub Serial #:

Customer Complaint:

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >2 grams: yes no Endplay: no yes If no

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on lower BRG cone faces: yes no In service date: Failed:

Comments:

Disposition:

Root cause:

1 records were found

Report Selection Criteria:

Division: ALL
Product Class: ALL
Product Model: ALL
Sub-Assembly: ALL
System: ALL
Claim Type: ALL
Payee: ALL
Paid Fiscal Year: ALL
Build Fiscal Year: ALL
Serial Number: ALL
Paid From Date: ALL Paid To Date: ALL
Build From Date: ALL Build To Date: ALL
Comment Key Words: - - - -
Pay Action: ALL

ArvinMeritor Claim Number: E1803144 (Approved)

Customer Information

Name: FREIGHTLINER CORP. (C708ET)

Claim/Batch: TJCD0002A932T FRT-MAY 20 2002

Work Order Number: 68932-01

VIN: 1FUJANC001LHP2726

Vehicle Age: 17. Month(s) Vehicle OEM: FREIGHTLINER CORPORATION

Amount Requested	Amount Paid
Parts: 430.41	430.41

SKF 000926

Labor: 66.75	66.75
Other: .00	.00
Freight: .00	.00
Policy:	.00
Total: 497.16	**497.16**

Product Information	Claim Information
Product Model: FF981	Claim Type: OEM ON-HWY
Sub Assembly: HUB	Service Claim: No
Failed Part Code Desc:	In-Service Date: 12/12/2000
Problem Code Desc: IMPROPER FIT/ALIGNMENT	Failed Date: 04/29/2002
Serial Number: AVF00140911	Paid Date: 06/08/2002
Repl Serial Number:	Odometer Reading/Unit: 351,201 Kilometers 218,223M
Failed Part:	Written By: SCOTT WOODY
Problem Location: Not Applicable	Authorized By: SCOTT WOODY
Plant: Asheville	
Material Inspected:	Inspect By:

Parts Information

Qty	Part Number
1.00	HFFU007832

Claim Comments

OEM - DWG: FRONT AXLE HUB BEARING LOOSE
OEM - CHECK R/N FRONT HUB FOR BEING LOOSE FOUND BEARING FAILURE IN
OEM - SEALED RIGHT FRONT HUB PERFORMED TRBLSHOOT, REMOVED WHEEL A
OEM - SSY, INSPECTED ALL PARTSSPINDLE, ETC AND REPLACED HUB AS REQ
OEM - UIRED, REINSTALLED ALL PARTS "T" TIME TO INSPECT ALL PARTS F
OEM - OR REUSE
OEM - AL

SKF 000927

SKF Steer Hub Inspection

Customer: ERB Transport Claim #: N/A Mileage: 31,700 051005 Kilo

Vehicle: 2HSCHASR22C033981 Hub Serial #: 07201-0334847

Customer Complaint: MUR Rearing Nazzy

Complete hub received: yes no Highly progressive incident: yes no Remover used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >2 grams: yes no Bodyplay: no yes If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner RRG cone faces: yes no In service date: 08/31/01 Failed: 11/27/02

Comments: IB+OB brg rows VG, grease VG, no internal abuttress.

Disposition: INVALID 07/15/02

Root cause: NPF

Customer: ____ Claim #: ____ Mileage: ____

Vehicle: ____ Hub Serial #: ____

Customer Complaint: ____

Complete hub received: yes no Highly progressive incident: yes no Remover used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >2 grams: yes no Bodyplay: no yes If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner RRG cone faces: yes no In service date: ____ Failed: ____

Comments: ____

Disposition: ____

Root cause: ____

SKF Steer Hub Inspection

Customer: Salem : Freightliner Claim #: E1R00556 Mileage: 177,926

Vin#: 1FUJA6CG62LK06625 Hub Serial #: 05001-0331306

Customer Complaint: Hub Bearing Broken

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >4 grams: yes no Endplay: yes no If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner RRG cone faces: yes no In service date: 07/06/02 failed: 07/17/02

Comments: OB Bearing row VG, grease good color, IB row spalled OR RX 2 spots
1 W/black stain - IR debris cleaned - mostly grease

Sent to Bruce McGlone

Disposition: VALID 07/16/02

Root cause: IB Seal Leak - Ingress

Customer: ____ Claim #: ____ Mileage: ____

Vin#: ____ Hub Serial #: ____

Customer Complaint: ____

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >4 grams: yes no Endplay: yes no If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner RRG cone faces: yes no In service date: ____ failed: ____

Comments: ____

Disposition: ____

Root cause: ____

FOCUS Report

1 records were found

Report Selection Criteria:

Division: ALL
Product Class: ALL
Product Model: ALL
Sub-Assembly: ALL
System: ALL
Claim Type: ALL
Payee: ALL
Paid Fiscal Year: ALL
Build Fiscal Year: ALL
Serial Number: ALL
Paid From Date: ALL Paid To Date: ALL
Build From Date: ALL Build To Date: ALL
Comment Key Words: - - - -
Pay Action: ALL

ArvinMeritor Claim Number: E1800556 (Approved)

Customer Information

Name: FREIGHTLINER CORP. (C708ST)

Claim/Batch: NTFDQ002P10ST FRT-MAY 13 2002

Work Order Number: 9106458

VIN: 1FUJA6CG02LE06627

Vehicle Age: 10. Month(s) Vehicle OEM: FREIGHTLINER CORPORATION

Amount Requested	Amount Paid
Parts: 420.12	420.12

SKF 000930

Labor: 62.10	62.10
Other: .00	.00
Freight: .00	.00
Policy:	.00
Total: 482.22	**482.22**

Product Information
Product Model: FW961
Sub Assembly: HUB
Failed Part Code Desc:
Problem Code Desc: BRKN/CHIP/CRACKED/RUPTRD
Serial Number: AVF01055533
Repl Serial Number:
Failed Part:
Problem Location: Not Applicable
Plant: Asheville
Material Inspected: No

Claim Information
Claim Type: OEM ON-ENY
Service Claim: No
In-Service Date: 07/06/2001
Failed Date: 04/17/2002
Paid Date: 06/04/2002
Odometer Reading/Unit: 179,926 Miles
Written By: SCOTT WOODY
Authorized By: SCOTT WOODY

Inspect By:

Parts Information

Qty	Part Number
1.00	HFFU00T836

Claim Comments

OEM - DNG: FRONT AXLE BEARING BROKEN
OEM - CHECK TRUCK RIGHT FRONT TIRE HAS PLAY F CHECKED AND FOUND FR
OEM - ONT TIRE HAVING LATTERAL PL AY AND FOUND IT HAD HAD HUB BEAR
OEM - ING AND REMOVED AND REPLACED IT WITH NEW ONE AND ALSO CLEANE
OEM - D SPINDLE AND REPPLACED TIRE AND CHECKED AND WORK

SKF Steer Hub Inspection

Customer: Pezmeå Freightliner Claim #: E1814586 Mileage: 69,356

Vehicle: 1FUJBBC1-58LK07917 Hub Serial #: 05701-0332562

Customer Complaint: HRIB Bearing Noisy; Rattles

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grease: yes no O/B seal purge >4 grease: yes no Endplay: no yes if no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: 10/11/01 failed: 03/28/02

Comments: OB non VG, grease VG, IB non VG, M internal process

Disposition: Invalid 07/31/02

Root cause: NYF

Customer: ____ Claim #: ____ Mileage: ____

Vehicle: ____ Hub Serial #: ____

Customer Complaint: ____

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grease: yes no O/B seal purge >4 grease: yes no Endplay: no yes if no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: ____ failed: ____

Comments: ____

Disposition: ____

Root cause: ____

1 records were found

Report Selection Criteria:

Division: ALL
Product Class: ALL
Product Model: ALL
Sub-Assembly: ALL
System: ALL
Claim Type: ALL
Payee: ALL
Paid Fiscal Year: ALL
Build Fiscal Year: ALL
Serial Number: ALL
Paid From Date: ALL Paid To Date: ALL
Build From Date: ALL Build To Date: ALL
Comment Key Words: - - - -
Pay Action: ALL

ArvinMeritor Claim Number: E1814586 (Approved)

Customer Information

Name: FREIGHTLINER CORP. (C7082T)

Claim/Batch: MLFD000028094T FRT-JUN 24 2002

Work Order Number: 574197

VIN: 1FUJBBCG52LE07917

Vehicle Age: 6. Month(s) Vehicle OEM: FREIGHTLINER CORPORATION

Amount Requested	Amount Paid
Parts: 411.64	411.64

SKF 000933

Labor: 55.00	55.00
Other: .00	.00
Freight: .00	.00
Policy:	.00
Total: 467.44	**467.44**

Product Information	Claim Information
Product Model: FF991	Claim Type: OEM ON-HWY
Sub Assembly: HUB	Service Claim: No
Failed Part Code Desc:	In-Service Date: 10/11/2001
Problem Code Desc: CHATTER/NOISY/VIBRATION	Failed Date: 03/28/2002
Serial Number:	Paid Date: 07/16/2002
Repl Serial Number:	Odometer Reading/Unit: 69,356 Miles
Failed Part:	Written By: SCOTT WOODY
Problem Location: Not Applicable	Authorized By: SCOTT WOODY
Plant: Asheville	
Material Inspected: No	Inspect By:

Parts Information

Qty	Part Number
1.00	[illegible]

Claim Comments

OEM - DMS: FRONT AXLE,HUB BEARING NOISY,RATTLES
OEM - SPUN TIRES,BALANCE OK FOUND EXCESSIVE BEARING NOISE IN FRONT
OEM - RIGHT HAND HUB MEASURED END PLAY ON HUB 001 REPLACED HUB DU
OEM - N TO STEP 9 OF BULLETIN TF0251 REPLACED FOR NOT TURNING SMOO
OEM - TH UNDER SPIN AND NOISY

SKF 000934

SKF Steer Hub Inspection

Customer: Rudd's Freightliner Claim #: E1783276 Mileage: 124,232 miles

Vin#: 1FUJAZ AB31PG63335 Hub Serial #: 03801 - 0329677

Customer Complaint: Hub Bearing Binds; Stick

Complete hub rotation: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >4 grams: yes no Endplay: yes no If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grounds: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: 10/30/00 Failed: 03/15/02

Comments: Paint inside hubcap cavity L - OB ron VG - grease good, IB ron VG - grease VG no internal abuses

Disposition: INVALID 07/03/02

Root cause: NPF

Customer: ____ Claim #: ____ Mileage: ____

Vin#: ____ Hub Serial #: ____

Customer Complaint: ____

Complete hub rotation: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >5 grams: yes no O/B seal purge >4 grams: yes no Endplay: no yes If no ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grounds: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: ____ Failed: ____

Comments: ____

Disposition: ____

Root cause: ____

2nd Claim This VIN

1 records were found

Report Selection Criteria:

Division: ALL
Product Class: ALL
Product Model: ALL
Sub-Assembly: ALL
System: ALL
Claim Type: ALL
Payee: ALL
Paid Fiscal Year: ALL
Build Fiscal Year: ALL
Serial Number: ALL
Paid From Date: ALL Paid To Date: ALL
Build From Date: ALL Build To Date: ALL
Comment Key Words: - - - -
Pay Action: ALL

ArvinMeritor Claim Number: E1783276 (Approved)

Customer Information

Name: FREIGHTLINER CORP. (C7085T)

Claim/Batch: EBFD0002A696T FRT-APR 01 2002

Work Order Number: 132410

VIN: 1FUJAEA831PG83335

Vehicle Age: 17. Month(s) Vehicle OEM: FREIGHTLINER CORPORATION

Amount Requested	Amount Paid
Parts: 416.80	416.80

SKF 000936

FOCUS Report

Labor: 53.10	53.10
Other: .00	.00
Freight: .00	.00
Policy:	.00
Total: 469.90	**469.90**

Product Information
Product Model: FF981
Sub Assembly: HUB
Failed Part Code Desc:
Problem Code Desc: SEIZED/LOCKED UP
Serial Number:
Repl Serial Number:
Failed Part:
Problem Location: Not Applicable
Plant: Asheville
Material Inspected: No

Claim Information
Claim Type: OEM ON-ENT
Service Claim: No
In-Service Date: 10/30/2000
Failed Date: 03/18/2002
Paid Date: 04/23/2002
Odometer Reading/Unit: 125,232 Miles
Written By: SCOTT WOODY
Authorized By: SCOTT WOODY
Inspect By:

Parts Information

Qty	Part Number
1.00	SS 3165079
1.00	EFFU00T832

Claim Comments

OEM - DMG: FRONT AXLE,HUB BEARING BINDS,STICKS,
OEM - 853 SPUN BITH STEER WHEELS WITH WHEEL BALANCER COULD NEAR
OEM - GROWLING NOISE FROM RIGHT HUB REMOVED HUB CAP, OUTTER NUT, I
OEM - INNER NUT, WHEEL AND HUB INSTALLED, TORQUED AND PAINTED NEW N
OEM - UN INSTALLED AND TORQUED HUB CAP AND WHEEL SPUN WHEEL, COULD
OEM - NO LONGER
OEM - R

SKF 000937

SKF Steer Hub Inspection 70,931

Customer: Freightliner Corp. Claim #: E18C08520 Mileage: 127,000 Kib

Vin #: 1FUJA8CG02LJ8245 Hub Serial #: N/A Rusty Aiken

Customer Complaint: Bus [illegible] Worn

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >.5 grams: yes no Endplay: no yes if no .006"

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooves: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: 10/05/01 Failed: 04/19/02

Comments: OB row grease rusty - small side face & clip ring grove corroded does not wipe away with finger. IB row very dirty - OR RW pitted - rust exfoliation & grease at IR small side faces & OR [illegible] [illegible]

TOOL PICTURES - SAVED FOR DALE BELL - may be [illegible] [illegible] [illegible]

Disposition: OPEN 07/10/02

Root cause:

Customer: Claim #: Mileage:

Vin #: Hub Serial #:

Customer Complaint:

Complete hub received: yes no Highly progressive incident: yes no Hammer mark: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >.5 grams: yes no Endplay: no yes if no

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooves: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: Failed:

Comments:

Disposition:

Root cause:

FOCUS Report

1 records were found.

Report Selection Criteria:

Division: ALL
Product Class: ALL
Product Model: ALL
Sub-Assembly: ALL
System: ALL
Claim Type: ALL
Payee: ALL
Paid Fiscal Year: ALL
Build Fiscal Year: ALL
Serial Number: ALL
Paid From Date: ALL Paid To Date: ALL
Build From Date: ALL Build To Date: ALL
Comment Key Words: - - - -
Pay Action: ALL

ArvinMeritor Claim Number: E1608520 (Approved)

Customer Information

Name: FREIGHTLINER CORP. (C708ST)

Claim/Batch: UTCD0002B3437 FRT-JUN 03 2002

Work Order Number: 130342

VIN: 1FUJANCG02LJ02415

Vehicle Age: 7. Month(s) Vehicle OEM: FREIGHTLINER CORPORATION

Amount Requested

Parts: 454.14

Amount Paid

454.14

SKF 000939

Labor: .00	.00
Other: 38.88	.00
Freight: .00	.00
Policy:	.00
Total: 492.22	**454.14**

Product Information	Claim Information
Product Model: FF981	Claim Type: OEM ON-ENT
Sub Assembly: HUB	Service Claim: No
Failed Part Code Desc:	In-Service Date: 10/05/2001
Problem Code Desc: INEFFECT/INOPER/WORN OUT	Failed Date: 04/19/2002
Serial Number:	Paid Date: 07/08/2002
Repl Serial Number:	Odometer Reading/Unit: 127,000 Kilometers
Failed Part:	Written By: SCOTT WOODY
Problem Location: Not Applicable	Authorized By: SCOTT WOODY
Plant: Asheville	
Material Inspected: No	Inspect By:

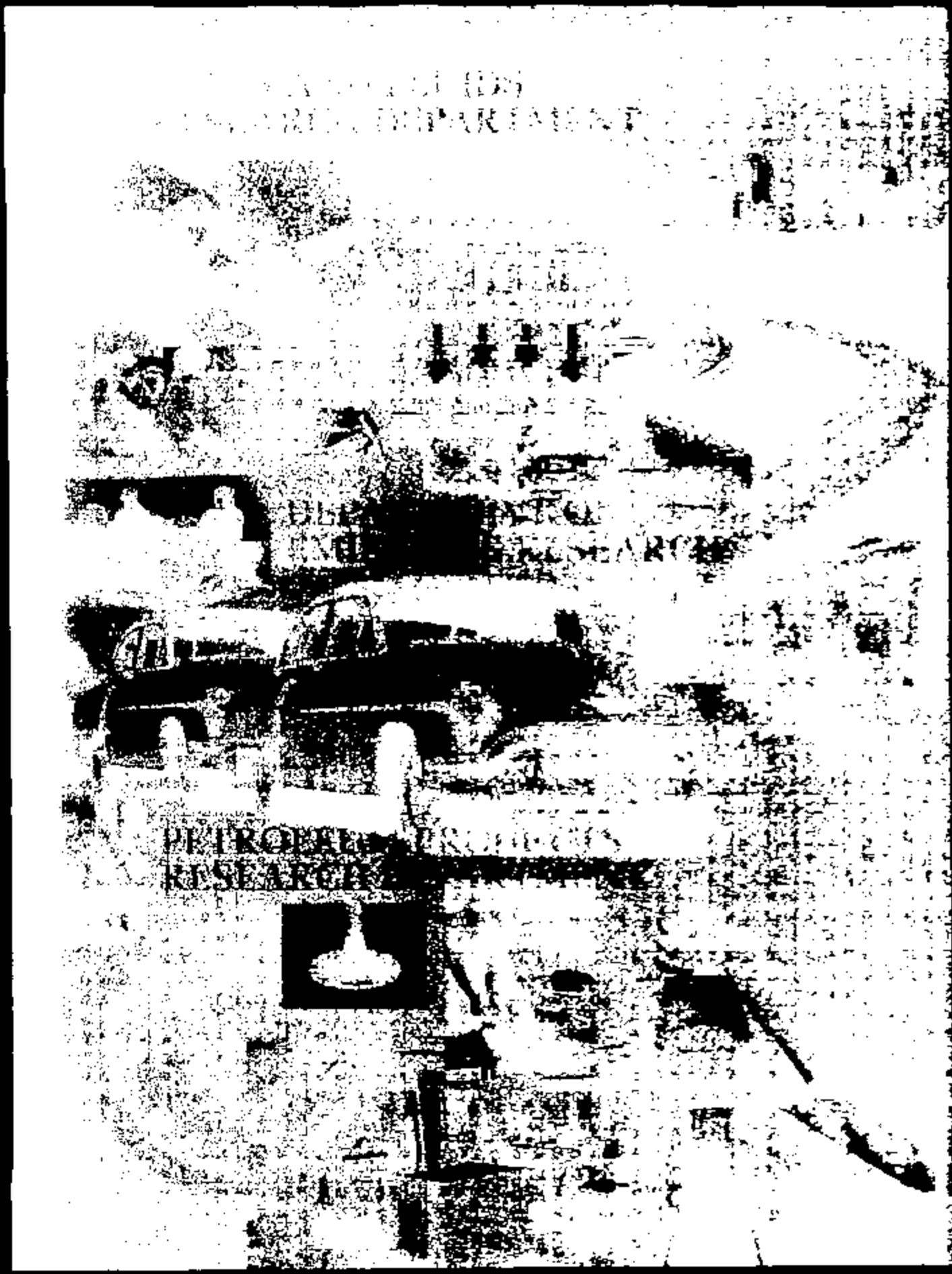
Parts Information

Qty	Part Number
1.00	KIT1434

Claim Comments

OEM - DMG: FRONT AXLE,HUB BEARING WORN
OEM - CHECK FOR FRONT HUB WHEEL BEARING LOOSE/ BEARING GS WORN IN H
OEM - UB/ REPLACE HUB WITH NEW SUBLET REPAIR PERFORMED BY HG MACHE
OEM - IL TRUCK SERVICE, POBOX 828, SYDNEY, N S B1P 6J1 (902) 539-4
OEM - 755

SKF 000640



SKF 000941

SOUTHWEST RESEARCH INSTITUTE™
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November 14, 2002

Mr. John Turner
SKF Automotive Division
46815 Port Street
Plymouth, MI 48170

SUBJECT: Final Report of the *"Evaluation of Front Wheel Bearings on a Class 7 Track"*

Dear Mr. Turner:

Enclosed are two copies of our final report on the *"Evaluation of Front Wheel Bearings on a Class 7 Track"*. Please contact me at (210) 522-6986 should you have any questions or need further assistance.

Best regards,

Brent Shoffner
Senior Research Engineer
Fleet and Field Evaluations Section

BAS/clm
Enclosure(s)

DETROIT, MICHIGAN (248) 353-2660 • HOUSTON, TEXAS (713) 977-1377 • WASHINGTON, DC (301) 881-4098

SOUTHWEST RESEARCH INSTITUTE™
6220 Culebra Road Post Office Drawer 28510
San Antonio, Texas 78228-0510

AUTOMOTIVE PRODUCTS AND EMISSIONS RESEARCH DIVISION

Evaluation of Front Wheel Bearings on a Class 7 Truck

Prepared by

Brent A. Shoffner

FINAL REPORT
SwRI Project 08 05549

Prepared for

SKF USA, Inc.
Plymouth, Michigan

October 26, 2002

Approved by:

Larry A. Eckhardt
Manager
Fleet and Field Evaluations Section

The results of this report relate only to the items tested.
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SKF 000944

APPENDIX

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I. INTRODUCTION

At the request of SKF USA, Inc. (SKF), Southwest Research Institute (SwRI®) tested front wheel bearings utilizing a class-7 single axle diesel truck and trailer rig. The purpose of the test program was to evaluate a right and a left sealed bearing wheel end supplied by SKF.

In the setup phase the right and left front wheel spindles of the truck were instrumented with thermocouples to measure temperature. Thermocouples were also installed in the brake pads for the front hubs. These temperature parameters as well as vehicle speed and ambient temperature were recorded using a Campbell™ 23X micrologger.

Mileage accumulation designated Phase 1 was conducted primarily on Interstate Highway 35 south of San Antonio at speeds of 65-68 miles per hour. Front wheel bearing endplay of both the right and left front wheel bearings was measured at intervals of approximately 2,000 test miles. Weekly status reports which included the temperature, endplay measurements, and other pertinent information were sent to SKF via e-mail.

After the right spindle temperatures exceeded a threshold temperature specified by SKF, a video camera was installed in the cab of the truck to view the driver and a second camera was installed outside the cab to view the right front wheel. A flat computer screen was installed in the cab of the truck to display vertical vibration of the driver's seat mounting bracket. The vehicle was towed to the Continental General Proving Grounds in Uvalde, Texas. The truck and trailer rig was driven until the right front bearing rollers ejected. This phase of operation was documented with the video cameras installed on the truck as well as video taken from a chase vehicle. Temperatures and vehicle speed were also documented.

II. PROGRAM PROCEDURE

A. Setup Phase

1. Truck and Trailer Rig

The single axle truck (unit no. 47298) was a 1997 model year Freightliner Century Classic with a vehicle identification number of 1FUWNTCB9VL841291. The truck had a Detroit Diesel 55-12.0L diesel engine. The front axle was an FF-961 (LX-63) "Easy Steer Plus" rated at 12,000 lbs. The truck had Rockwell 15 X 4 Q+ extended lube cam front brakes. The trailer was a 45-foot flat bed as shown in Appendix A.

The front suspension was aligned to specification and the tie rod ends were replaced. Prior to mileage accumulation the rig was ballasted to load the steering axle near rated capacity. The fifth wheel was moved to the forward most position and a bracket was attached to the front of the truck frame, which held tractor weights to achieve approximately 11,800 lbs. of weight on the front axle. The weights on the axles are given in Table 1.

SKF 000946

Table 1 – Truck Unit No. 47298 and Trailer Axle Weights

Description	Weight (lbs.)
Front axle	11,800
Truck drive axle	19,580
Trailer axles	9,400
Total truck and trailer rig	40,780

2. Installation of the Test Hubs and Instrumentation

The left and the right front wheel hubs for evaluation were supplied by SKF. The right and left tire and wheel assemblies were removed from the truck. The brake drum and brake shoes were removed. The right and left front wheel hubs were removed as well as the steering knuckles. The brake pads were drilled and two thermocouples were installed in the right and the left brake pad. The four brake pad thermocouple locations are designated left front, left rear, right front, and right rear. Refer to page 3 of Appendix B.

The right and left wheel spindles were drilled to facilitate installation of thermocouples to measure spindle inner and outer temperatures. Refer to pages 1 and 2 of Appendix B for a sketch and a photograph of the thermocouple locations. Thermocouples were installed in plugs which were pressed into the spindle so that when the hubs were installed, the plugs contacted the inside diameter of the hub.

The Campbell™ 23X datalogger recorded the parameters listed below at 6-minute intervals. However, when any of the four spindle temperatures reached a threshold of 150°F, all the parameters were recorded at 1 Hertz. The threshold was changed during the program to 200°F. An audible alarm was activated when any of the spindle temperatures exceeded 250°F.

a. Julian date
b. Military time (hours, minutes)
c. Time (seconds)
d. Left inner spindle (°F)
e. Left outer spindle (°F)
f. Right inner spindle (°F)
g. Right outer spindle (°F)
h. Left brake pad front (°F)
i. Left brake pad rear (°F)
j. Right brake pad front (°F)
k. Right brake pad rear (°F)
l. Ambient temperature (°F)
m. Truck speed (mph)

A heat sensitive bolt with a red button indicator on the bolt head was installed in the center of each front wheel hubcap. The red button was designed to pop out when the temperature of the bolt reached approximately 250°F. The threaded end of the bolt protruded approximately 5/8 inch from the inside surface of the hub cab. Later in the program at 16,347 test miles two strips of heat sensitive tape were applied to the inside and outside of both the right and the left hubcaps. Refer to Appendix L for photographs of a hubcap with a heat sensitive bolt and heat sensitive tape. The heat sensitive tape strips had circles designed to change color when a given temperature was encountered. The temperature designations are given in Table 2.

Table 2 – Ranges of the Temperature Strips Mounted on the Hubcaps

Temperature Strip #1	Temperature Strip #2
Six Temperatures	Five Temperatures
200°F	240°F
220°F	280°F
260°F	320°F
300°F	360°F
340°F	400°F
380°F	

B. Phase 1 Mileage Accumulation

Mileage accumulation after the test setup was conducted on the highway until the right inner spindle temperatures exceeded 250°F. This was designated Phase 1. The truck was driven during two shifts of ten hours each per day. Drivers were given instructions regarding the test program prior to driving the test vehicle. The following is a summary of the training provided to the drivers:

1. The drivers were told that the front bearings on the truck were test units.
2. The drivers were instructed to pull off the road and stop if the audible alarm triggered by a spindle temperature was heard.
3. The drivers were instructed to call the project manager or backup person if the heat sensitive bolt had popped out.
4. The drivers were instructed to fill out a Daily Driver Log for every shift of operation. A copy of the Daily Driver Log form is included in Appendix C. The importance of making comments and filling out the Daily Driver Log was stressed.
5. The driving route was given to the drivers.

The test vehicle was driven from SwRI to highway 410 and south on highway 410 to Interstate Highway 35. The driving route consisted primarily of highway speeds on Interstate Highway 35 south of San Antonio. This section of Interstate Highway 35 has some wide curves and rolling hills. The truck was driven back and forth on the southbound and northbound lanes between Fischer Road at mile marker 144 on the north end of the route and Exit 122 on the south end. Prior to completion of the shift, the truck and trailer rig was driven back to SwRI via highway 410. If no problems or delays occurred, then about 500 miles could be accumulated during each shift.

SKF 000948

1. Driver's Comments

The driver's comments pertaining to the front bearing evaluation program in Phase 1 are listed in the table in Appendix G. At the beginning of the program on 5/31/02 after about 4,000 test miles, the drivers complained of vibration and shake in the cab at speeds of 65 mph and higher. It was also reported that the truck steering pulled to the right. The right front tire which was cupped on the outer edge was replaced, but that did not fix the problem. The tire and wheel assembly was balanced and that did resolve the problem. During the program there were several instances where the audible alarm for the spindle temperature threshold sounded. However, these occurrences were false alarms caused by thermocouple wire and connector problems.

Starting on 9/11/02 drivers began to comment that there was a vibration in the steering wheel during braking maneuvers. During the night shift at about 1:00AM at approximately 76,900 test miles, the audible alarm sounded due to the right inner spindle temperature exceeding 250°F. The spindle temperature versus time graphs for Phase 1 are included in Appendix K.

2. Bearing Endplay Measurements

During Phase 1 mileage accumulation, bearing endplay was measured at intervals of approximately 2,000 miles. A checklist form for the technician was developed and used for these measurements. This form is included in Appendix D. When mileage accumulation Phase 1 began, the mechanics were instructed to measure endplay with the tire off the ground using a dial indicator and pushing and pulling the wheel with about 50 lbs. force. The force was applied by gripping the wheel with a hand placed at the 9:00 o'clock position on the wheel and the other hand at the 3:00 o'clock position. This inspection technique was designated the original method.

The complete table of the bearing measurements recorded during the program is shown on page 1 of Appendix E. A graph of the bearing measurements for the right front bearing is shown on page 2 of Appendix E. At the 4,199 test mile bearing inspection, noise was detected in the left front bearing during wheel and tire rotation. However, during the entire test program the left front bearing never exhibited any endplay using the original method or any of the other three methods developed during the program.

At zero test miles the right front bearing exhibited bearing noise. At 42,379 test miles a SwRI Senior Technician noticed that although the endplay as measured by the original method was zero, the tire and wheel assembly would move when approximately 50 lbs. of force was exerted at the 12:00 o'clock position at the top of the tire. A measurement technique was developed based on this finding and was designated the Chadwell Method (named for the senior technician who discovered the wheel and tire movement).

SKF 000949

The following is a description of the Chadwell bearing endplay measurement method. Photographs are shown in Appendix F.

a. The front of the truck was jacked up so that the front tire did not contact the ground.
b. The tire was then lowered to the ground only enough to prevent wheel rotation by hand effort.
c. The base of a dial indicator with a least count of 0.001 inches was secured to the end of the spindle.
d. The dial indicator pointer was placed in a vertical position above the spindle about 0.25 inches from the inside diameter wheel flange.
e. The technician pushed with approximately 50 lbs. of hand effort force at the top of the tire at the 12:00 o'clock position.
f. The dial indicator was zeroed. The technician then pulled with approximately 50 lbs. of hand effort force at the top of the tire. The reading of the dial indicator was the measurement recorded.
g. The technician would rotate the wheel and take several measurements using the same method. The maximum measurement taken at several angular wheel locations was recorded as the final measurement.

At 43,379 test miles the right front wheel bearing movement measured with the Chadwell Method was 0.014 inches. After the right front spindle temperatures exceeded 250°F on the morning of September 18th, the Chadwell Method measurement was 0.064 inches. Refer to the graph on page 2 of Appendix E.

The endplay measured using the original method was 0.00 inches up to 52, 568 test miles. It was thought that the bottom side of the inner race was worn. With the weight of the tire and wheel assembly applying pressure to the top of the inner race, the bearing did not exhibit endplay. To prove this point the tire and wheel assembly was removed and the endplay was measured applying force to the rotor. This technique was designated the rotor only method.

a. The dial indicator was mounted on the end of the spindle and the pointer was placed on the rotor.
b. The rotor was pushed in with approximately 50 lbs. of hand effort force gripping the rotor at 9:00 o'clock and 3:00 o'clock positions.
c. The dial indicator was zeroed and pushed straight in without cocking the rotor from side to side or top to bottom. The dial indicator reading was recorded.
d. Measurements were taken at several angular positions of the rotor and the maximum reading was considered the final result.

The 9:00/3:00 o'clock rotor only measurement was instituted into the program on the right front wheel bearing at 54,406 test miles. That result was 0.017 inches of deflection. At that inspection interval the original method result was 0.003 inches of endplay. A second rotor only measurement method was added at 61,871 test miles. The rotor was gripped at the 12:00 o'clock and 6:00 o'clock position for the second rotor measurement method.

C. Phase 2 – Documentation of the Right Front Bearing Failure

After the right inner spindle temperature reached 250°F, video cameras were installed at two locations on the test truck to document the right bearing impending failure. The rear window of the truck was removed and a box was built to install a video camera which would video tape the driver. Refer to Appendix H. A microphone was rigged for the driver so that he could describe the handling of the truck during and after the bearing failure. Another camera was mounted on a bracket secured to the right running board of the truck to video tape the right front wheel.

A single axis accelerometer was mounted in the vertical direction on the driver's seat support. Refer to Appendix M. The signal was displayed on a flat computer screen which was mounted on the dashboard. The screen was positioned so that it would be included in the video taken by the inside camera which had a wide-angle lens. The computer screen is shown in Appendix L. A sample videotape from the two truck cameras was sent to SKF for approval of the quality. An SKF representative approved the sample video.

The cameras were removed and the truck was towed with the front wheels off the ground from the SwRI campus in San Antonio, Texas to the Continental General Proving Grounds located south of Uvalde, Texas. Another truck was used to haul the 45-foot trailer to the proving grounds. The Continental General Proving Grounds has an 8.5-mile oval track which SwRI subcontracted to conduct Phase 2. On the afternoon of 10/9/02 John Turner of SKF and Larry Eckhardt, Brent Shoffner, James Chadwell, Gene Dickinson, and Kevin Rayborn of SwRI received the safety and orientation briefing from Joe Garcia of Continental General. The SKF / SwRI Team is shown in Appendix J. After safety training the 45-foot trailer was connected to the truck (unit no. 47298).

On the morning of Thursday 10/10/02 the SKF / SwRI Team arrived at the Continental General Proving Grounds. Additional heat sensitive tape strips with a low temperature of 190°F were applied to the right front wheel. The truck cameras were remounted and the truck and trailer rig was driven on the oval track.

The temperature data were recorded during track operation. The graphs of spindle temperatures and brake pad temperatures versus test time during phase 2 are shown in Appendix O. On 10/10/02 approximately 549 miles were accumulated on the oval track at speeds of 65-68 mph. For six hours the right front spindle temperatures remained below 200°F. During that time, lane change maneuvers of up to 7 per mile across 3 lanes were made in an effort to increase the spindle temperatures. Near the end of the day the right inner spindle temperature increased above 350°F. However, at about 6:00 PM the spindle temperatures were again running below 200°F despite lane change maneuvers and the testing was discontinued for 10/10/02.

On 10/11/02 the spindle temperatures remained below 200°F for the first 4 hours of operation which included the same lane change maneuvers as performed on 10/10/02. At about 2:00 PM both right spindle temperatures exceeded 250°F. At about 4:00 PM another maneuver was made in addition to the lane changes. The steering wheel was pulled rapidly back and forth with maximum driver effort. However, the truck stayed in the inner lane. This might have contributed to further deterioration of the right front wheel bearing. The final events of testing on 10/11/02 are discussed in detail in Section III, Findings and Discussion.

III. FINDINGS AND DISCUSSION

A. Driver's Comments

1. Phase 1

During Phase 1 the drivers began to comment that vibration was present in the steering wheel during braking maneuvers. This comment was first recorded on a Driver Daily Log for a shift on 9/9/02, which started with 69,517 test miles and ended with 69,910 test miles. At the bearing measurement interval prior to this shift (69,144 test miles) the right front spindle bearing endplay was 0.049 inches as measured using the Chadwell Method. The right inner spindle temperature exceeded 250°F at approximately 76,900 test miles. Other than the comment regarding the vibration when braking, there were no other driver observations which could be attributed to the right front bearing condition during Phase 1.

2. Phase 2

During Phase 2 the driver was listening for and observing any detail that might indicate a change in the right front bearing condition. In addition an observer in the truck was watching the right spindle and brake pad temperatures and relaying increased values to the driver. The drivers and observers in Phase 2 were paying more attention to potential symptoms of a right front bearing problem than a driver in a truck and trailer rig in a typical commercial operation. Refer to page 1 of Appendix N showing the driver and typical vibration screen during operation prior burn out of the bearing grease.

When the grease burned out of the right front bearings in Phase 2, the driver began to notice a slight pull in the steering wheel to the right. This was on the order of magnitude of a steering wheel pull, caused by a slight crown in the highway. The observer could see the smoke from the burning grease and related this to the driver. Refer to page 2 of Appendix N. The driver then directed his attention to the right rear view mirror and could then see the smoke. No smoke entered the cab or was noticeable though the windshield. When the brake pad temperatures began to elevate, the brake pad burning smell was slightly noticeable in the cab for a 1-2 seconds. The brake smell was noted by the driver of the water truck chase vehicle which was behind the test truck.

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The truck was driven on the oval track for approximately 44 miles at speeds of 55 mph to 65 mph after the grease burned out of the bearing. During this time the truck continued to pull slightly to the right at about the same effort. The smoke gradually subsided over the next 44 miles. Prior to slowing down to exit the track for videotape changes, the driver performed a medium to hard braking maneuver. The truck brake pedal effort seemed normal. During the actual braking maneuver to exit the track the brake pedal effort was normal and the steering wheel did not vibrate. A photograph of the right brake drum is shown on page 3 of Appendix P.

After the videotape change the truck was driven back out onto the track and was accelerating. At about 35 mph the driver began to feel steering wheel shake at the same frequency as the wheel wobble. The chase vehicle radioed the driver that the right front wheel was wobbling. The observer could also view the wheel wobble in the video monitor for the outside camera. Refer to page 3 of Appendix F. Roller ejection was observed by the chase vehicle and this was radioed to the driver and observer in the truck. Refer to page 4 of Appendix N. The driver felt the cab front end "hop" and at that point was directed by the SKF representative on site to slow down and stop.

The remains of the hubcap and other parts were collected and given to the SKF representative on site. A photograph of the spindle end after roller ejection is shown in Appendix P.

B. Bearing End Play Measurements

The complete table of endplay measurements taken during the program is included in Appendix E. Table 3 contains a summary of the right front wheel bearing measurements as they relate to pertinent test events. The remarks describe the subjective bearing noise observed during bearing measurement intervals.

Table 3 – Right Front Bearing Endplay Measurements.

Date	Test Miles	Original Method (inches)	Rotor Only 9:00/3:00 (inches)	Chadwell Method (inches)	Remarks Regarding Bearing Noise
5/22/02	0	0.000	[redacted]		Start of Test. Bearing noise is observed.
9/9/02	Approx. 69,517	Driver's comments about steering wheel vibration during braking began.			
9/15/02	74,936	0.009	0.039	0.075	Bearing noise was lower pitch and more pronounced than previous.
9/18/02	Approx. 76,900	The right inner spindle temperature exceeded 250°F at about 76,900 test miles			
9/18/02	76,916	0.009	0.044	0.064	Wheel rotation was slower than previous with the same hand effort.
10/11/02	77,465	0.010	0.040	0.094	Rollers could be heard audibly rolling over the top of the inner race and hitting the adjacent roller.
10/11/02	77,882	The grease burned out of the bearing.			
10/11/02	77,927	The rollers ejected.			

C. Temperature Measurements

1. Phase 1

The right front spindle temperature measurements versus time for Phase 1 are shown in Appendix K. Neither the spindle inner or outer temperature exceeded 250°F until approximately 76,900 test miles at 1:00 AM on the morning of 9/18/02. The graph of spindle temperature versus time when this event occurred is shown on the last page of Appendix K. The truck was driven to SwRI while the driver monitored the inner spindle temperature on the datalogger display.

The heat sensitive bolt on the right front hubcap did not pop out during phase 1. None of the temperature circles on the heat sensitive tape changed color during Phase 1. This indicated that the heat sensitive tape on either the inside or outside of the hubcap had not reached 200°F which was the lowest temperature circle.

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2. Phase 2

Graphs of both the spindle temperatures and the brake pad temperatures during Phase 2 are shown in Appendix O. When the grease burned out of the bearing at about 5:00 PM on 10/11/02 the spindle inner temperature reached a maximum of 912°F and the spindle outer temperature reached a maximum of 652°F. The truck was driven at speeds of 55 – 65 mph on the track for about 44 miles after the grease burned out of the bearing. During that time the right rear brake pad temperature generally increased to a maximum of 1333°F. The right front brake pad temperature reached a maximum of 988°F and then decreased to a range of about 700 - 800°F.

After changing the videotapes and subsequent roller ejection at about 30-35 mph, the right rear brake pad temperature reached a maximum of 1352°F and the right front brake pad temperature reached a maximum of 816°F. The right outer spindle temperature was a maximum of 610°F and the spindle inner temperature was a maximum of 543°F.

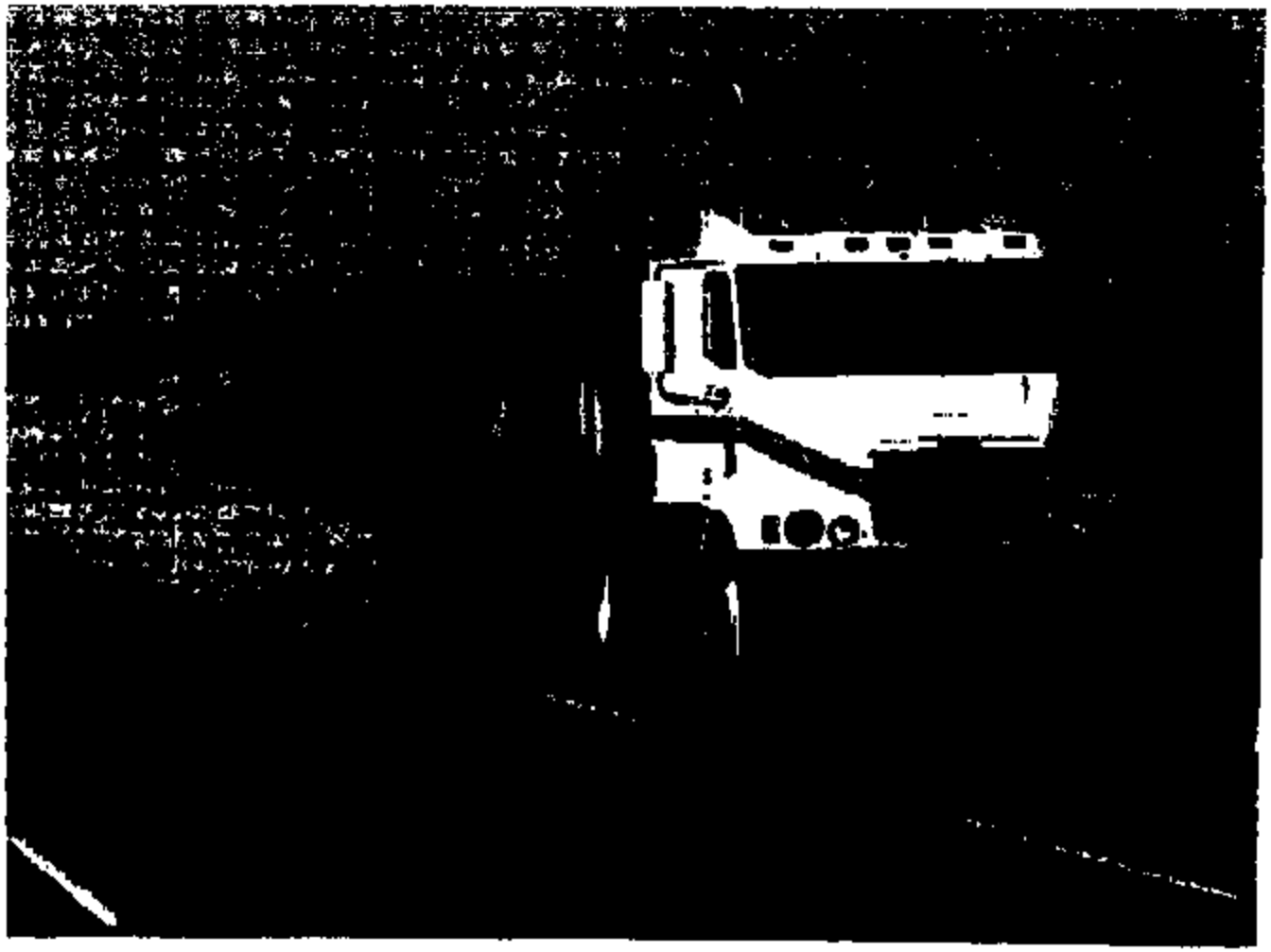
At the stop prior to the laps when the grease burned out of the bearing, the 190°F temperature circle on a temperature strip on the right front wheel was colored. At the stop for video tape changes after the grease had burned out of the bearing, all the temperature circles had changed color on all the tape strips on the right front wheel. At this point the red button on the heat sensitive bolt was also observed to have popped out. Refer to page 1 of Appendix P.

D. Video

As of 10/26/02 the original videotapes taken during Phase 2 are stored in the SwRI Photographic Department. Duplicate VHS tapes of all the original videotapes have been made. A sample video in VHS format of the major events which occurred on 10/11/02 from the best camera angles was assembled and sent to SKF the week of 10/14/02. SwRI is awaiting direction from SKF whether to produce a final edited videotape or send the original videotapes to SKF.

APPENDIX A
Truck and Trailer Rig

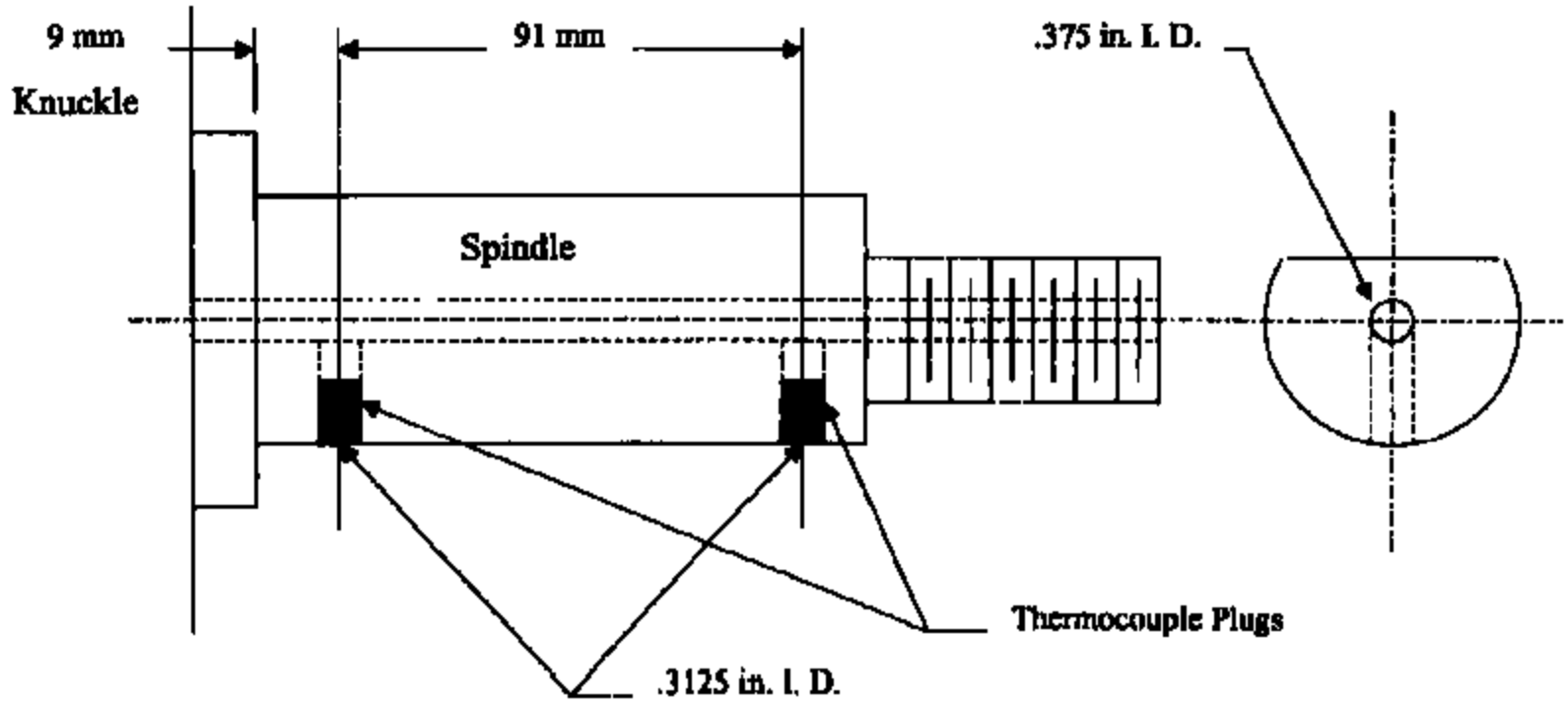
Truck and Trailer Rig on the Continental General Proving Grounds 8.5-Mile Oval Track



A-1 of 1

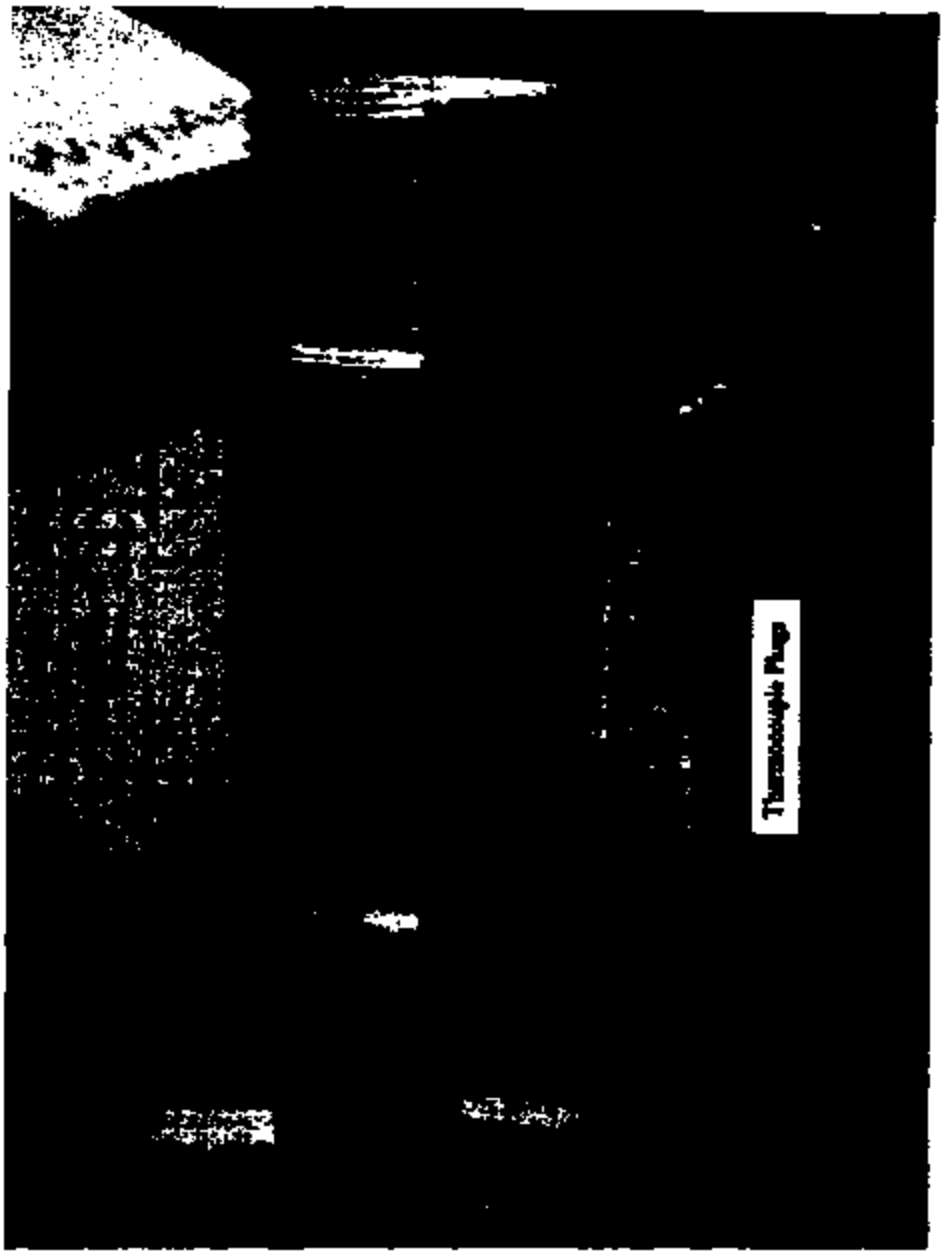
APPENDIX B
Spindle and Brake Pad Thermocouples

Sketch of the Thermocouple Locations in the Spindles



SKF 000849

Front Spindle



Brake Pad Thermocouples

SKF 000981

APPENDIX C
Daily Driver Log

Daily Driver Log

Date	
Driver's Name	
Beginning Odometer	
Ending Odometer	

1. If the audible alarm sounds, pull off the road in a safe place and call one of the contact people listed below.
2. Perform a minimum of 5 passing maneuvers on the highway per shift even if you have to simulate lane changes to achieve five.

	Pretest Questionnaire	Yes	No
1	The temperature indicator bolt on front right or left hub cap has popped up – RH or LH side (circle correct side) ***If the temperature indicator bolt has popped out, do not drive the truck and call one of the contact people listed below.***		

	Lunch Questionnaire	Yes	No
1	The temperature indicator bolt on front right or left hub cap has popped up – RH or LH side (circle correct side) ***If the temperature indicator bolt has popped out, do not drive the truck and call one of the contact people listed below.***		

	Post-Test Drive Situation Questionnaire	Yes	No
1	Steering the truck was easy – It remained straight on the road. Little correction of the steering wheel was required		
2	The Steering Wheel Pulled to Left or Right. The third spoke was at _____ o'clock (In example: Spoke was at 7 o'clock position)		
3	The brakes overheated and begin to smell		
4	I felt unusual vibration in the steering		
5	I heard unusually loud noises coming from the axle or wheels		

Contact Personnel

Brent Shoffner: (210) 522-6986 (work), (210) 493-6017 (home), 1-800-625-9280 (pager)
Larry Eckhardt: (210) 522-2980 (work), (210) 679-0682 (home), (210) 553-1949 (pager)
James Chadwell: (210) 522-2838 (work), (210) 496-7102 (home), (210) 377-7635 (pager)

Driver's Comments: _____

_____

_____

APPENDIX D
Bearing Inspection Checklists

Right Front Bearing Inspection
Truck # 47298

Senior Technician_____
Date: _____ **Military Time:** _____ **Odometer:** _____

1. _____ Have the temperature indicator ranges on the "hub cap outside" heat sensitive tape changed color? Yes □ or No □.
   If yes, which one(s)? _____.
   Has the heat sensitive bolt in the hubcap popped out? Yes □ or No □.
2. _____ Jack up the front end of the truck and place jack stands under the front end.
3. _____ Rotate the wheel clockwise. Is the bearing quiet/smooth?
   Yes □ or No □.
4. _____ Remove the hubcap.
   Have the temperature indicator ranges on the "hub cap inside" heat sensitive tape changed color. Yes □ or No □.If so, which one(s)? _____?
   Place the magnetic base of a dial indicator with a .001 inch least count on the end of the spindle and the pointer at 12:00 o'clock 0.25 inches outside the inner wheel flange.
   Push on the wheel with hands at 9:00 and 3:00 o'clock and zero the gage.
5. _____ Pull on the wheel with approximately 50 lbs. of force (hands at same location) and record the end play reading here _____ inches.
6. _____ Lower the jack until the wheel contacts the ground only enough to prevent rotation.
   Push the top of the tire at 12:00 o'clock and zero the gage.
   Pull with about 50-lbs. force and record the maximum deflection here_____.
7. _____ Remove the wheel and drum.
8. _____ Mount the dial indicator base on the end of the spindle and the pointer on the brake rotor at 12:00 o'clock.
9. _____ Push on the rotor with hands at 9:00 and 3:00 o'clock to mechanical stop and zero the gage.
10. _____ Pull on the rotor to mechanical stop (hands same location) and record maximum deflection here _____.
11. _____ Push on the rotor with hands at 6:00 and 12:00 o'clock to mechanical stop and zero gage.
12. _____ Pull on the rotor to mechanical stop (hands same location) and record maximum deflection here _____.
13. _____ If #10 is greater than 0.003 inches, then pull the key to the truck and do not replace in truck unless approved by Brent Shoffner at 522-6986 *(work) or 493-6017 (home). If #10 is 0.003 inches or less then go to #14.*
14. _____ Return checklist to Brent Shoffner.
15. _____ Remove the dial indicator.
    Reinstall drum, wheel, and hubcap.
    Torque lug nuts to 450-500 lb.-ft. and the hubcap to 350 lb.-ft.

If Brent Shoffner is not available, call Larry Eckhardt at 522-2980 (work), 679-0682 (home), or 553-1949 (pager).

Revision D – 8/16/02

Left Front Bearing Inspection
Truck # 47298

Senior Technician_____
Date:_____ **Military Time:**_____ **Odometer:**_____

16._____ Have the temperature indicator ranges on the " hub cap outside" heat sensitive tape changed color? Yes □ or No □. If so, which one(s)? _____
Has the heat sensitive bolt in the hubcap popped out? Yes □ or No □.
If "Yes", then go to Step A. If "No, then go to Step #2.

17._____ Jack up the front end of the truck and place jack stands under the front end.

18._____ Rotate the wheel counter-clockwise. Is the bearing quiet/smooth?
Yes □ or No □.

19._____ Remove the hubcap.
Have the temperature indicator ranges on the "hub cap inside" heat sensitive tape changed color. Yes □ or No □.If so, which one(s)? _____
Place the magnetic base of a dial indicator with a 0.001 inch least count on the end of the spindle and the pointer at 12:00 o'clock 0.25 inches outside the inner wheel flange.
Push on the wheel with approximately 50 lbs. force with hands at 9:00 and 3:00 o'clock and zero the gage.

20._____ Pull on the wheel with approximately 50 lbs. of force (hands at same location) and record the end play reading here _____ inches.

21._____ Lower the jack until the wheel contacts the ground only enough to prevent rotation.
Push the top of the tire with approximately 50 lbs. force at 12:00 o'clock and zero the gage.
Pull with about 50-lbs. force and record the maximum deflection here_____.
If Step #5 or Step #6 is greater than 0.003 inches, then go to Step 7.
Otherwise go to Step B.

22._____ Remove the wheel and drum.
Remove the outer lock nut and tabbed washer.
Torque the nut to 700 lb.-ft. while rotating the wheel a minimum of 5 rotations.
Replace the tab nut and torque the outer lock nut to 250 lb.-ft.
Go to Step A.

A. _____ Pull the key to the truck and store it for pick-up by Brent Shoffner.
Call Brent *Shoffner at 522-6986 (work) or 493-6017 (home).*
If Brent Shoffner is not available, call Larry Eckhardt at 522-2960 (work), 679-0652 (home), or 553-1949 (pager).

B. _____ The left front bearing inspection is complete.

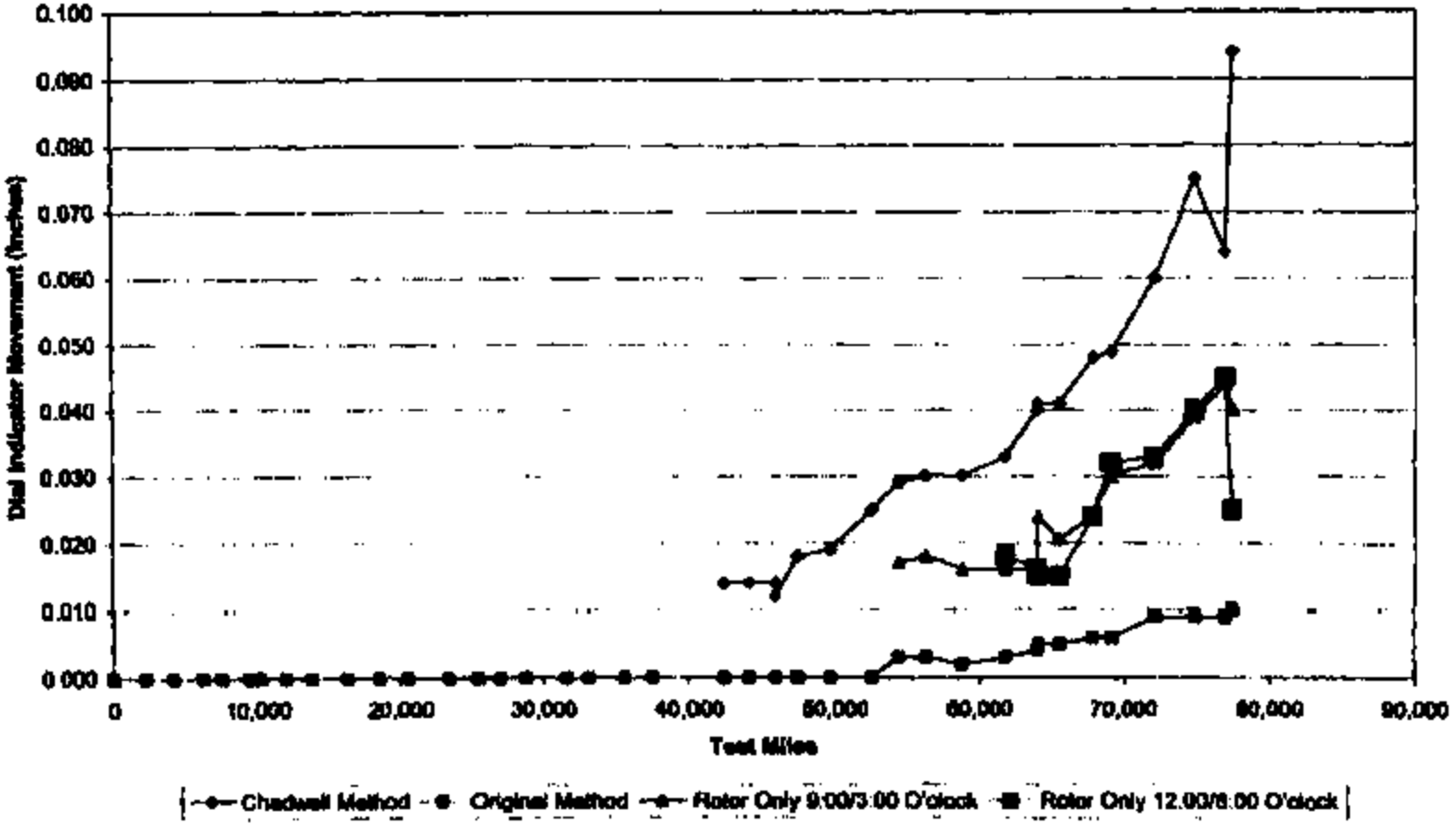
APPENDIX E
Bearing Endplay Measurements

SKF Bearing Evaluation Program

Test Miles versus Front Bearing End Play
Brent Shollhar 9/19/02
Start of Test Odome 181,112 miles

Date	Odometer	Test Miles	Left Front Bearing					Right Front Bearing					Temperature Strips			
													Left		Right	
			Notes	End Play Push/ Pull (inches)	End Play Chadwell Method* (inches)	Rotor Only End Play 12:00/6:00 O'clock (inches)	Rotor Only End Play 9:00/3:00 O'clock (inches)	Notes	End Play Push/ Pull (inches)	End Play Chadwell Method* (inches)	Rotor Only End Play 12:00/6:00 O'clock (inches)	Rotor Only End Play 9:00/3:00 O'clock (inches)	(Outside)	(Inside)	(Outside)	(Inside)
09/22/02	181,112	0	No	0.000				Yes	0.000							
09/23/02	183,340	2,228	No	0.000				Yes	0.000							
09/01/02	185,311	4,199	Yes	0.000				Yes	0.000							
09/03/02	187,408	6,296	Yes	0.000				Yes	0.000							
09/05/02	189,419	7,807	Yes	0.000				Yes	0.000							
09/07/02	190,988	9,484	Yes	0.000				Yes	0.000							
09/09/02	191,320	10,208	Yes	0.000				Yes	0.000							
09/12/02	193,128	12,016	Yes	0.000				Yes	0.000							
09/13/02	193,946	13,834	Yes	0.000				Yes	0.000							
09/16/02	197,408	16,247	Yes	0.000				Yes	0.000				Installed		Installed	
09/17/02	198,726	16,614	Yes	0.000				Yes	0.000				No Change		No Change	
09/18/02	211,772	29,810	Yes	0.000				Yes	0.000				No Change		No Change	
09/20/02	214,084	32,076	Yes	0.000				Yes	0.000				No Change		No Change	
09/20/02	216,488	34,644	Yes	0.000				Yes	0.000				No Change		No Change	
09/30/02	218,182	37,080	Yes	0.000				Yes	0.000				No Change		No Change	
07/03/02	219,944	38,832	Yes	0.000				Yes	0.000				No Change		No Change	
07/07/02	222,765	41,681	Yes	0.000				Yes	0.000				No Change		No Change	
07/08/02	224,388	43,188	Yes	0.000				Yes	0.000				No Change		No Change	
07/10/02	226,728	45,616	Yes	0.000				Yes	0.000				No Change		No Change	
07/12/02	228,965	47,871	Yes	0.000				Yes	0.000				No Change		No Change	
07/22/02	233,450	52,376	Yes	0.000				Yes	0.000	0.014	*		No Change		No Change	
07/16/02	236,210	55,104	Yes	0.000	0.000			Yes	0.000	0.014	*		No Change		No Change	
07/18/02	237,028	55,917	Yes	0.000	0.000			Yes	0.000	0.014	*		No Change		No Change	No Change
07/19/02	237,028	55,917								0.012	**					
07/19/02	237,028	55,917	Yes	0.000	0.000			Yes	0.000	0.013	*					
07/20/02	238,311	57,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
07/21/02	239,311	58,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
07/22/02	240,311	59,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
07/23/02	241,311	60,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
07/24/02	242,311	61,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
07/25/02	243,311	62,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
07/26/02	244,311	63,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
07/27/02	245,311	64,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
07/28/02	246,311	65,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
07/29/02	247,311	66,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
07/30/02	248,311	67,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
07/31/02	249,311	68,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/01/02	250,311	69,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/02/02	251,311	70,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/03/02	252,311	71,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/04/02	253,311	72,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/05/02	254,311	73,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/06/02	255,311	74,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/07/02	256,311	75,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/08/02	257,311	76,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/09/02	258,311	77,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/10/02	259,311	78,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/11/02	260,311	79,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/12/02	261,311	80,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/13/02	262,311	81,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/14/02	263,311	82,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/15/02	264,311	83,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/16/02	265,311	84,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/17/02	266,311	85,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/18/02	267,311	86,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/19/02	268,311	87,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/20/02	269,311	88,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/21/02	270,311	89,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/22/02	271,311	90,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/23/02	272,311	91,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/24/02	273,311	92,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/25/02	274,311	93,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/26/02	275,311	94,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/27/02	276,311	95,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/28/02	277,311	96,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/29/02	278,311	97,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/30/02	279,311	98,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
08/31/02	280,311	99,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/01/02	281,311	100,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/02/02	282,311	101,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/03/02	283,311	102,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/04/02	284,311	103,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/05/02	285,311	104,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/06/02	286,311	105,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/07/02	287,311	106,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/08/02	288,311	107,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/09/02	289,311	108,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/10/02	290,311	109,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/11/02	291,311	110,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/12/02	292,311	111,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/13/02	293,311	112,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/14/02	294,311	113,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/15/02	295,311	114,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/16/02	296,311	115,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/17/02	297,311	116,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/18/02	298,311	117,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/19/02	299,311	118,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/20/02	300,311	119,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/21/02	301,311	120,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/22/02	302,311	121,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/23/02	303,311	122,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/24/02	304,311	123,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/25/02	305,311	124,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/26/02	306,311	125,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/27/02	307,311	126,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/28/02	308,311	127,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/29/02	309,311	128,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
09/30/02	310,311	129,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/01/02	311,311	130,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/02/02	312,311	131,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/03/02	313,311	132,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/04/02	314,311	133,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/05/02	315,311	134,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/06/02	316,311	135,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/07/02	317,311	136,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/08/02	318,311	137,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/09/02	319,311	138,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/10/02	320,311	139,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/11/02	321,311	140,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/12/02	322,311	141,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/13/02	323,311	142,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/14/02	324,311	143,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/15/02	325,311	144,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/16/02	326,311	145,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/17/02	327,311	146,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/18/02	328,311	147,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/19/02	329,311	148,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/20/02	330,311	149,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/21/02	331,311	150,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/22/02	332,311	151,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/23/02	333,311	152,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/24/02	334,311	153,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/25/02	335,311	154,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/26/02	336,311	155,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/27/02	337,311	156,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/28/02	338,311	157,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/29/02	339,311	158,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/30/02	340,311	159,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
10/31/02	341,311	160,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/01/02	342,311	161,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/02/02	343,311	162,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/03/02	344,311	163,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/04/02	345,311	164,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/05/02	346,311	165,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/06/02	347,311	166,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/07/02	348,311	167,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/08/02	349,311	168,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/09/02	350,311	169,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/10/02	351,311	170,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/11/02	352,311	171,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/12/02	353,311	172,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/13/02	354,311	173,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/14/02	355,311	174,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/15/02	356,311	175,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/16/02	357,311	176,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/17/02	358,311	177,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/18/02	359,311	178,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/19/02	360,311	179,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/20/02	361,311	180,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/21/02	362,311	181,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/22/02	363,311	182,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/23/02	364,311	183,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/24/02	365,311	184,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/25/02	366,311	185,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/26/02	367,311	186,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/27/02	368,311	187,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/28/02	369,311	188,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/29/02	370,311	189,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
11/30/02	371,311	190,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/01/02	372,311	191,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/02/02	373,311	192,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/03/02	374,311	193,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/04/02	375,311	194,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/05/02	376,311	195,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/06/02	377,311	196,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/07/02	378,311	197,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/08/02	379,311	198,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/09/02	380,311	199,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/10/02	381,311	200,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/11/02	382,311	201,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/12/02	383,311	202,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/13/02	384,311	203,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/14/02	385,311	204,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/15/02	386,311	205,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/16/02	387,311	206,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/17/02	388,311	207,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/18/02	389,311	208,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/19/02	390,311	209,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/20/02	391,311	210,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/21/02	392,311	211,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/22/02	393,311	212,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/23/02	394,311	213,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/24/02	395,311	214,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/25/02	396,311	215,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/26/02	397,311	216,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/27/02	398,311	217,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/28/02	399,311	218,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/29/02	400,311	219,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/30/02	401,311	220,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
12/31/02	402,311	221,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/01/03	403,311	222,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/02/03	404,311	223,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/03/03	405,311	224,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/04/03	406,311	225,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/05/03	407,311	226,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/06/03	408,311	227,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/07/03	409,311	228,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/08/03	410,311	229,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/09/03	411,311	230,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/10/03	412,311	231,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/11/03	413,311	232,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/12/03	414,311	233,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/13/03	415,311	234,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/14/03	416,311	235,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/15/03	417,311	236,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/16/03	418,311	237,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/17/03	419,311	238,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/18/03	420,311	239,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/19/03	421,311	240,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/20/03	422,311	241,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/21/03	423,311	242,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/22/03	424,311	243,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/23/03	425,311	244,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/24/03	426,311	245,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/25/03	427,311	246,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/26/03	428,311	247,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/27/03	429,311	248,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/28/03	430,311	249,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/29/03	431,311	250,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/30/03	432,311	251,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
01/31/03	433,311	252,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
02/01/03	434,311	253,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
02/02/03	435,311	254,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
02/03/03	436,311	255,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
02/04/03	437,311	256,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
02/05/03	438,311	257,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
02/06/03	439,311	258,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
02/07/03	440,311	259,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
02/08/03	441,311	260,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
02/09/03	442,311	261,200	Yes	0.000	0.000			Yes	0.000	0.013	*		No Change		No Change	
02/10/03	443,311	262,200	Yes	0.000	0.000			Yes	0.000

SKF Bearing Evaluation Program
Right Front Bearing
Brent Shoffner 10/11/02



SKF 000619

APPENDIX F
Photographs of the Chadwell Endplay Measurement Method

Chadwell Measurement Method

Dial Indicator Position for the Chadwell Method

SKF 008972

APPENDIX G
Phase 1 Driver Comments

Driver's Comments Pertaining to the Front Wheel Bearing Evaluation Program During Phase 1

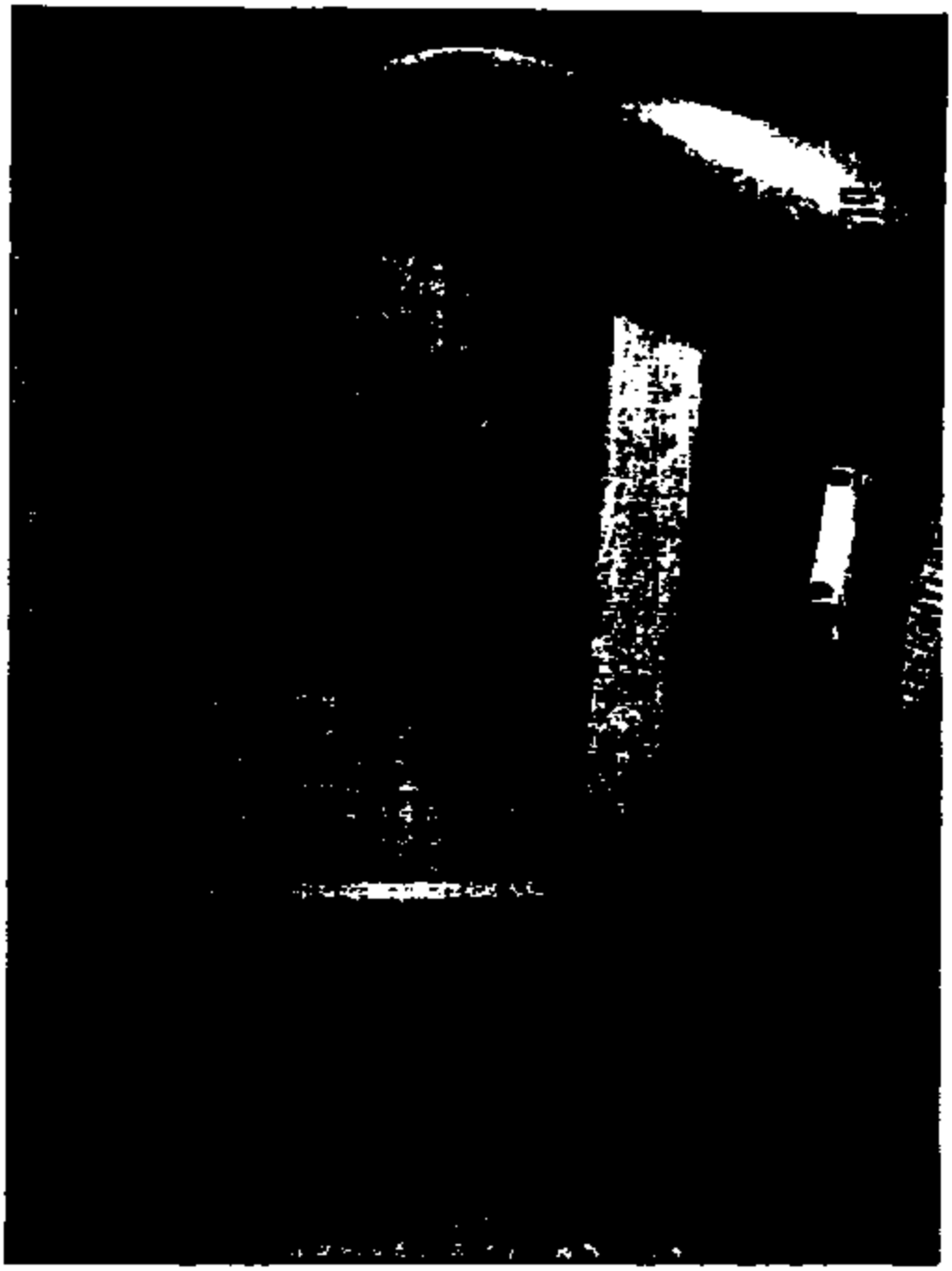
Start of shift date	Start of shift test miles	End of shift test miles	Driver Comments
5/30/02	3,564	3,628	The audible alarm sounded at 6:20 PM. The driver pulled over to the side of the road. A wrecker towed the vehicle to SwRI. Note: This was later found to be a false alarm due to thermocouple wiring problems.
5/31/02	3,715	4,199	Vibration was reported at speeds over 65 mph.
6/1/02	4,199	4,547	Steering pulls to the right. The right front tire is cupped on the outside edge.
6/1/02	4,547	5,006	Shakes very badly.
6/2/02	5,006	5,507	Vehicle pulls to the right. The vibration is extremely noticeable at speeds of 65 mph and above.
6/2/02	5,507	5,791	Had to slow down below 65 mph due to increasing vibration.
6/3/02	5,791	6,296	Right front tire is cupped on the outside edge. The truck has extreme vibration at 65 mph and above. Note: the right front tire was removed and replaced with a new tire after this shift and prior to the next shift.
6/3/02	6,296	6,800	The truck still shakes.
6/4/02	6,800	7,304	The vibration is just as bad as it was prior to replacing the right front tire.
6/4/02	7,304	7,488	The vibration is getting worse. The right front tire and wheel assembly was balanced after this shift and prior to the next shift.
6/5/02	7,488	7,624	The vibration problem seems to be fixed.
6/5/02	7,624	7,992	The right truck drive axle inner tire blew out and damaged the right drive axle outer tire. Replaced the right inner and outer truck drive axle tires. The audible alarm sounded at 10:07 PM. It was determined to be a false alarm due to thermocouple wiring and connector problems.
6/8/02	9,708	10,208	Audible alarm sounded intermittently. It was determined to be a false alarm due to thermocouple wiring and connector problems.
6/10/02	10,208	10,665	Vibration is increasing.
7/1/02	27,439	27,744	Left front tire has a slow leak.
7/2/02	28,233	28,441	Left front tire has been repaired.

7/2/02	28,441	28,828	The audible alarm sounded at about 11:15 PM. It was determined to be a false alarm due to thermocouple wiring and connector problems.
7/18/02	39,590	40,087	Front end weights had moved to the driver's side of the center of track.
7/19/02	40,087	40,588	Centered the front weights before starting the shift.
7/20/02	40,588	41,089	The audible alarm sounded intermittently at about 10:30 AM.
7/21/02	41,090	41,591	Audible alarm still going off but less frequently. It was determined to be a false alarm due to thermocouple wiring and connector problems.
8/8/02	53,068	53,402	Audible alarm was going on and off. It was determined to be a false alarm due to thermocouple wiring and connector problems.
8/23/02	63,989	64,025	On Friday 8/23/02 after the bearing inspection the driver complained that during a brake maneuver from 55 MPH the steering wheel shook. After investigation it was determined that SwRI had mis-aligned the right front brake drum slightly when it was reinstalled. The brake drum was installed correctly and the problem was cured.
9/9/02	69,517	69,910	Vibration when braking.
9/11/02	71,115	71,616	Steering wheel vibration when braking.
9/15/02	74,936	75,260	Audible alarm sounded at 10:15 PM. Truck driven back to SwRI. It was determined to be a false alarm due to thermocouple wiring and connector problems.
9/16/02	75,260	75,459	Vibration when braking.
9/17/02	76,467	76,916	The alarm came on at 1:00 AM. The right inner spindle temperature was exceeding 250°F. Drove the truck at speeds less than 55 mph back to SwRI.

APPENDIX H
Video Camera Installation

Inside Video Camera Enclosure From Outside the Truck

Inside Video Camera



APPENDIX 1
Computer Screen for Vertical Vibration of the Driver's Seat Mounting Bracket

Display Screen

SKF 0009840

APPENDIX J
SKF / SwRI Team

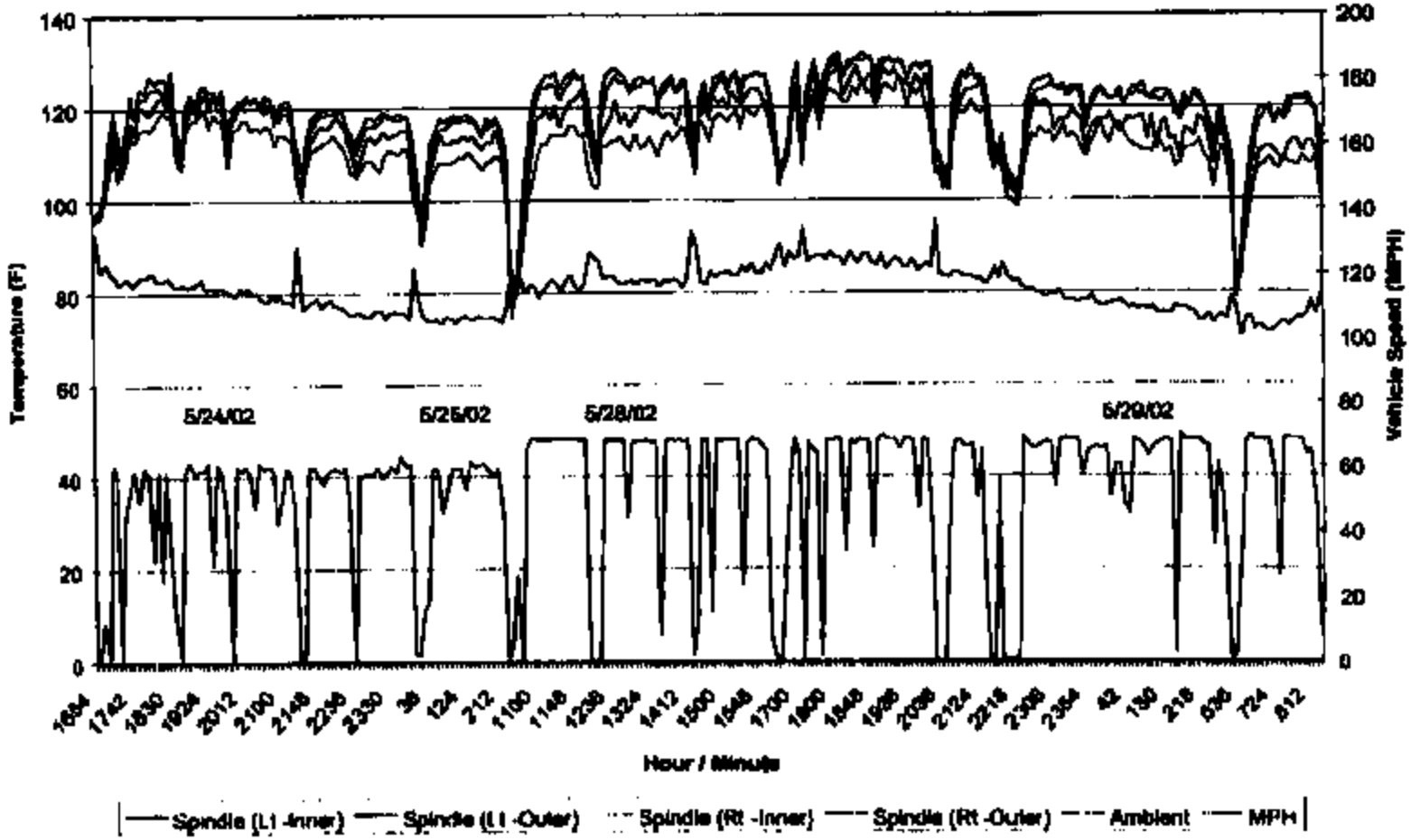
SKF / SwRI Team

From Left to Right: – Kevin Rayhons, James Chadwell, Brent Shoffner, Larry Eckhardt, Gene Dickinson, John Turner

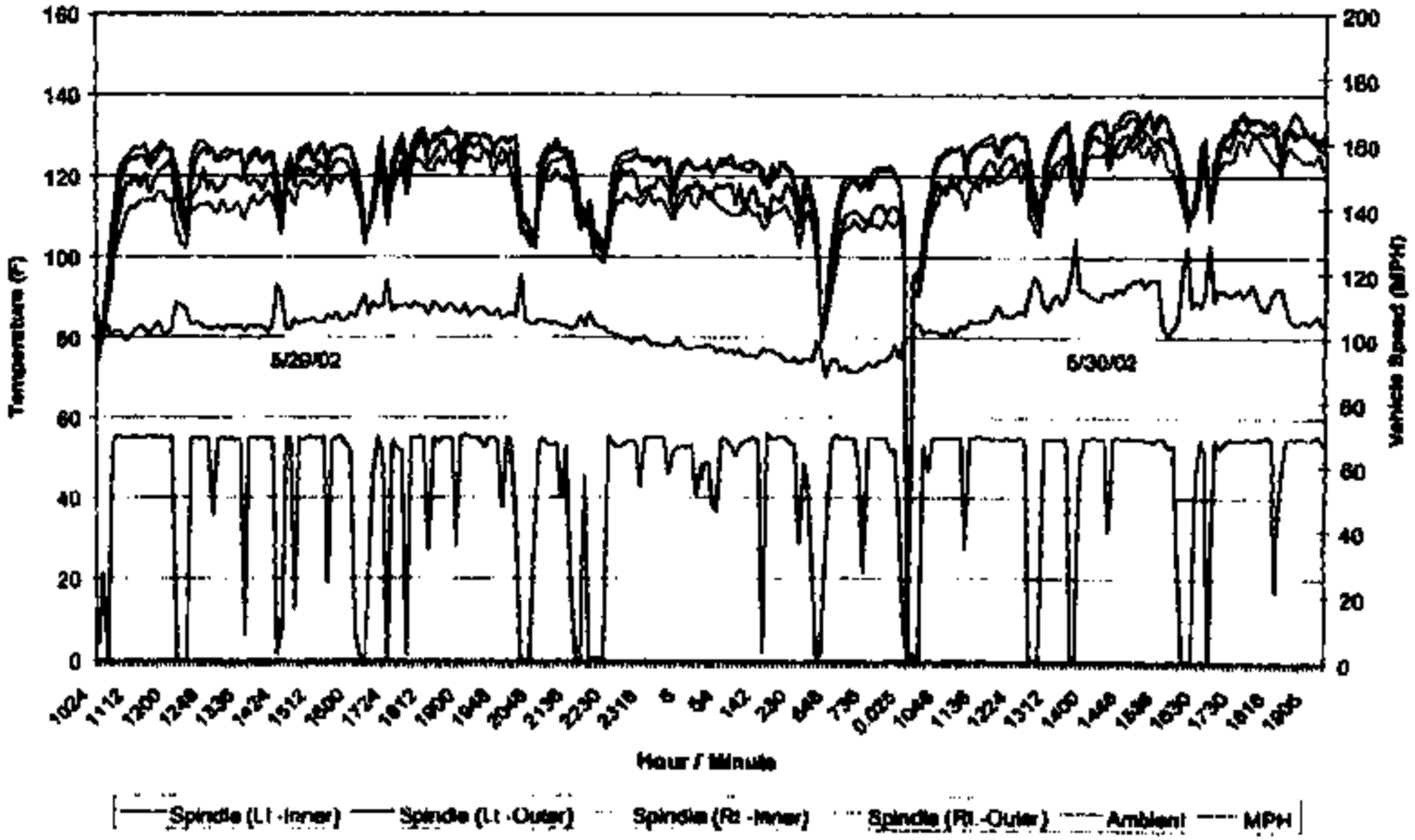
SKF 000982

APPENDIX K
Spindle Temperatures Versus Test Time for Phase 1

Truck 47298 - Spindle Temperature Versus Time
Brent Shoffner 5/29/02

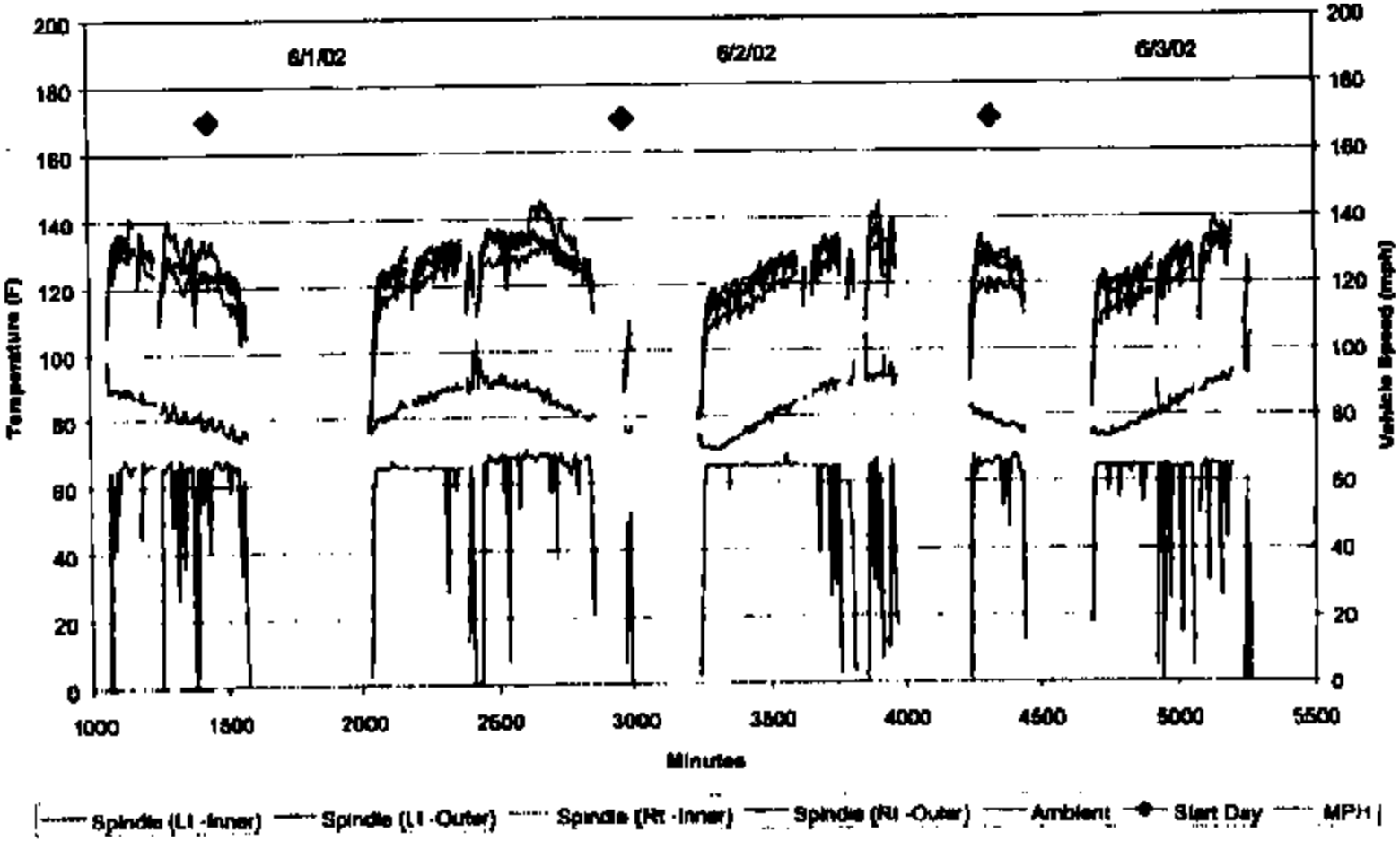


Truck 47298 - Spindle Temperature Versus Time
Brent Shoffner 5/30/02

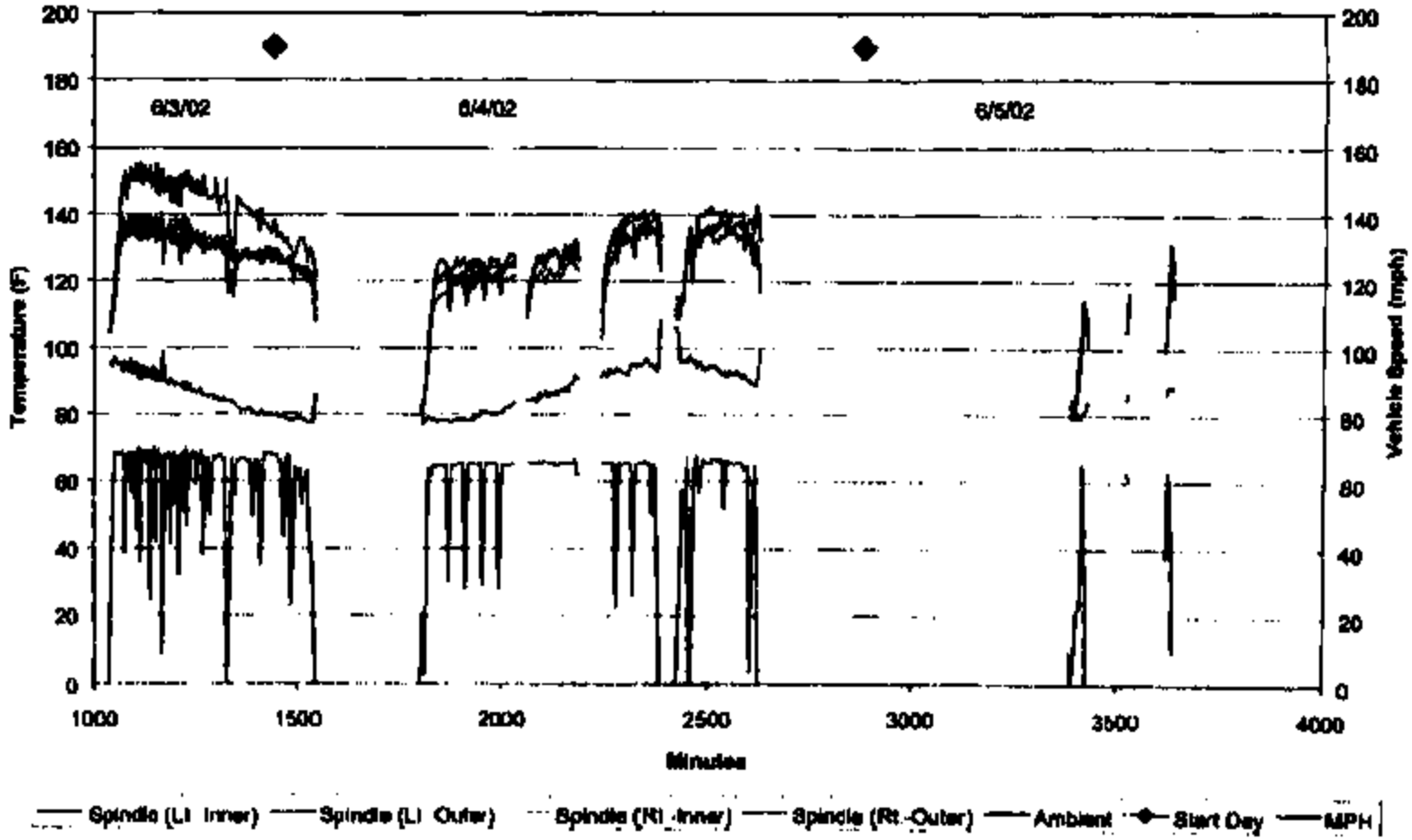


SKF 0009

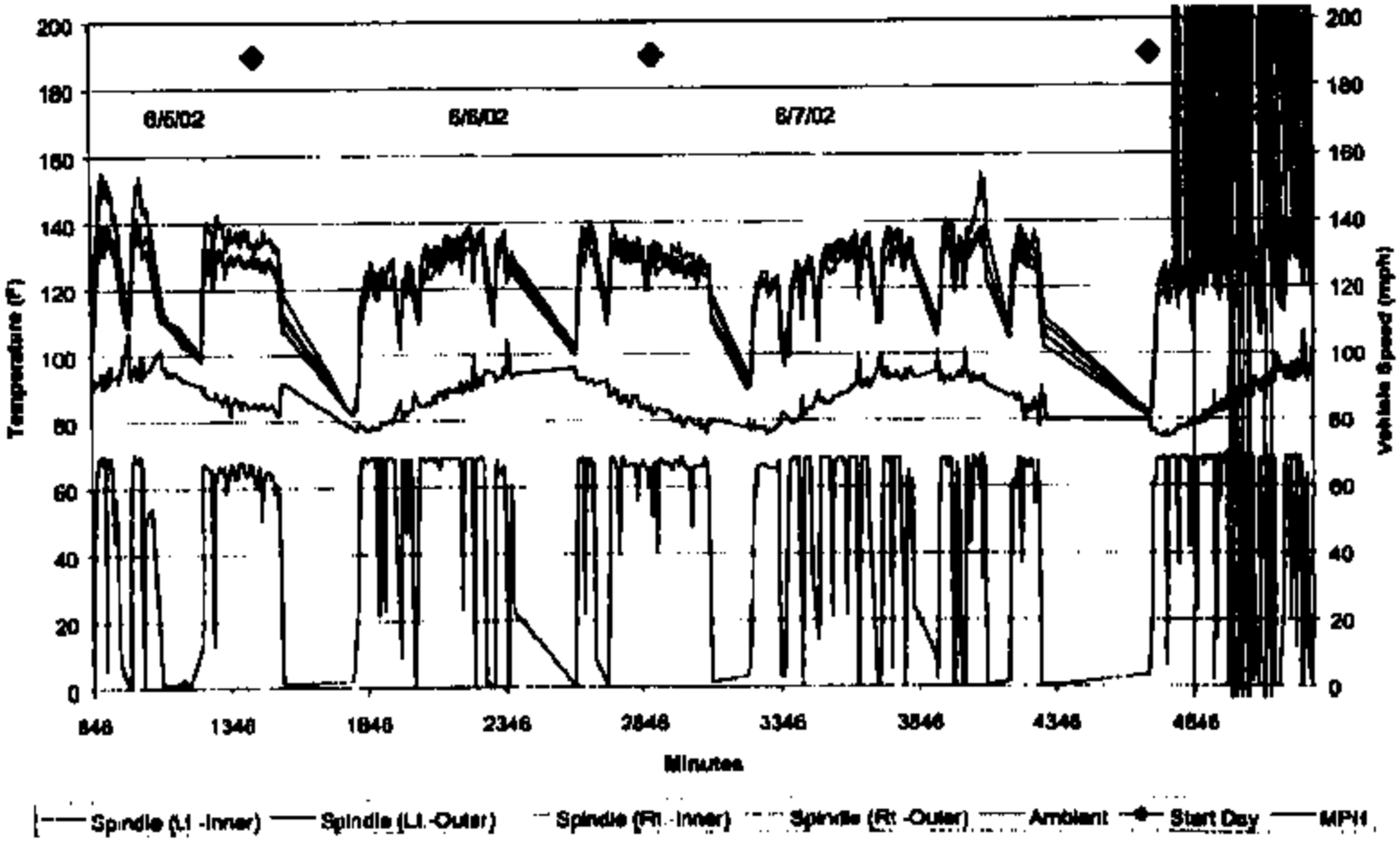
Truck 47286 - Spindle Temperatures Versus Time
Brent Shoffner 06/03/02



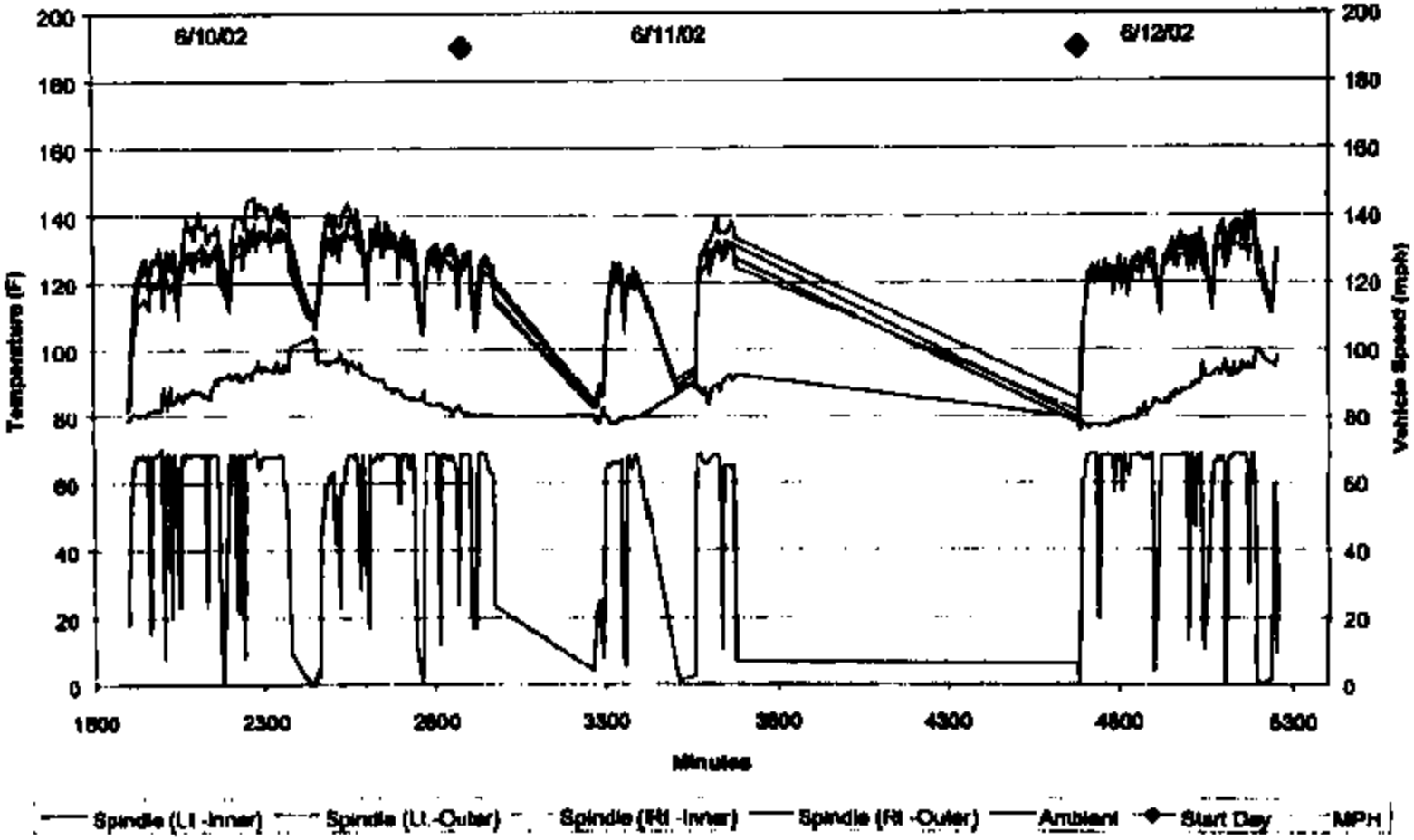
Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 06/05/02



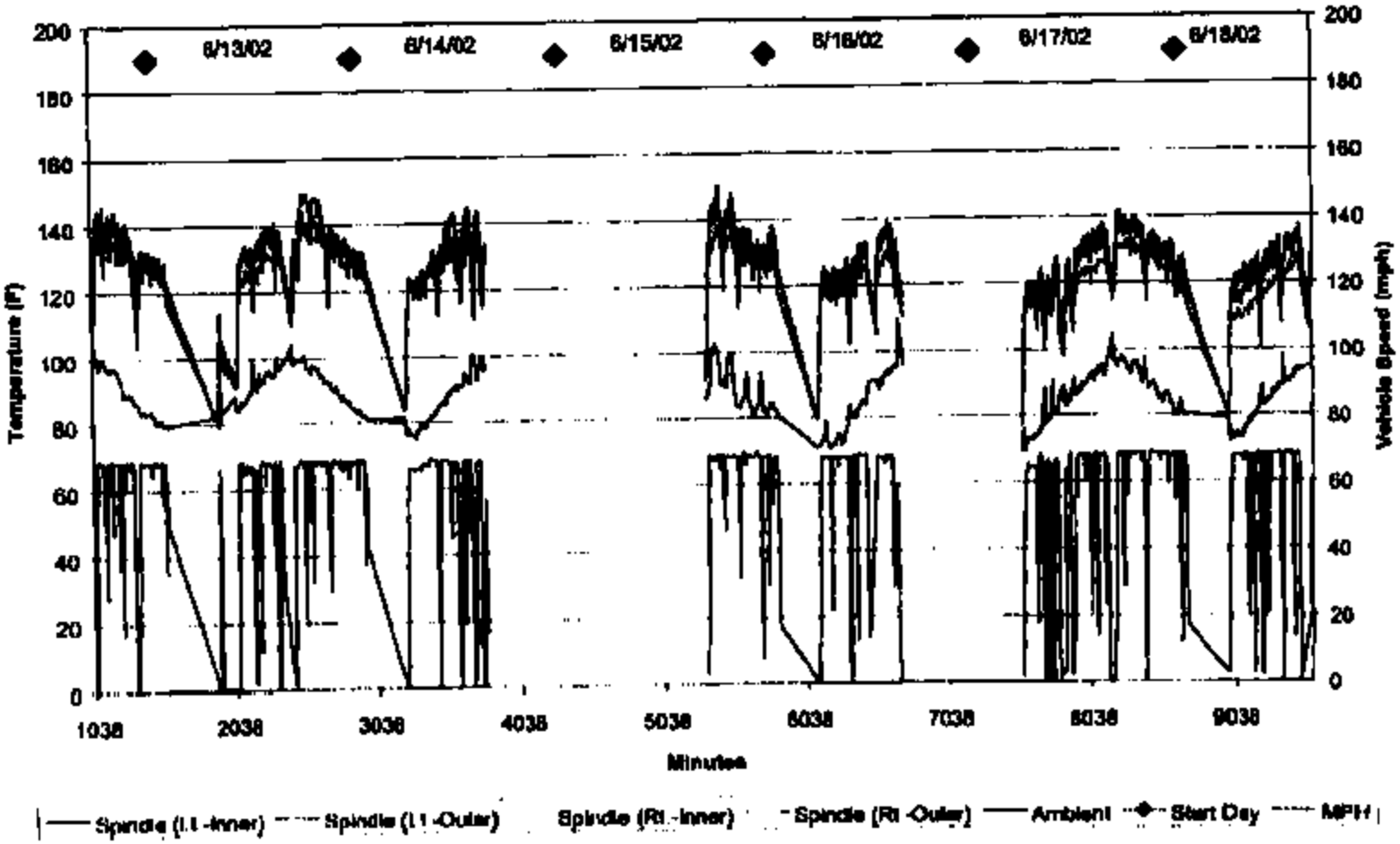
Truck 47296 - Spindle Temperatures Versus Time
Brent Shoffner 06/09/02



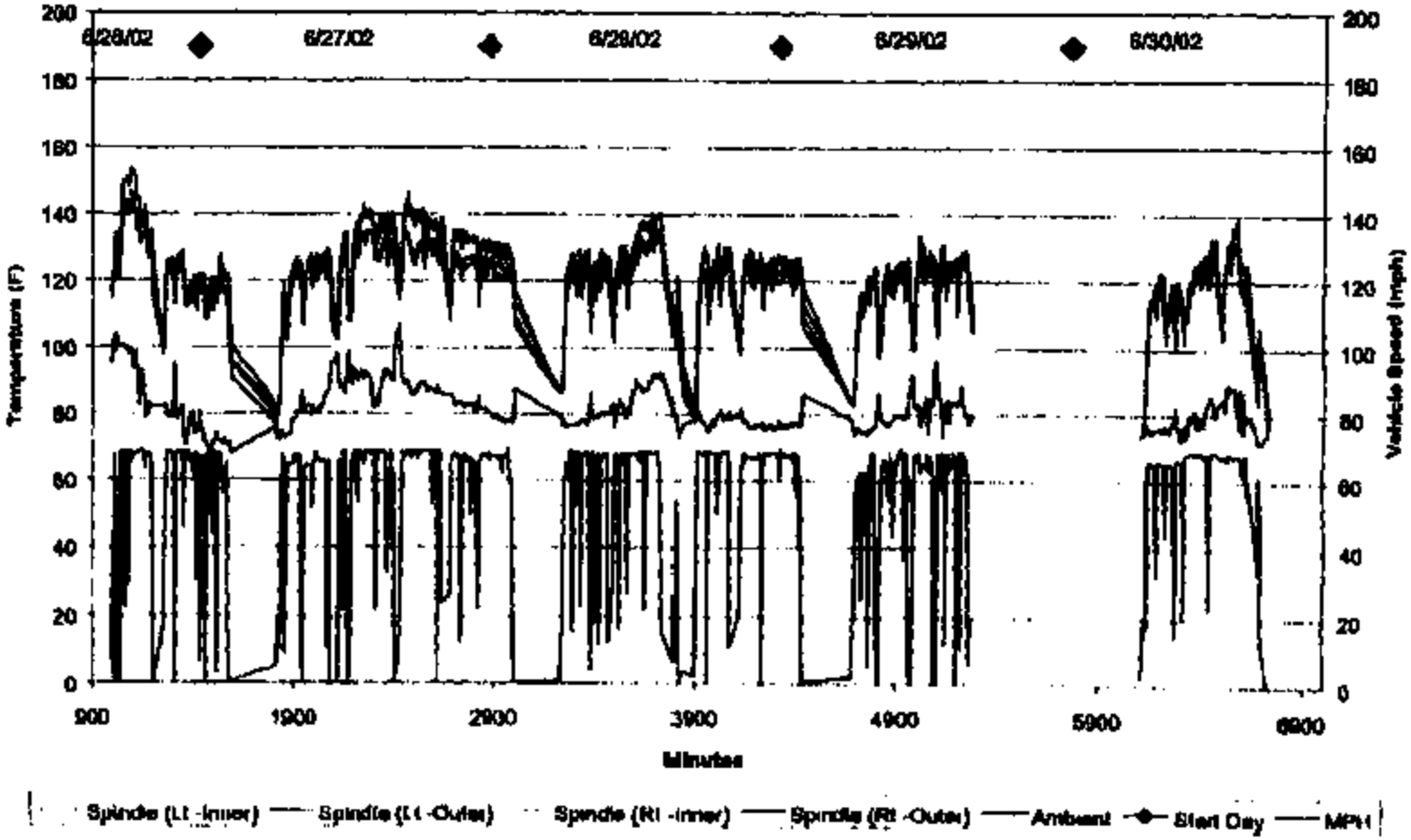
Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 06/12/02



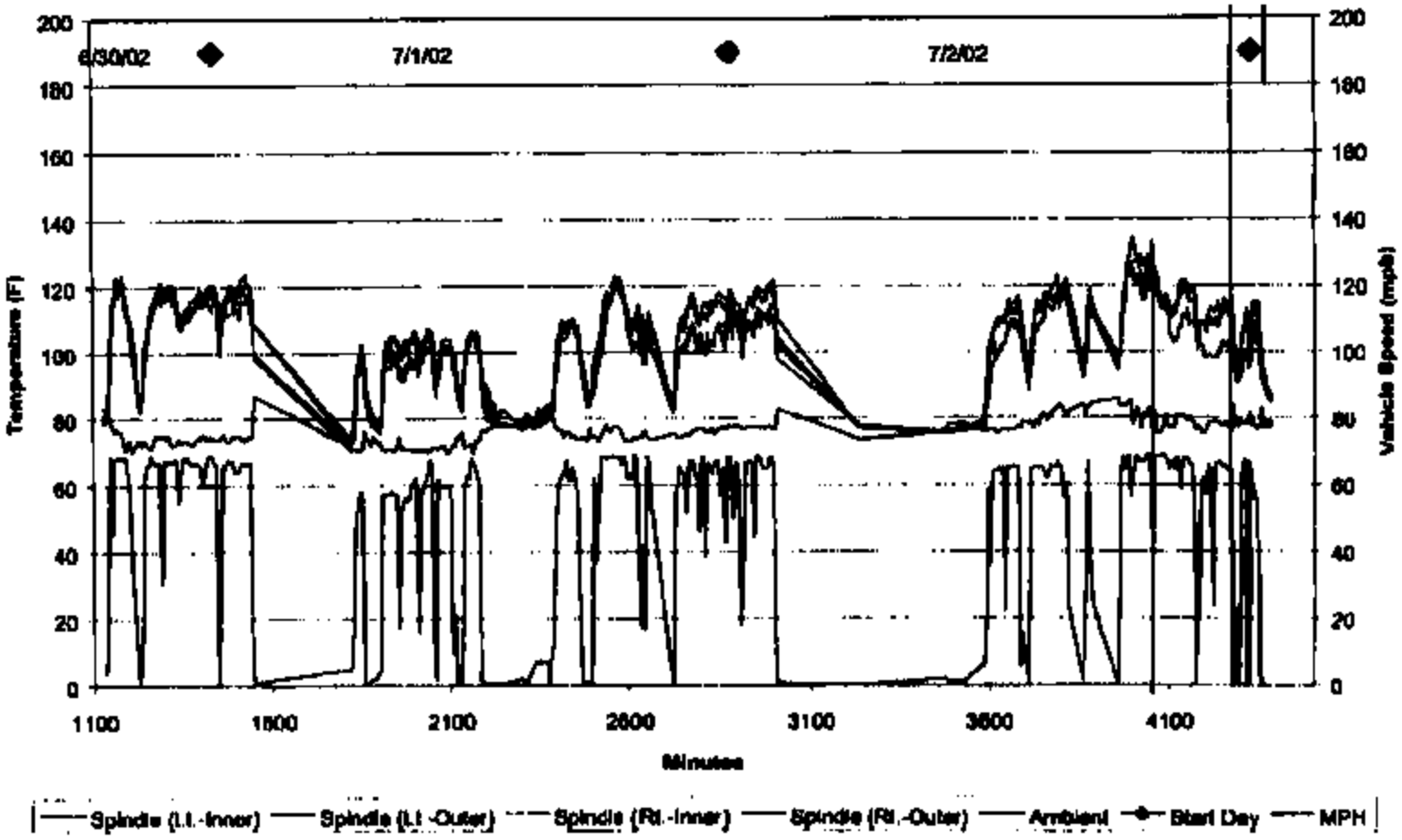
Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 06/18/02



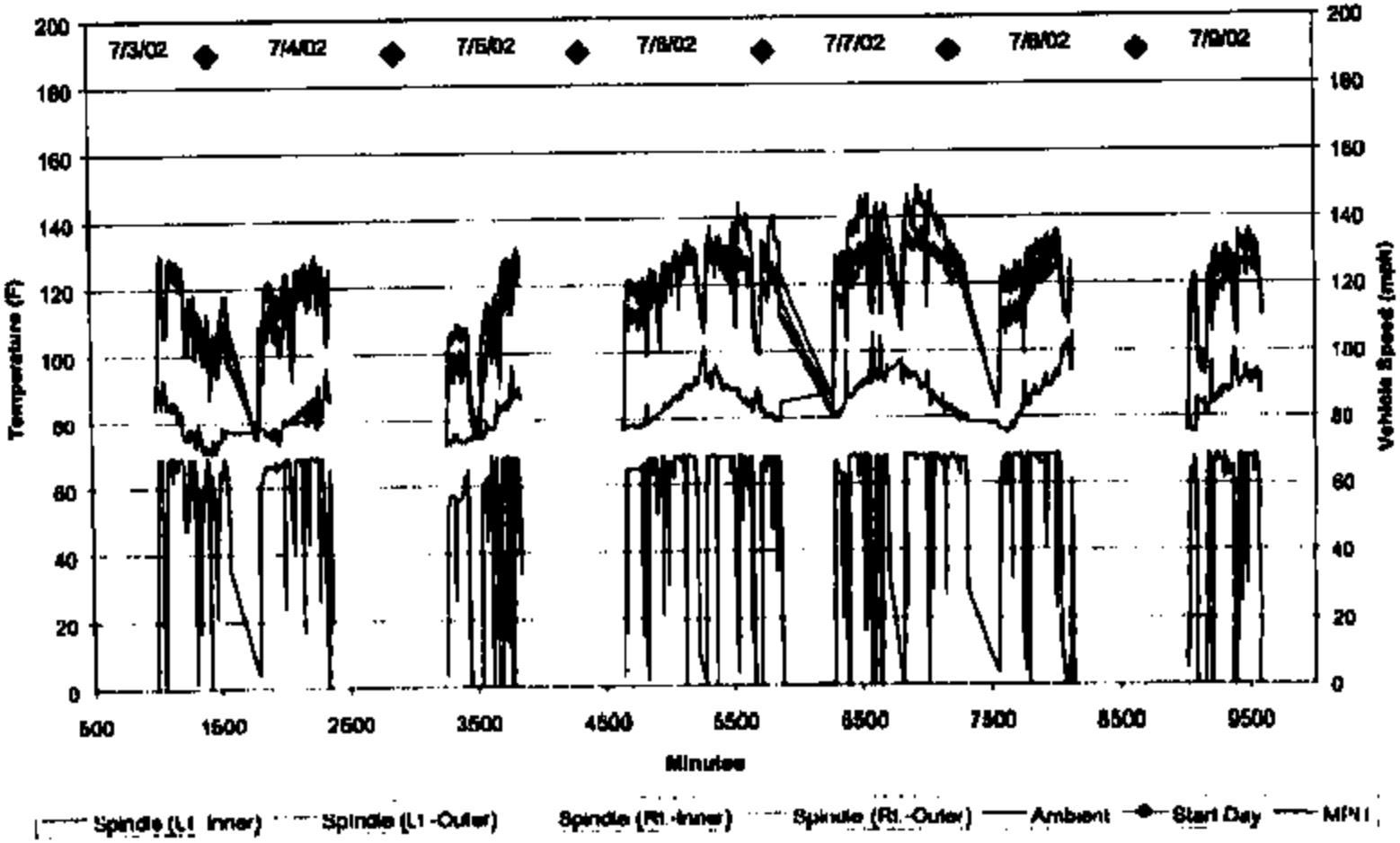
Truck 47296 - Spindle Temperatures Versus Time
Brent Shoffner 07/02/02



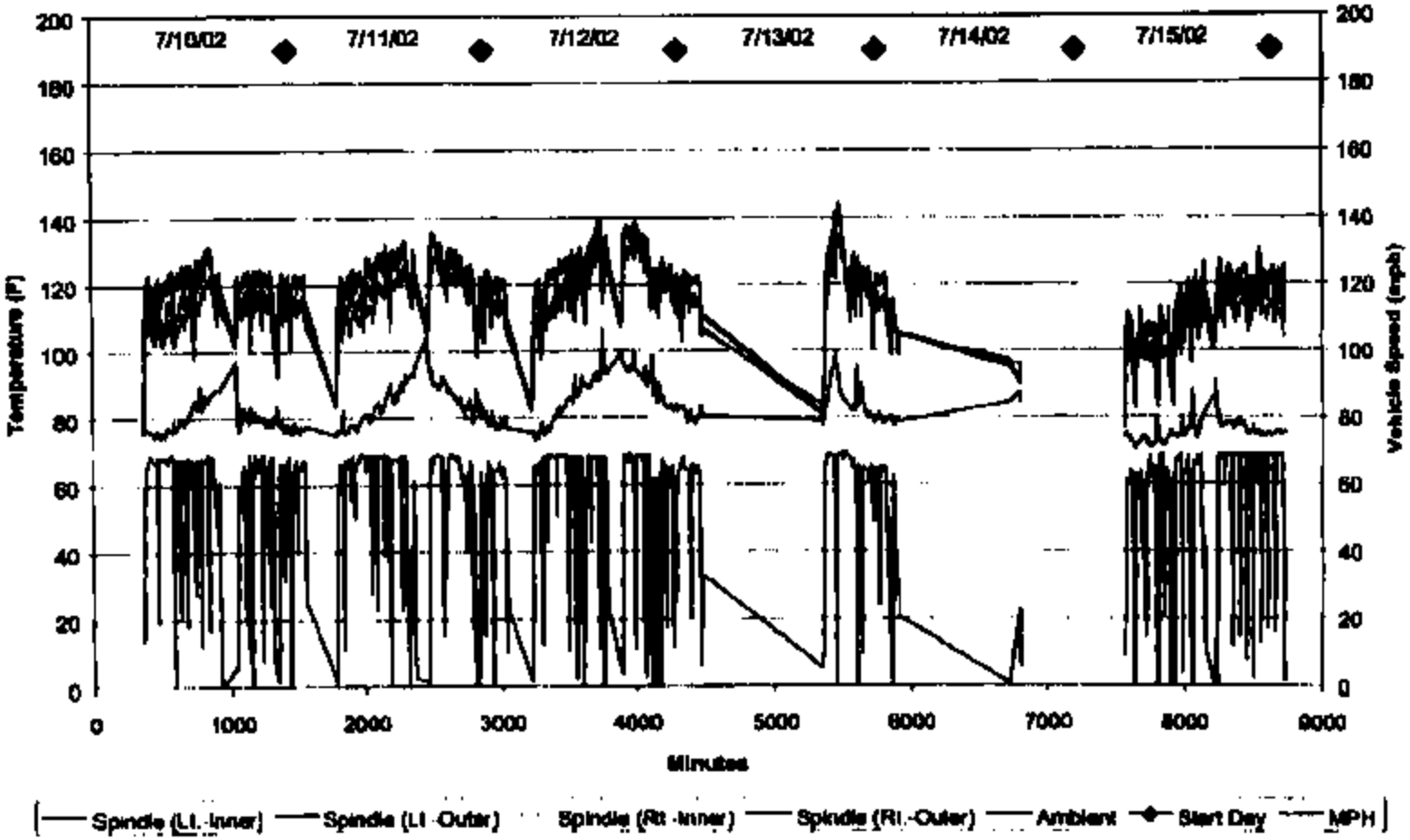
Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 07/03/02



Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 07/09/02

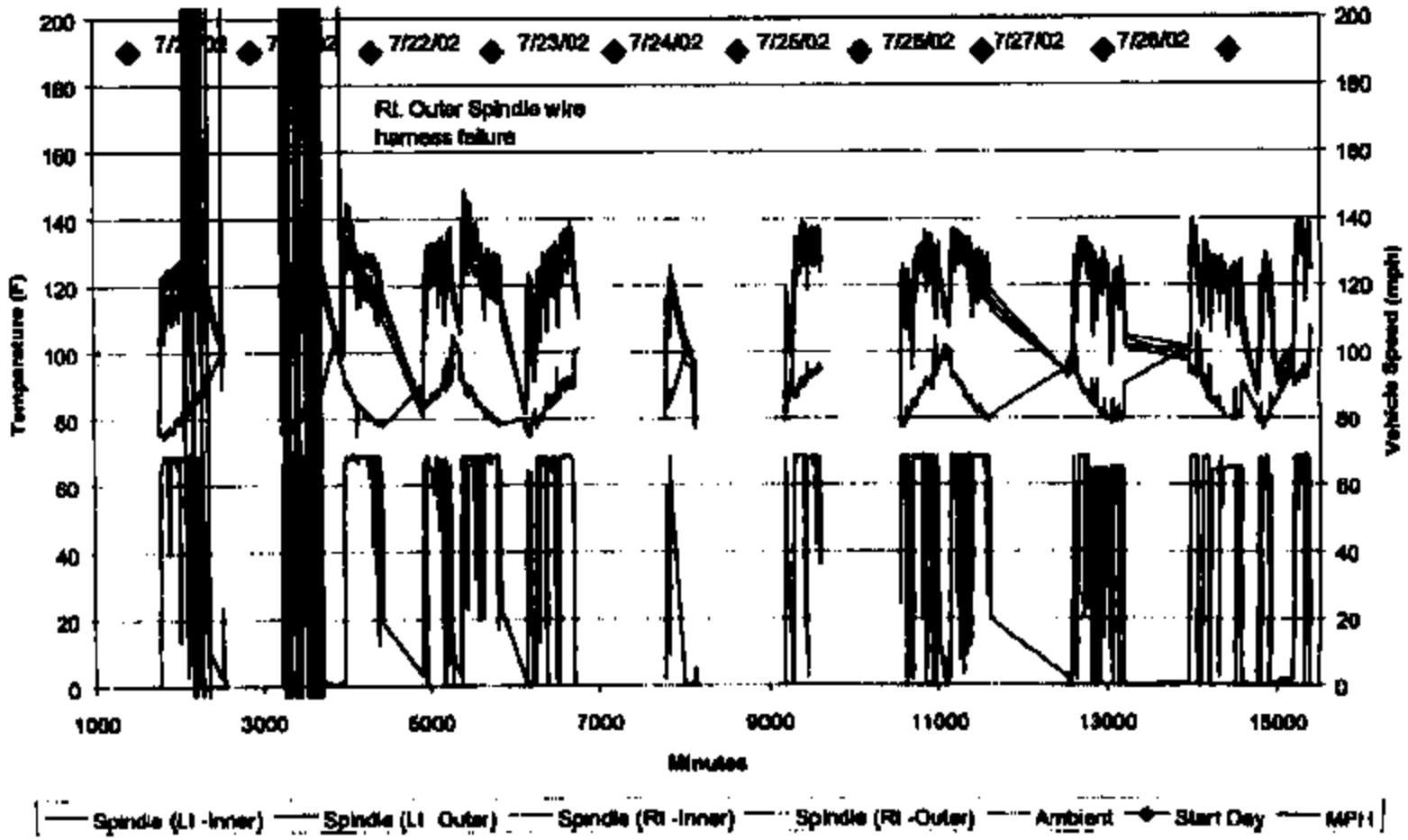


Truck 47296 - Spindle Temperatures Versus Time
Brent Shoffner 07/16/02

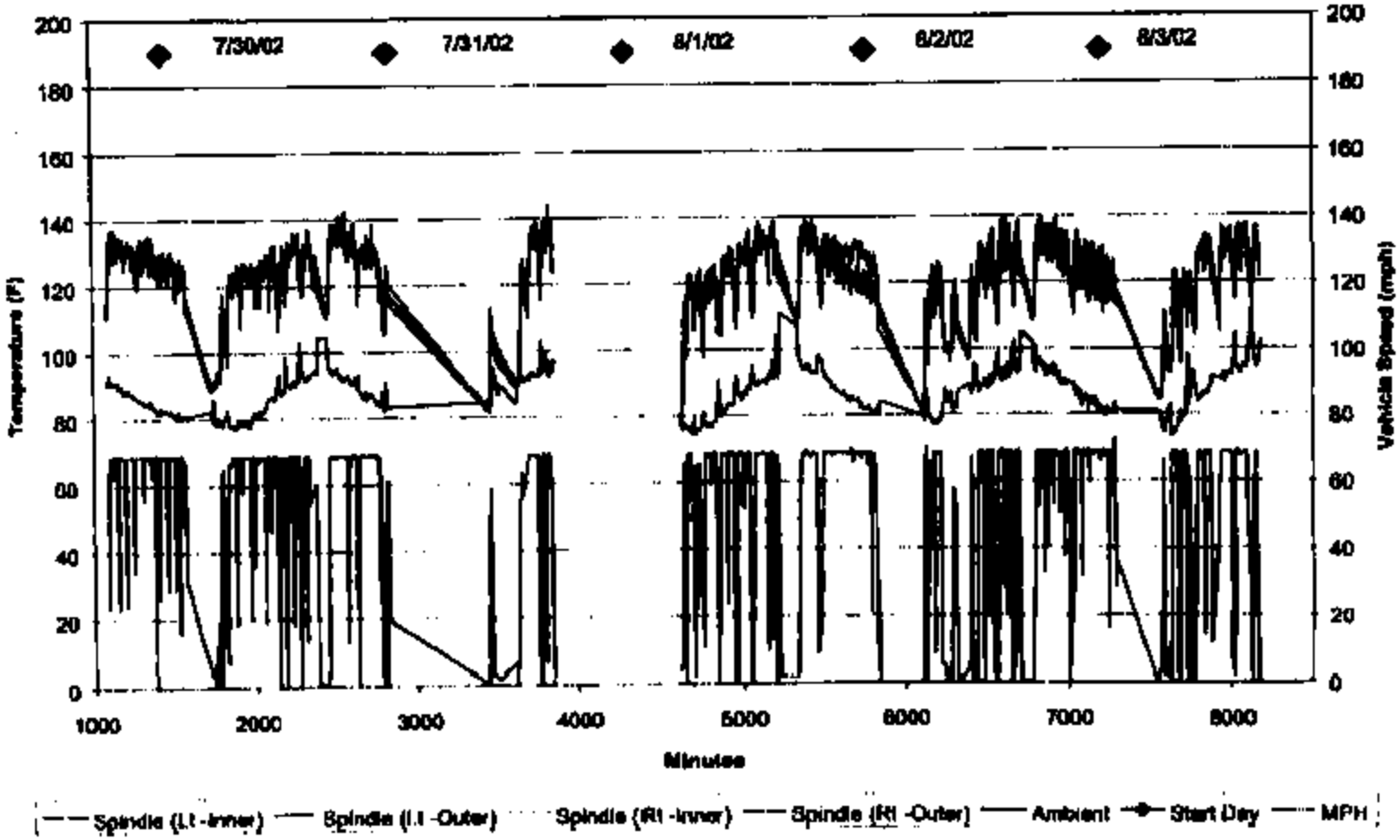


SKF 000994

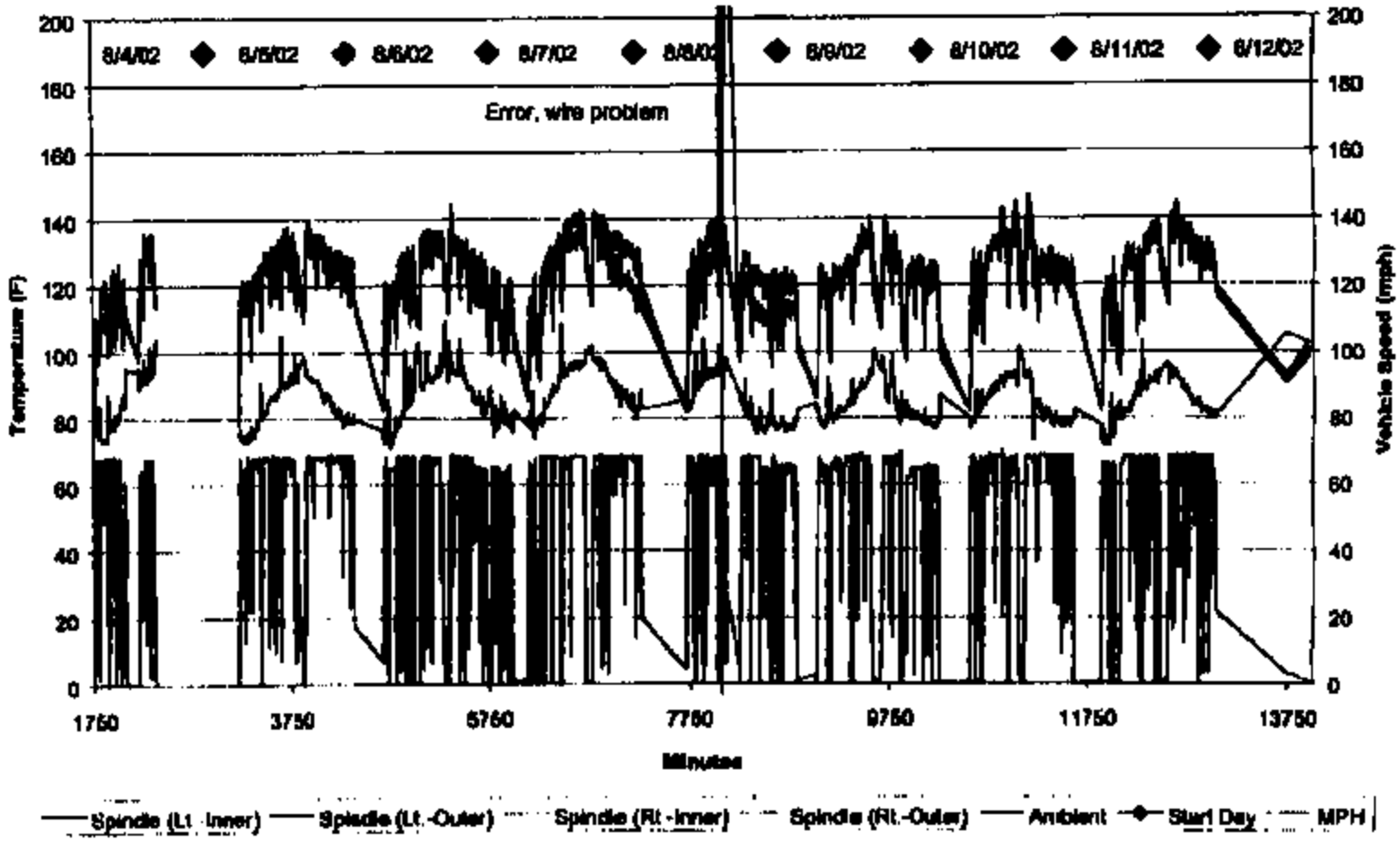
Truck 47295 - Spindle Temperatures Versus Time
Brent Shoffner 07/29/02



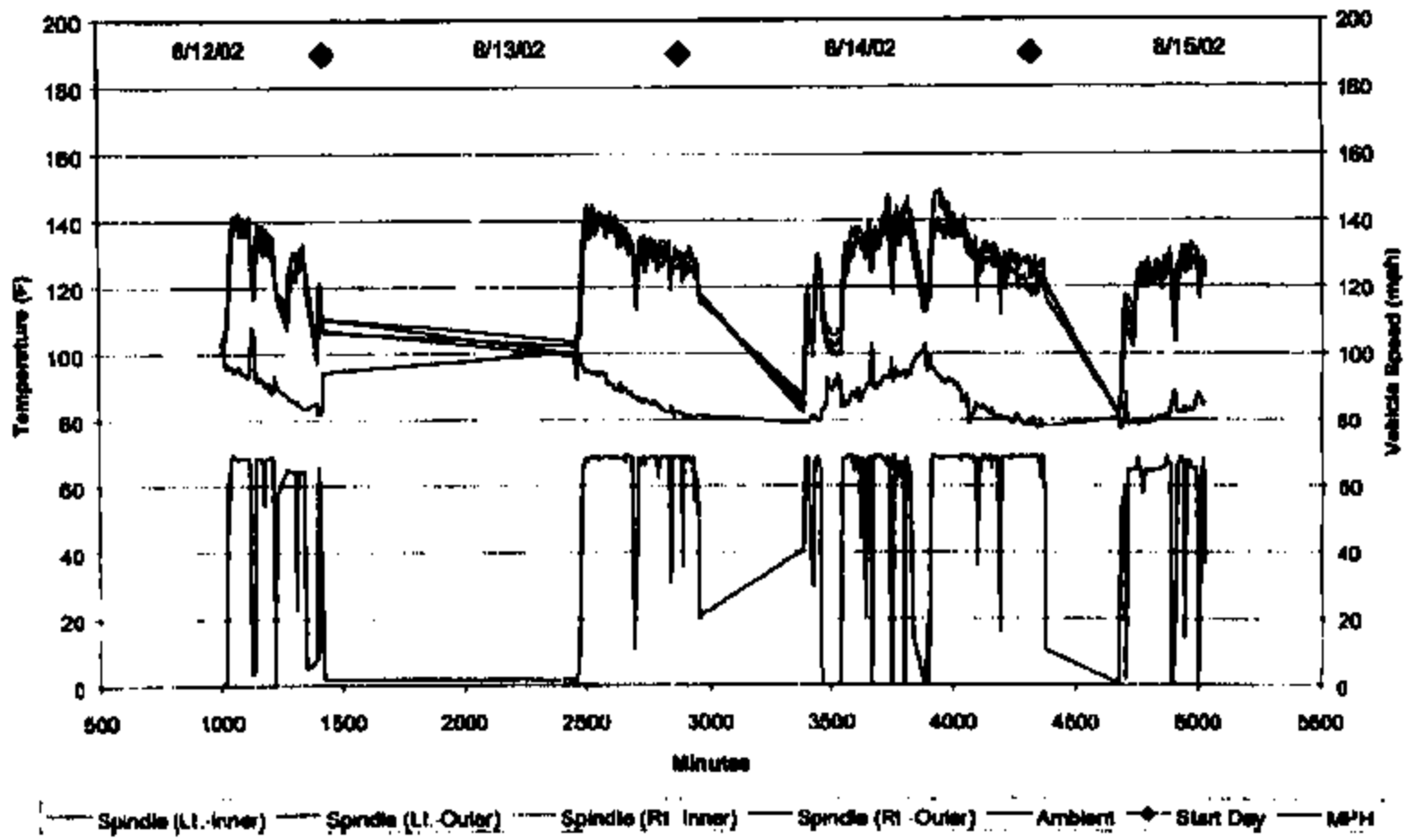
Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 08/03/02



Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 08/12/02



Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 08/15/02



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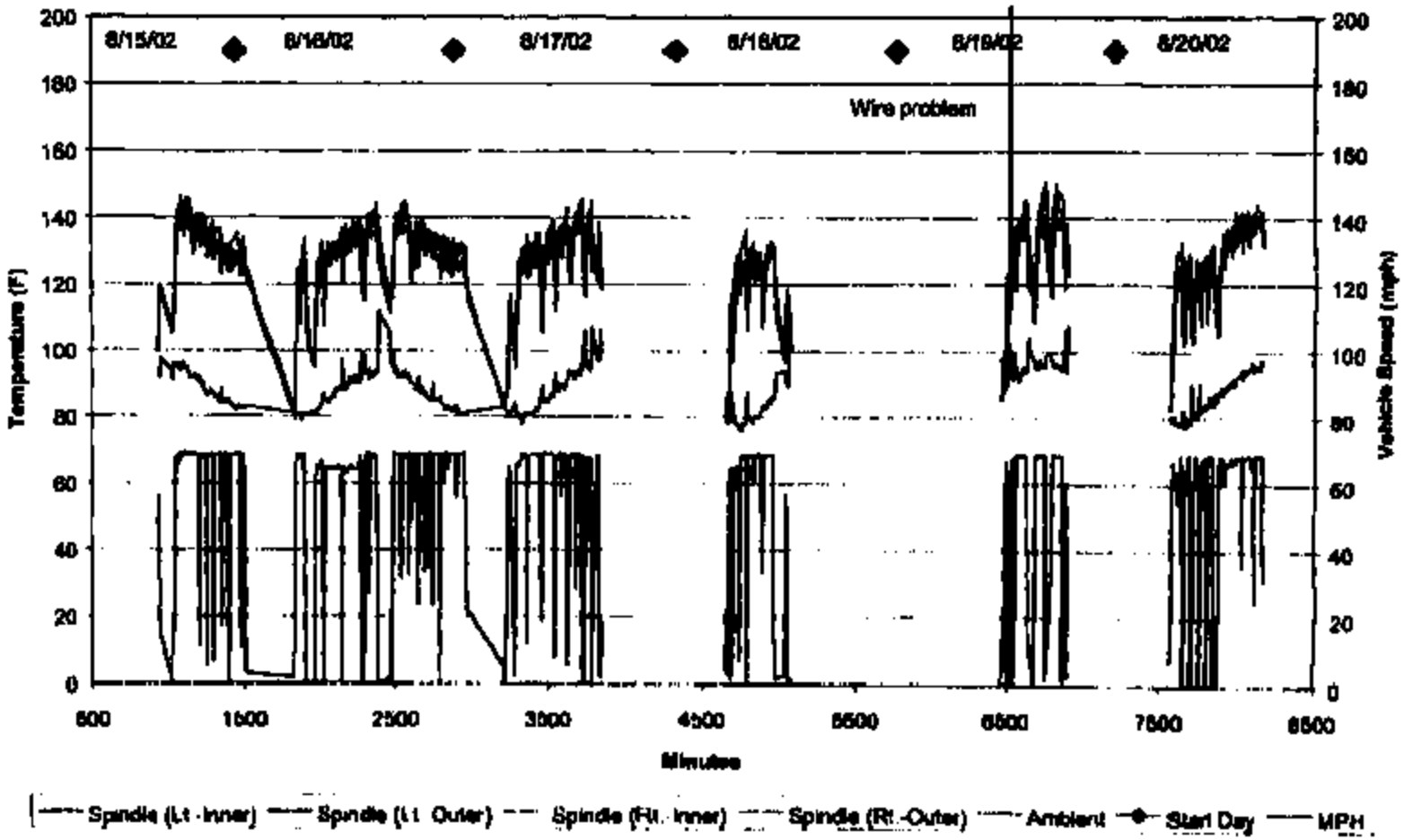
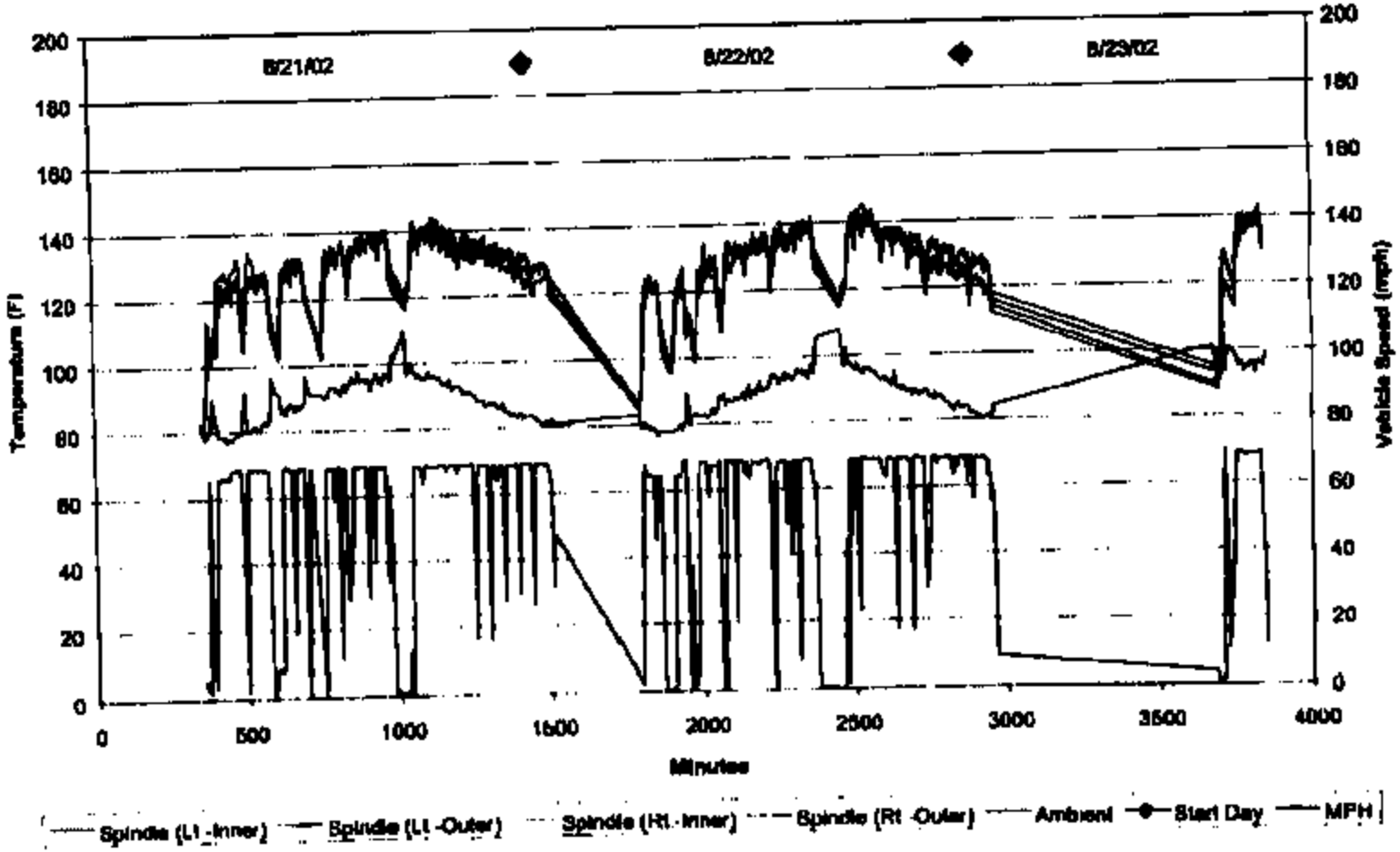
Brent Shoffner 08/20/02

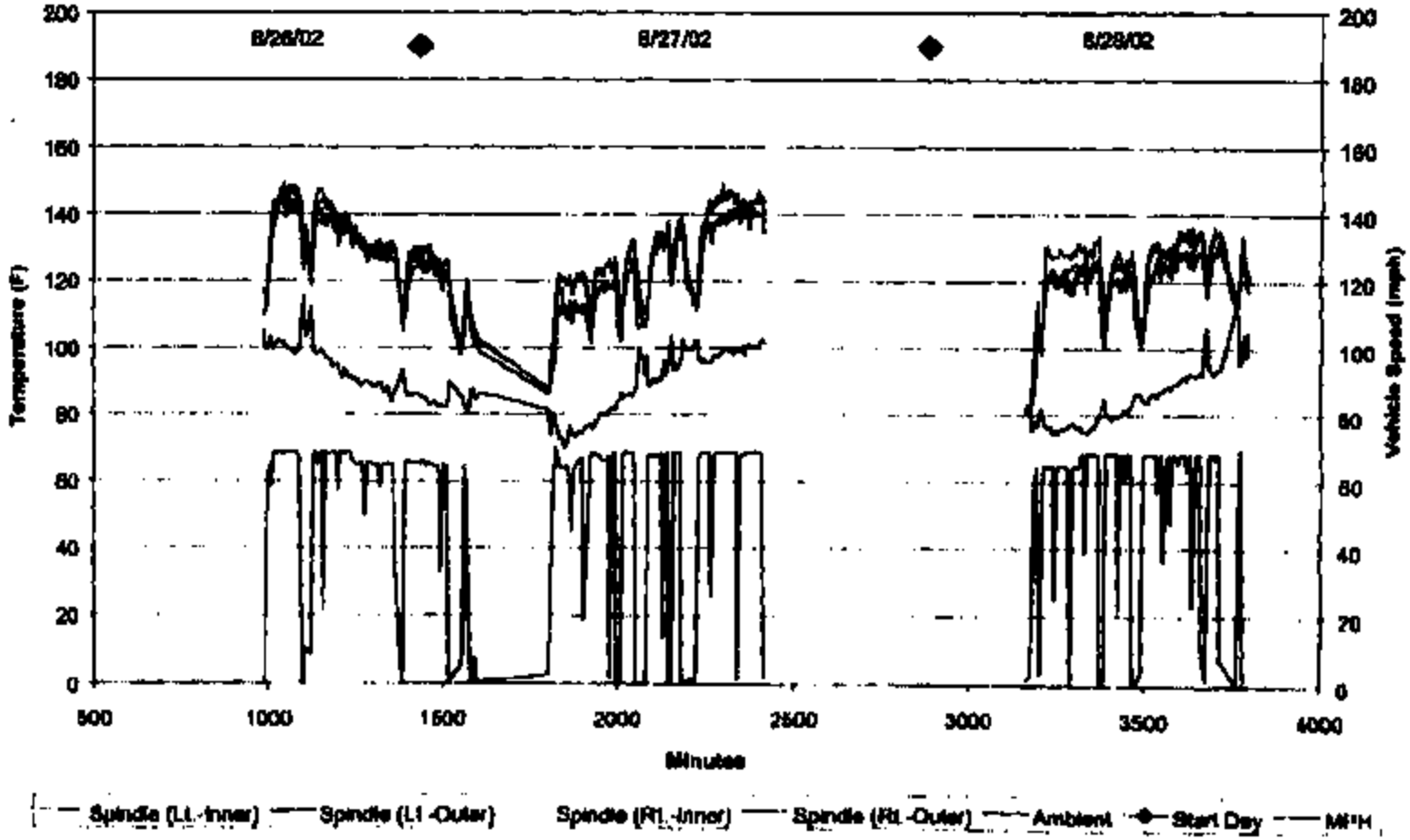


Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 08/23/02

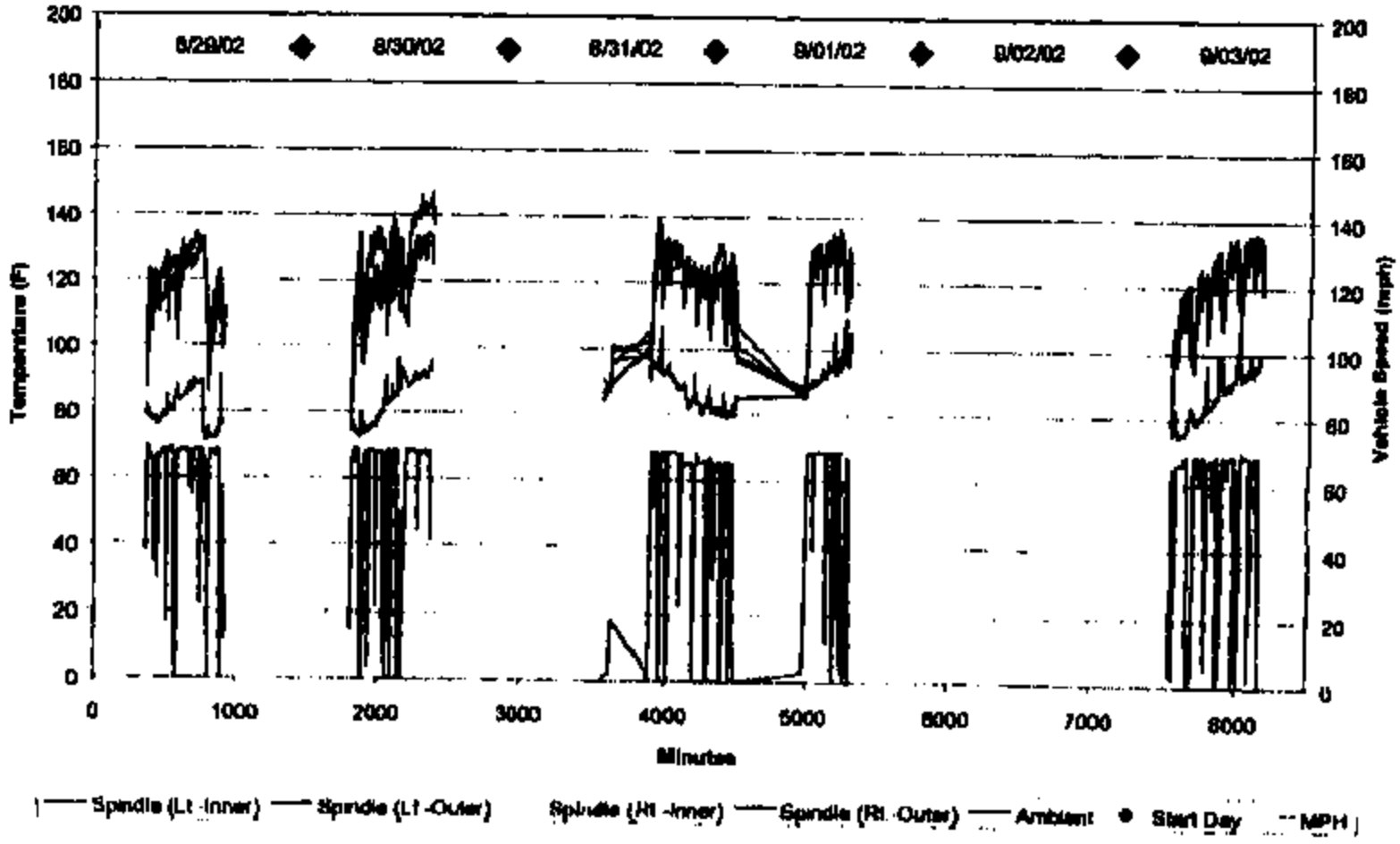


SKF 001000

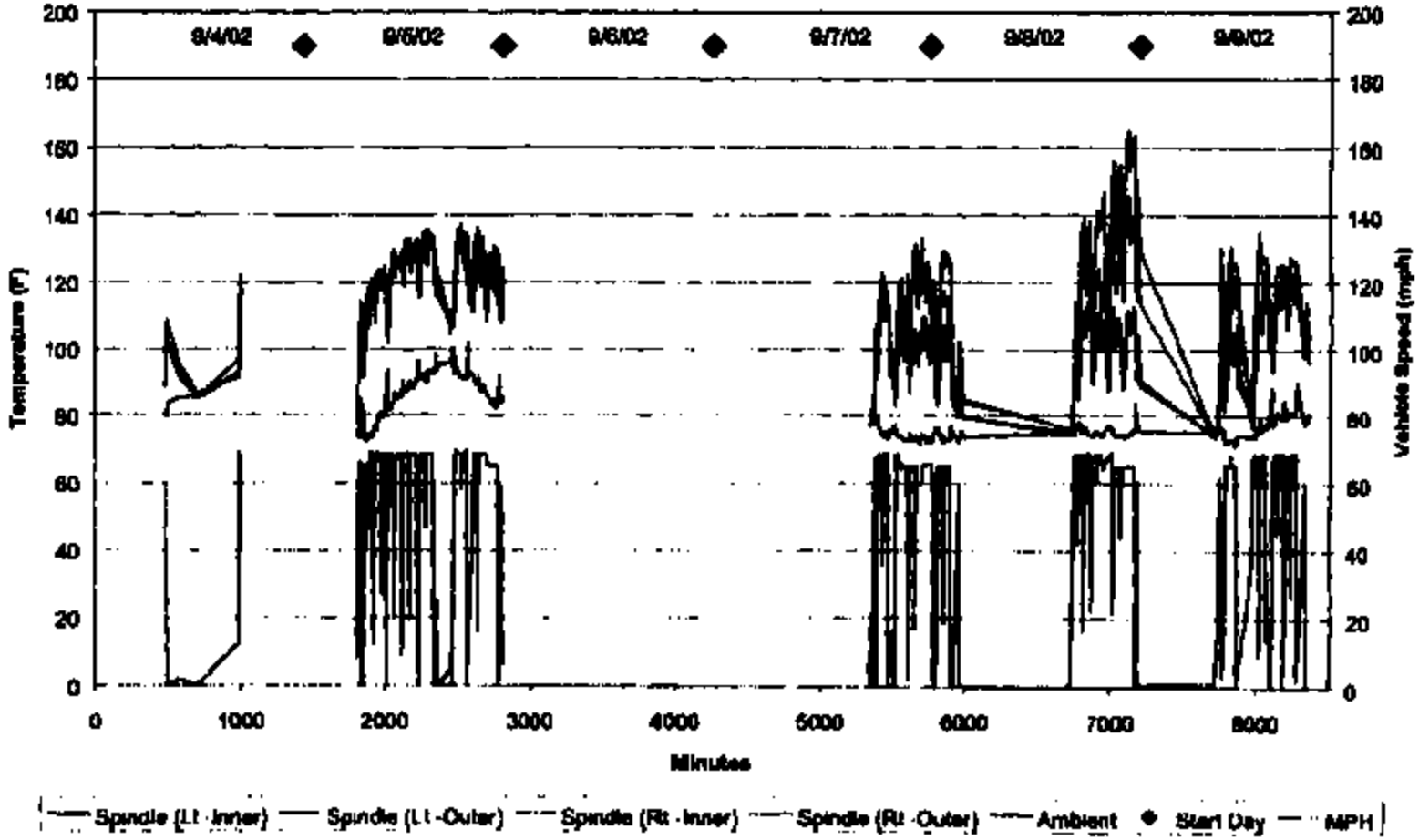
Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 08/28/02



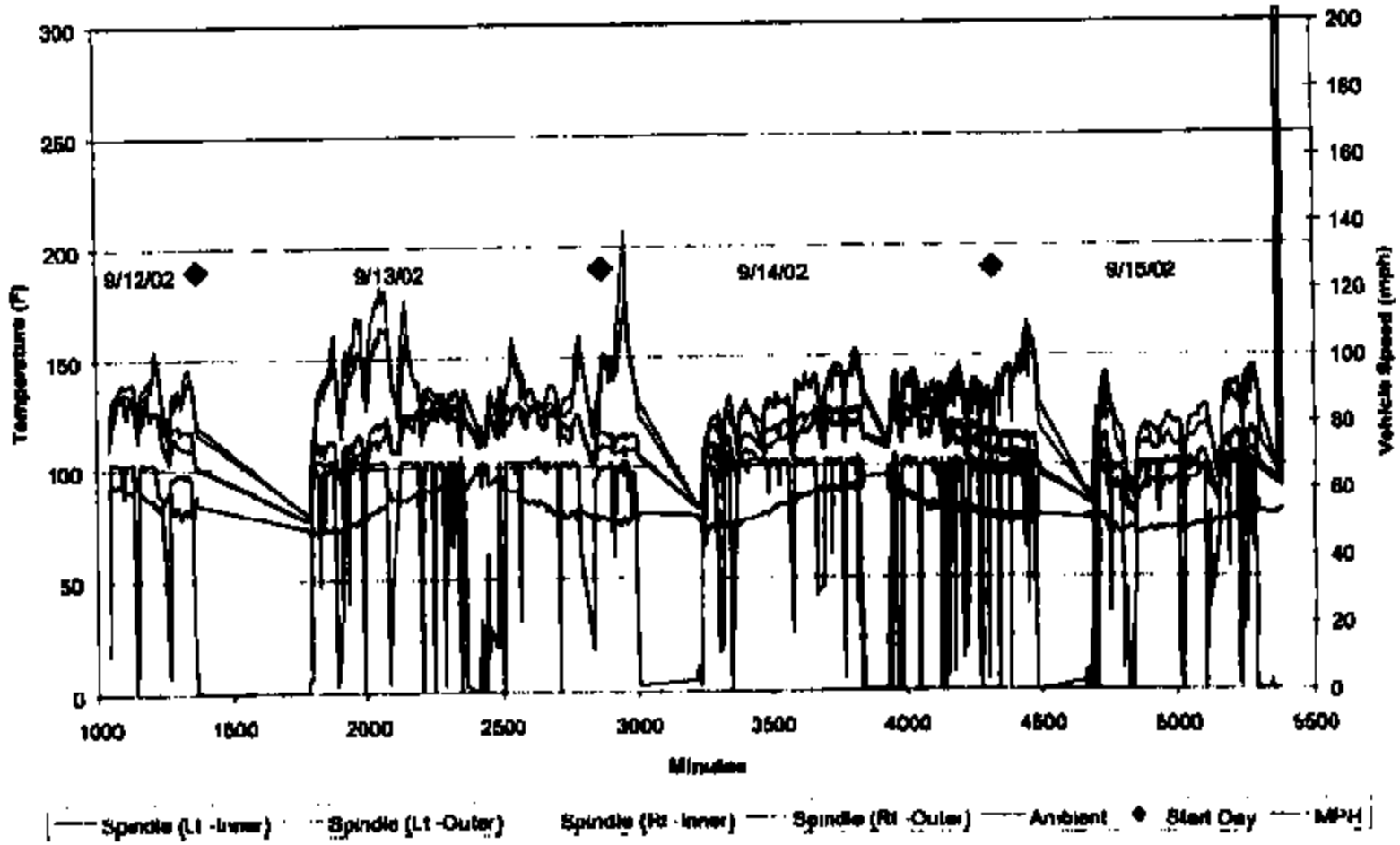
Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 09/03/02



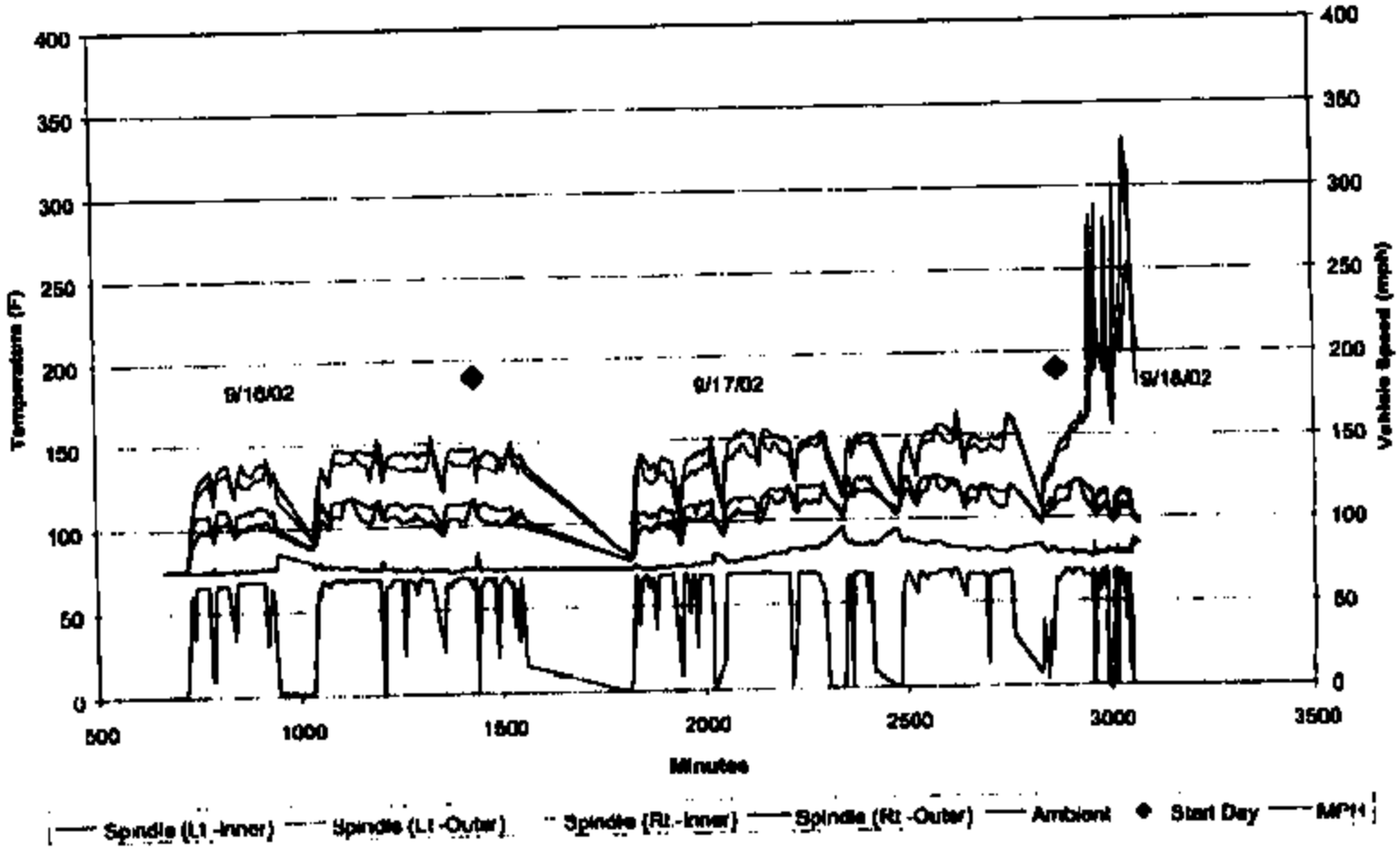
Truck 47295 - Spindle Temperatures Versus Time
Brent Shoffner 09/09/02



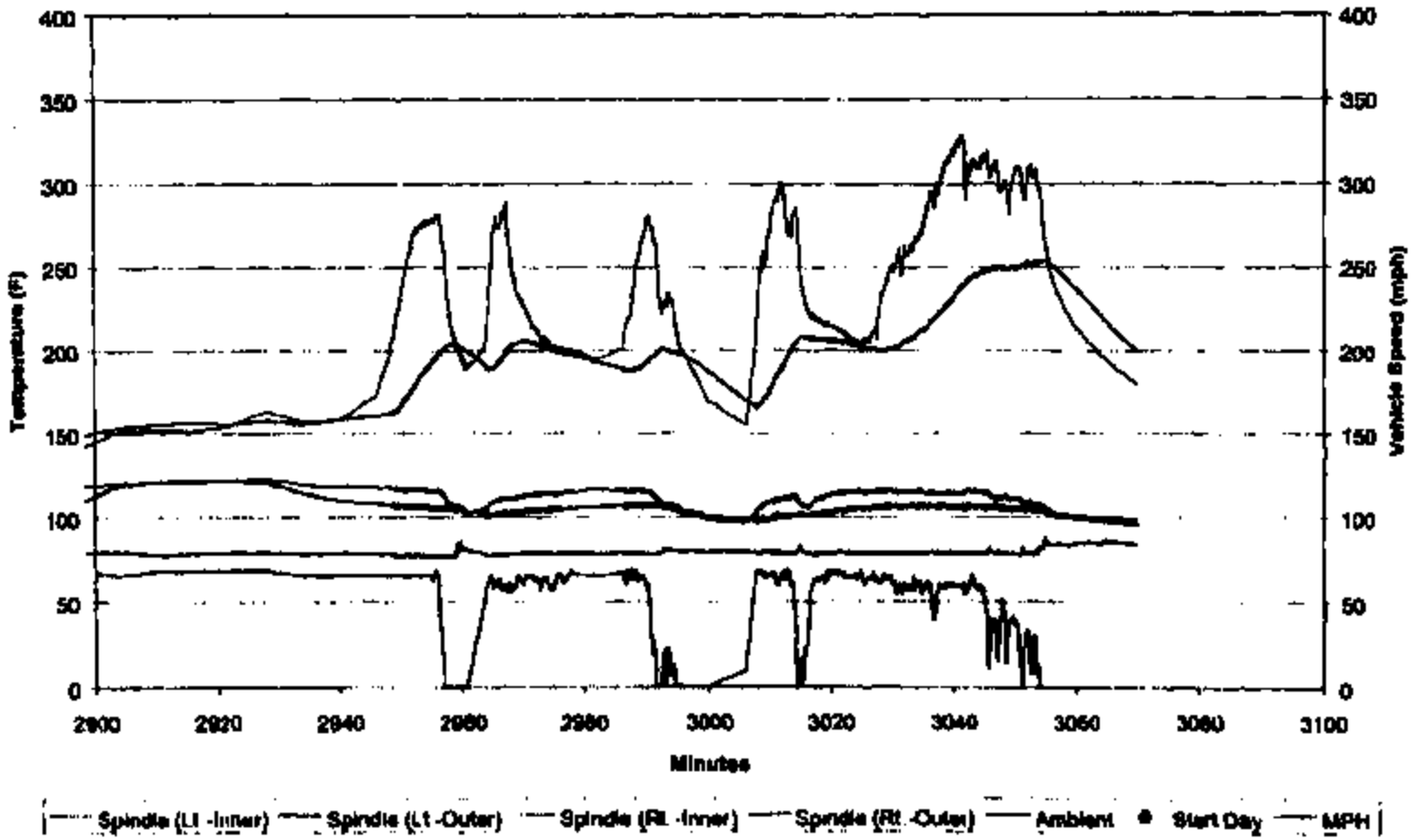
Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 09/15/02



Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 09/16/02



Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 09/18/02

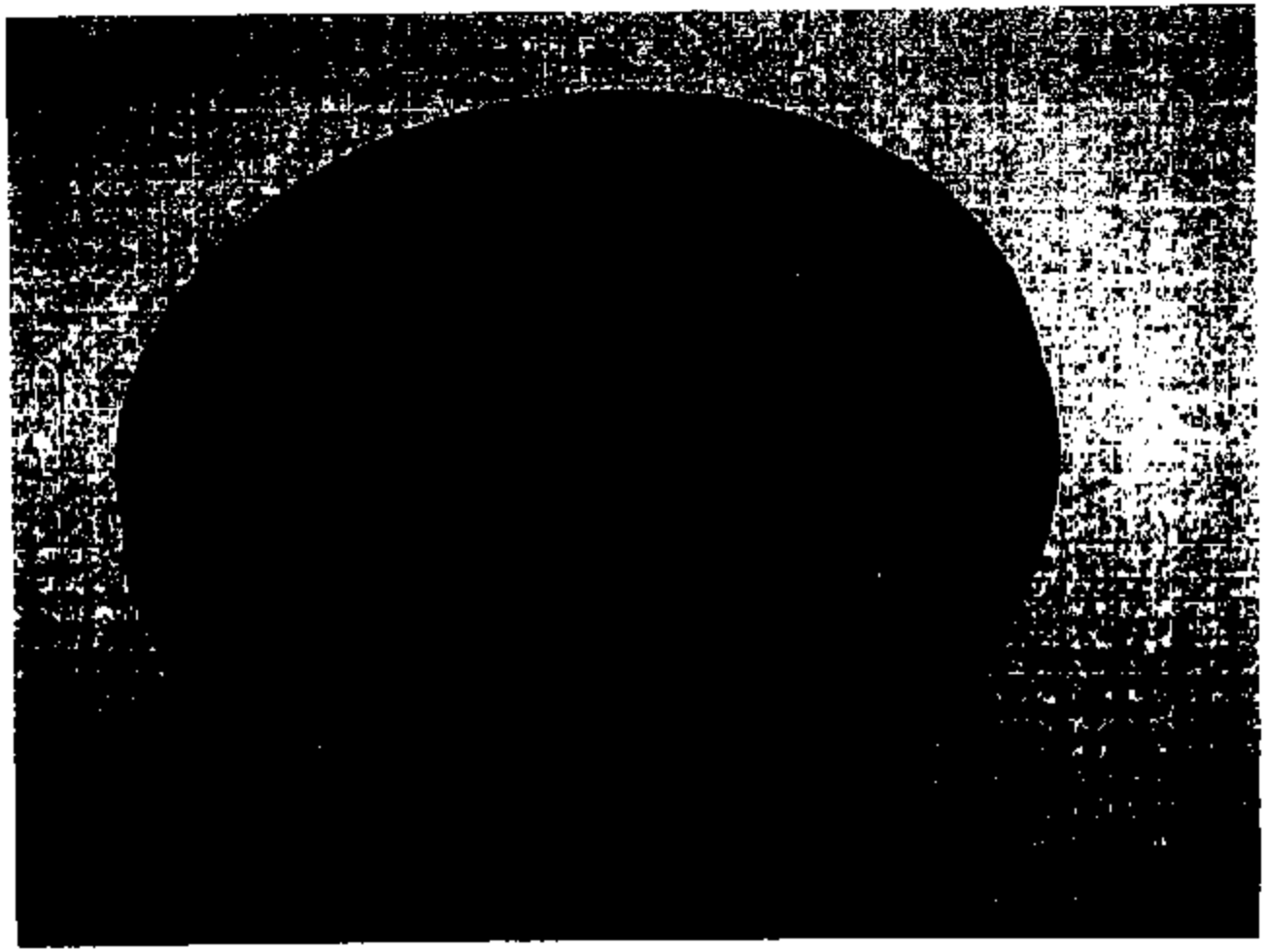


APPENDIX L
Hubcap with Temperature Indicators and Heat Sensitive Bolt

Outside of a hub cab showing the temperature indicator strips and the heat sensitive bolt

SKF 001068

Inside of a hub cap showing the temperature indicator strips and the heat sensitive bolt



SKF 001009

APPENDIX M
Accelerometer Mounting

Accelerometer Mounting on the Driver's Seat Bracket

SKF 001011

APPENDIX N
Still Pictures from the Video

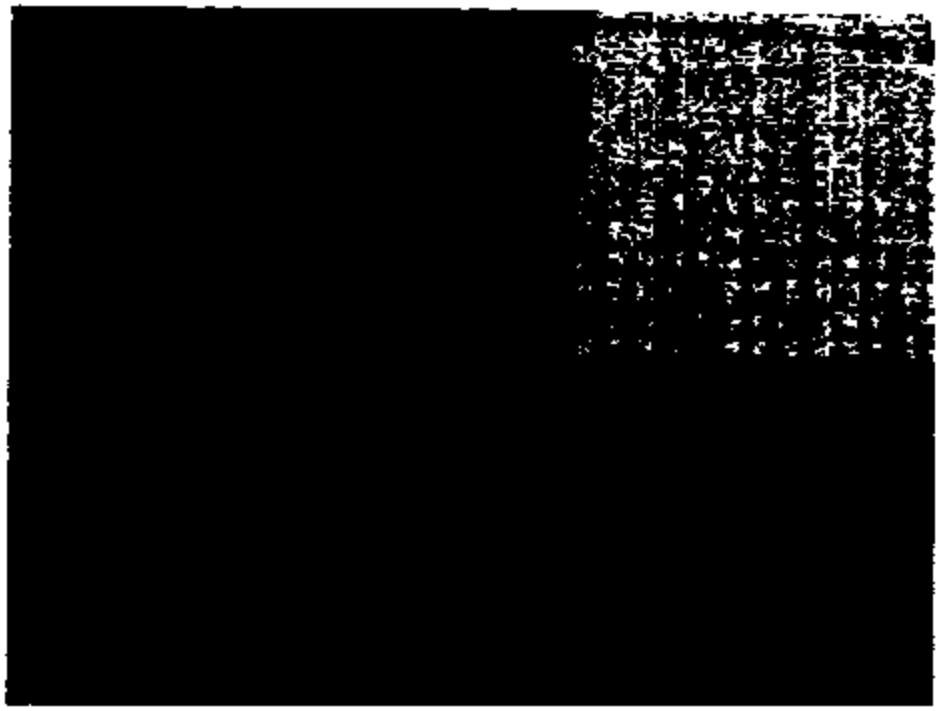
Vibration Screen and Driver Prior to Burn Out of the Bearing Grease

SKF 001013

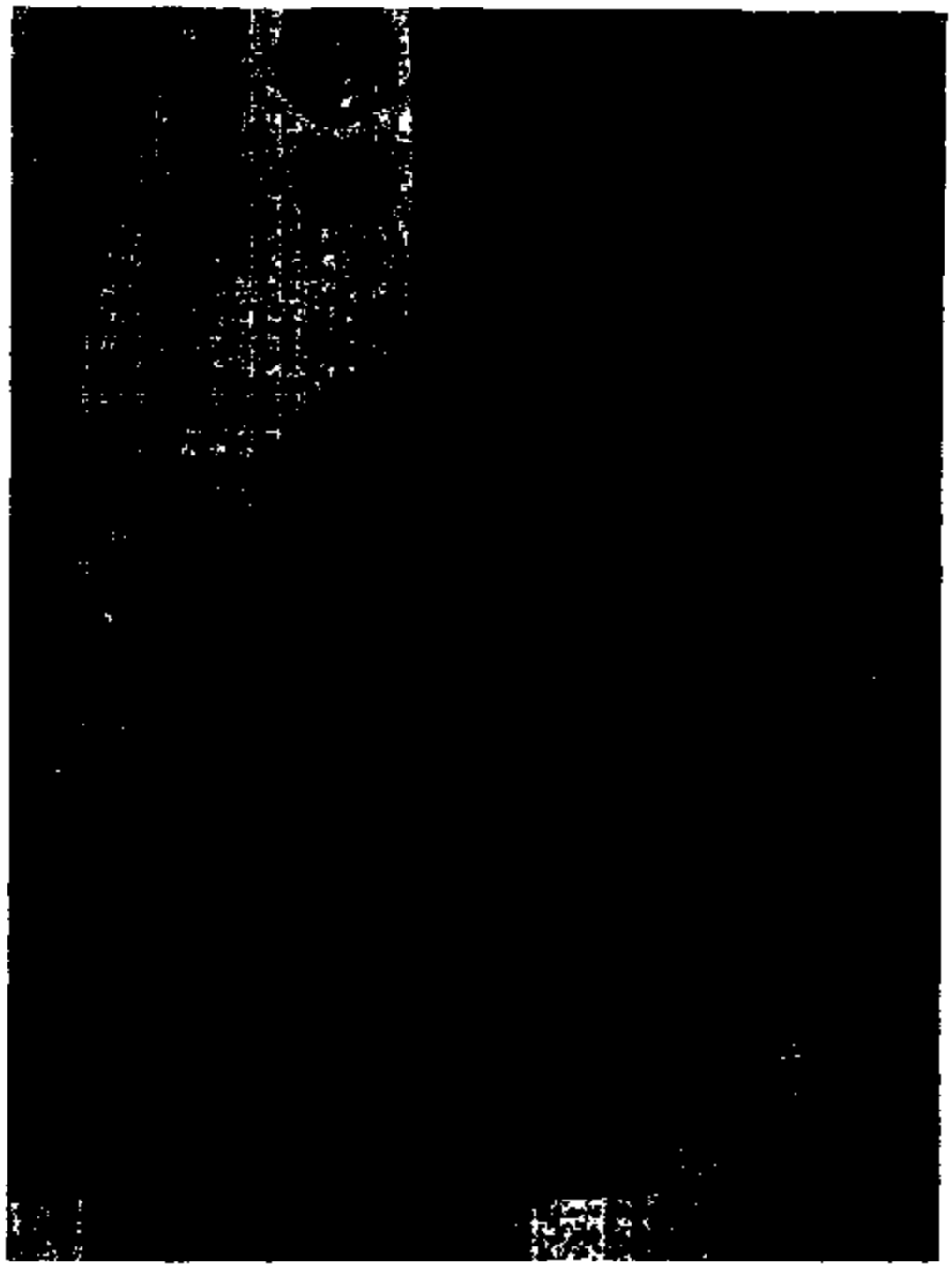
Smoke Observed During Burn Out of the Bearing Grease

SKF 001C

Wheel "Wobble" Immediately Prior to Roller Ejection

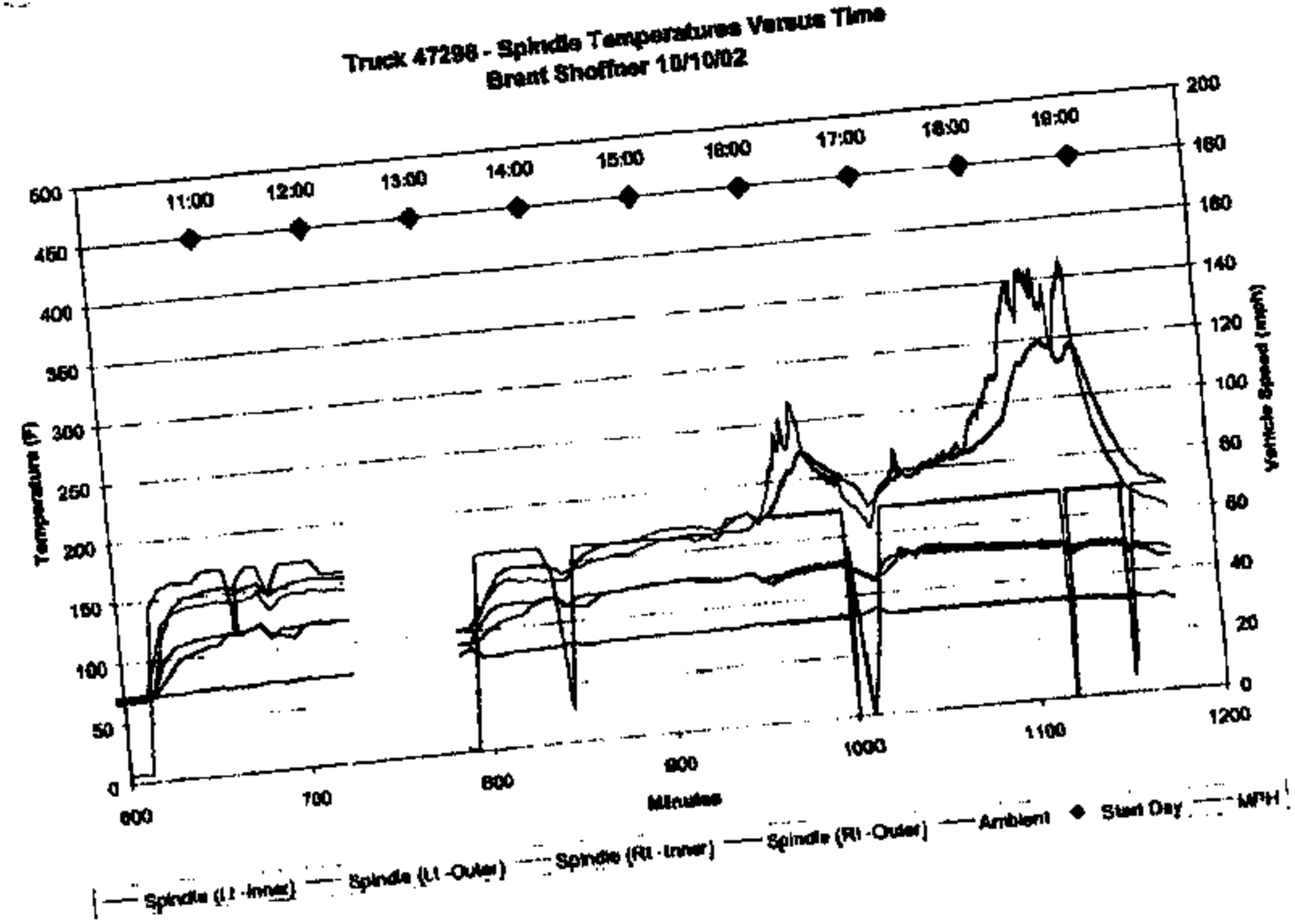


Roller Ejection

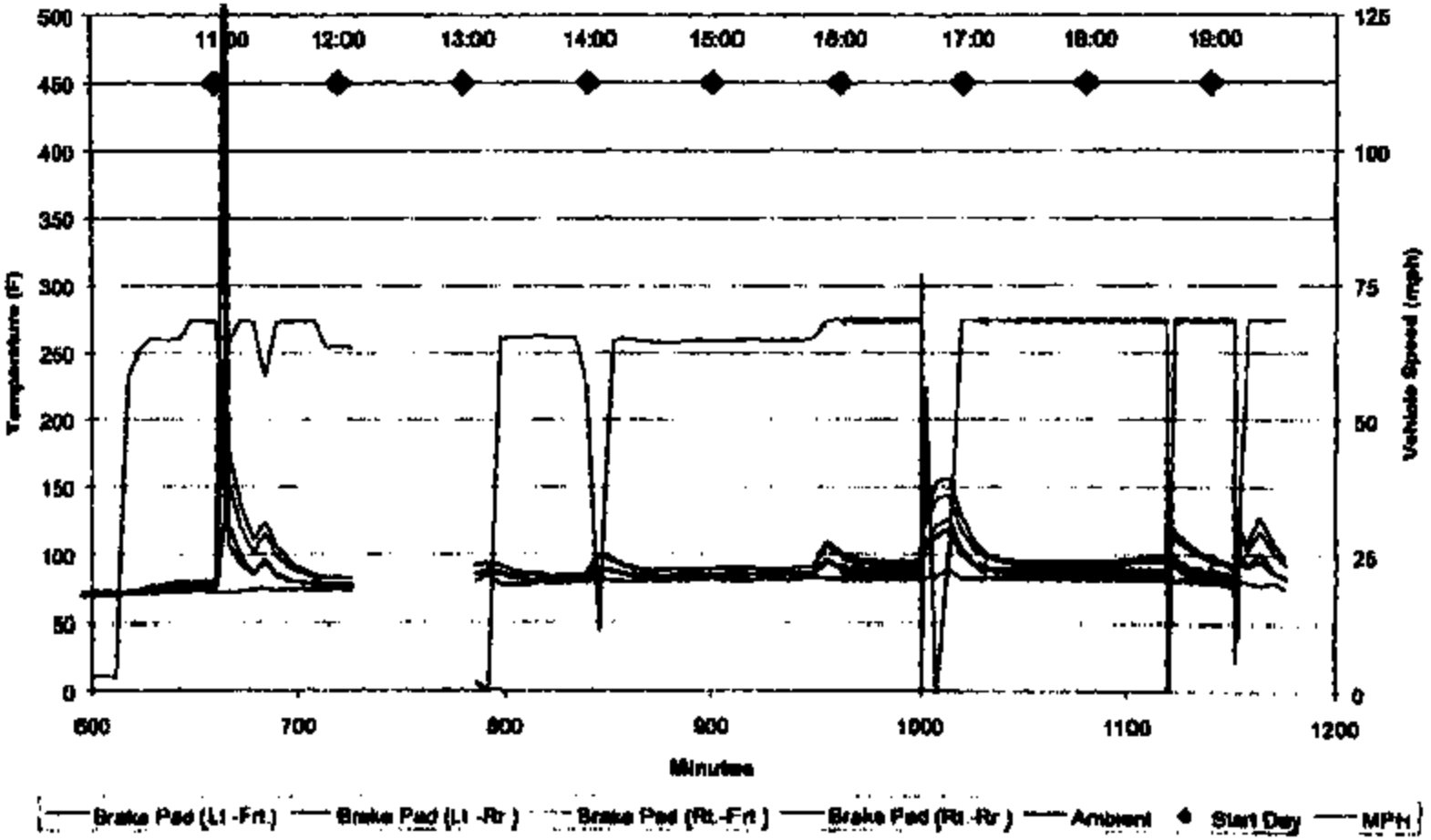


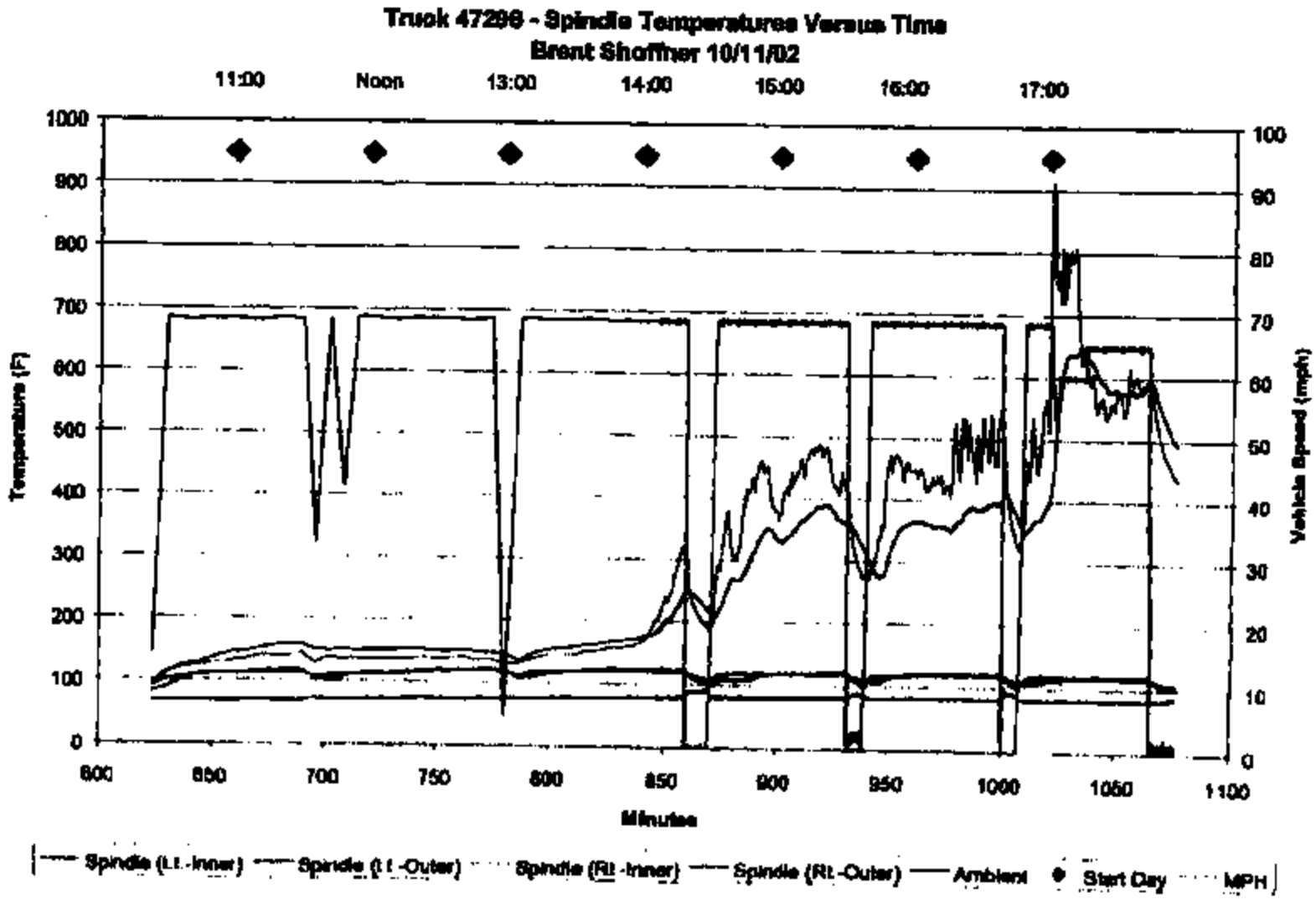
Vibration Screen and During Wheel Wobble

APPENDIX O
Temperature Versus Time Graphs During Proving Ground Operation


Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 10/10/02
Temperature (F)
Vehicle Speed (mph)
Minutes
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
Spindle (Lt -Inner)
Spindle (Lt -Outer)
Spindle (Rt -Inner)
Spindle (Rt -Outer)
Ambient
Start Day
MPH

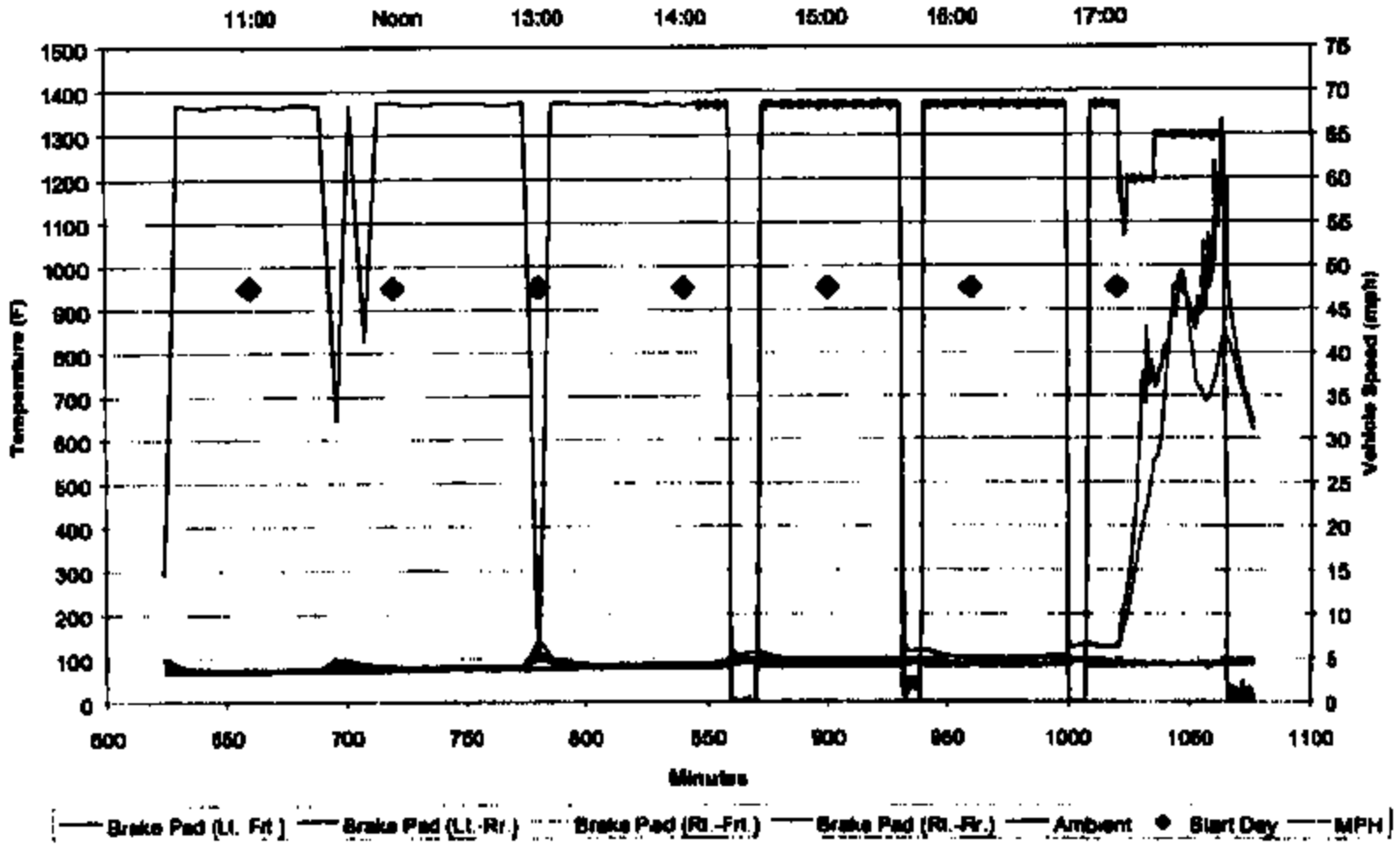
Truck 47298 - Brake Pad Temperatures Versus Time
Brent Shoffner 10/10/02

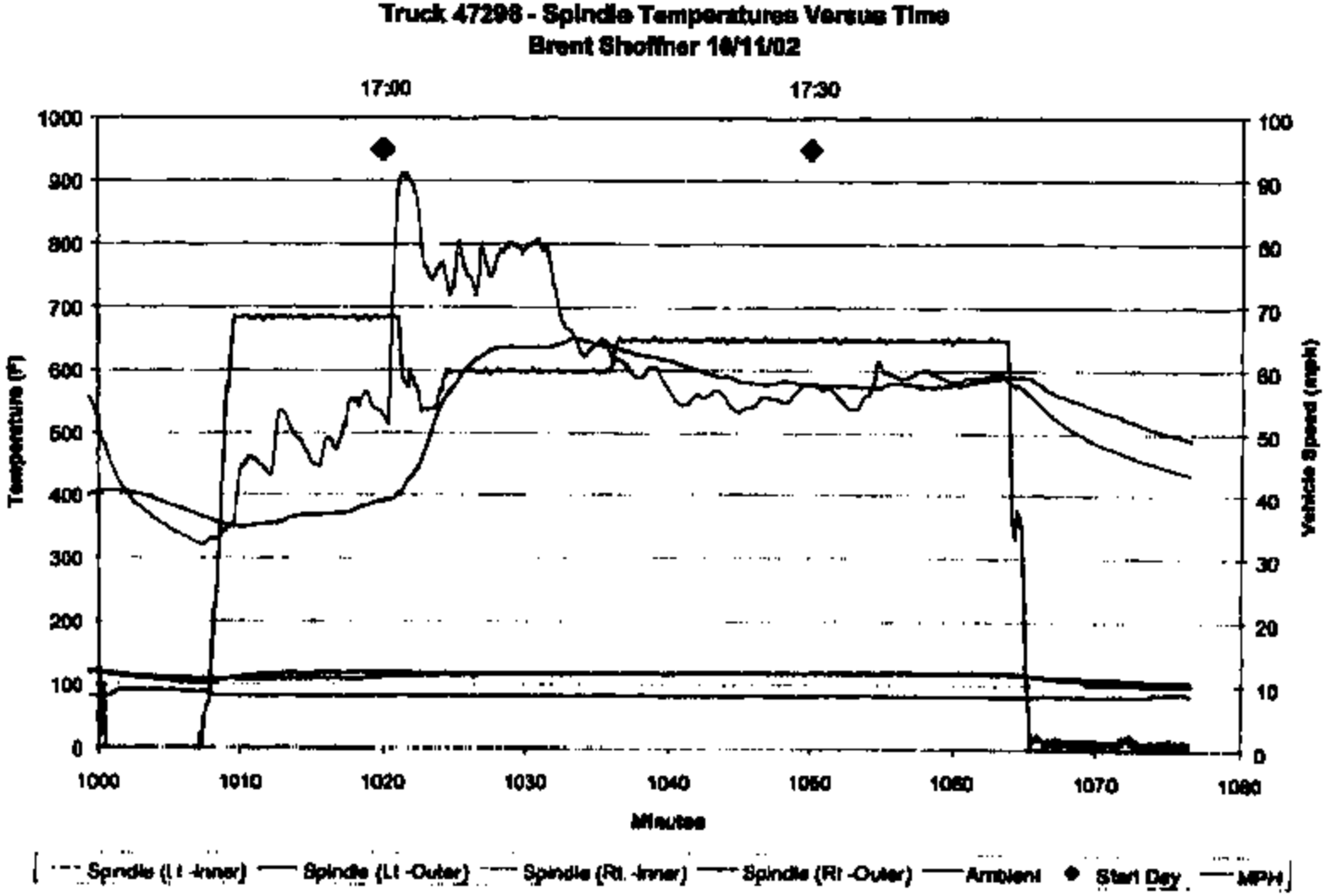



Truck 47296 - Spindle Temperatures Versus Time
Brent Shoffner 10/11/02
11:00
Noon
13:00
14:00
15:00
16:00
17:00
Temperature (F)
Vehicle Speed (mph)
Minutes
Spindle (Lt.-Inner)
Spindle (Lt.-Outer)
Spindle (Rt.-Inner)
Spindle (Rt.-Outer)
Ambient
Start Day
MPH

SKF 001021

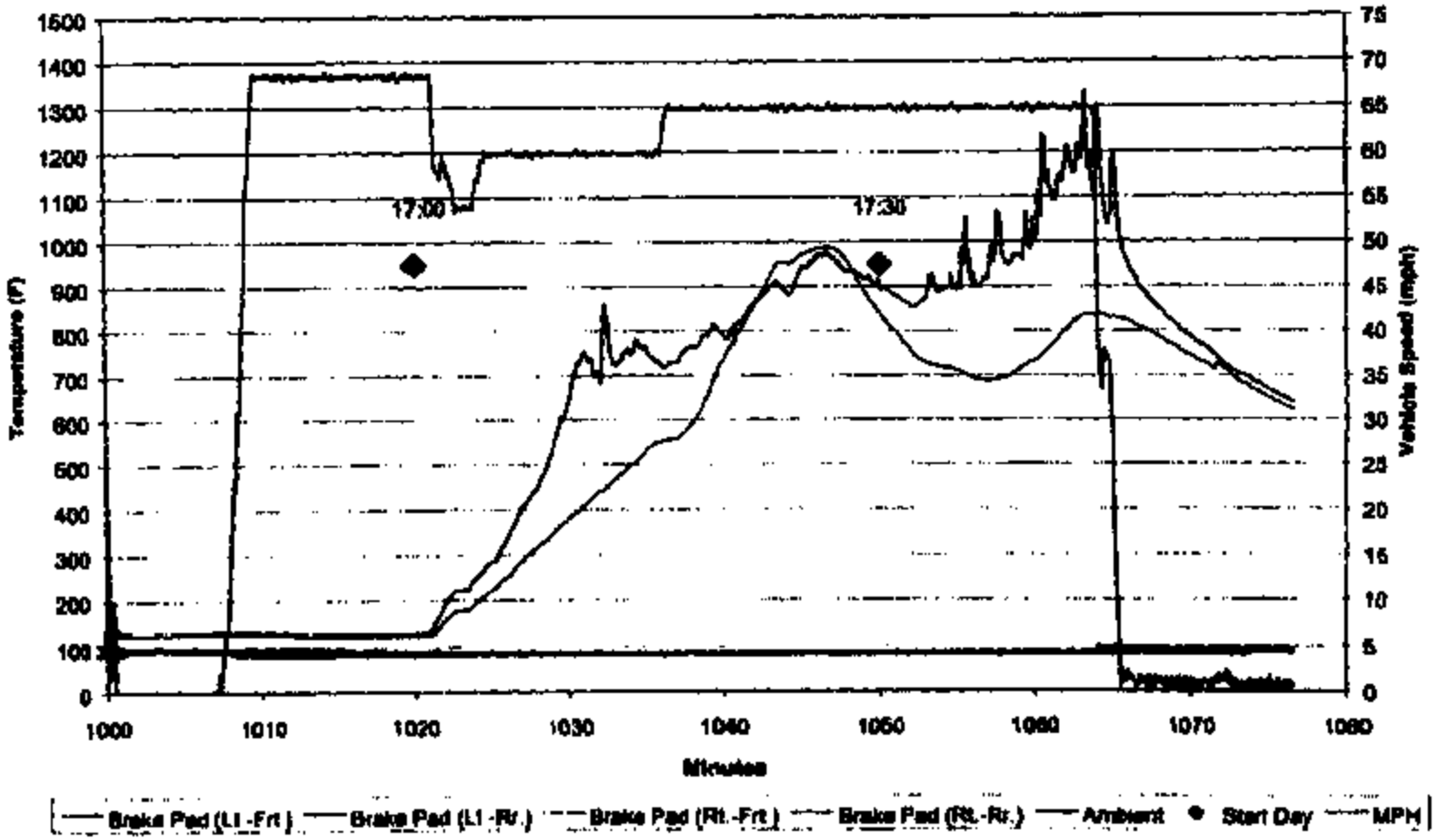
Truck 47298 - Brake Pad Temperatures Versus Time
Brent Shoffner 10/11/02

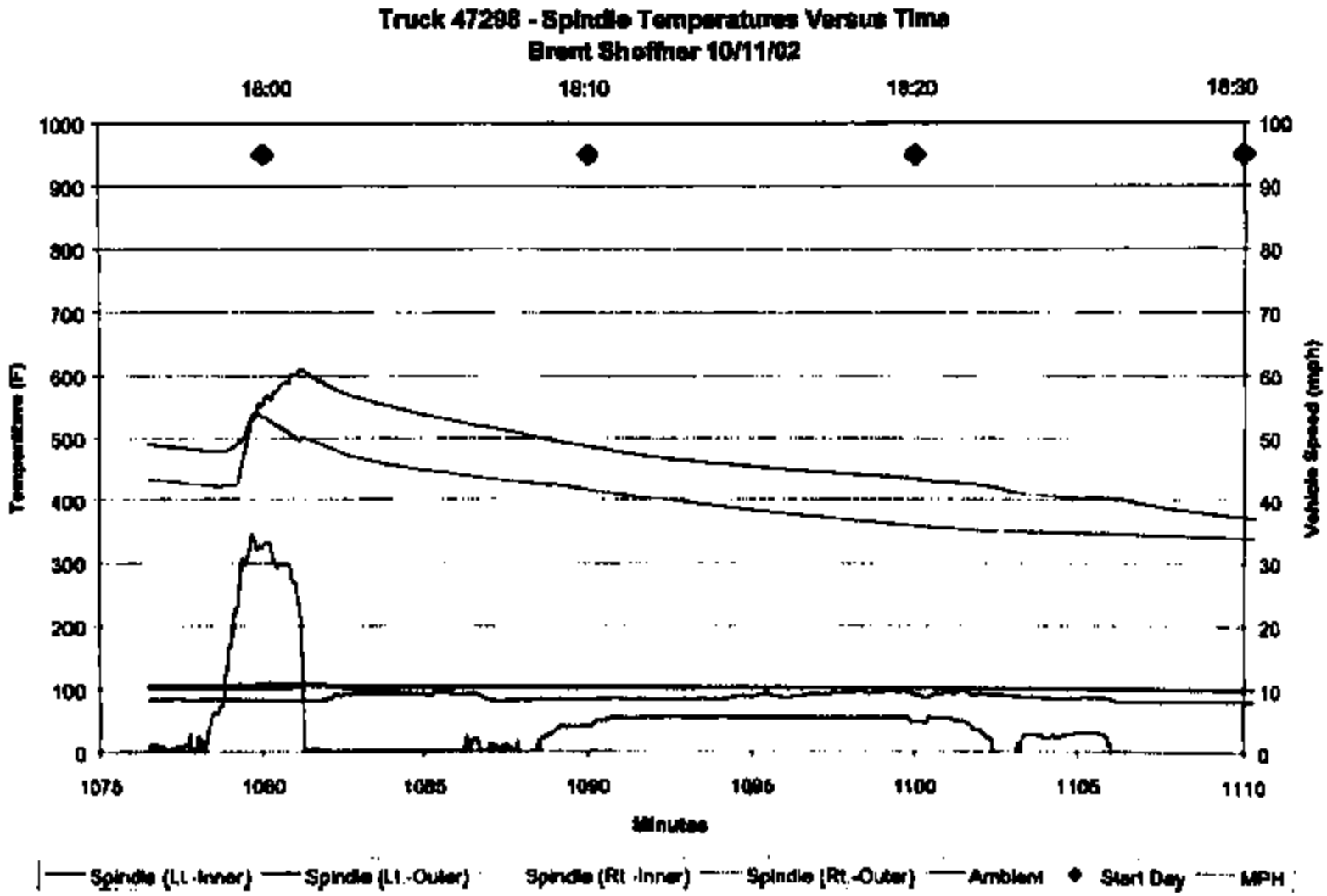



Truck 47298 - Spindle Temperatures Versus Time
Brent Sheffner 10/11/02
17:00
17:30
1000
900
800
700
600
500
400
300
200
100
0
Temperature (F)
100
90
80
70
60
50
40
30
20
10
0
Vehicle Speed (mph)
1000
1010
1020
1030
1040
1050
1060
1070
1080
Minutes
Spindle (Lt -Inner)
Spindle (Lt -Outer)
Spindle (Rt. -Inner)
Spindle (Rt -Outer)
Ambient
Start Day
MPH

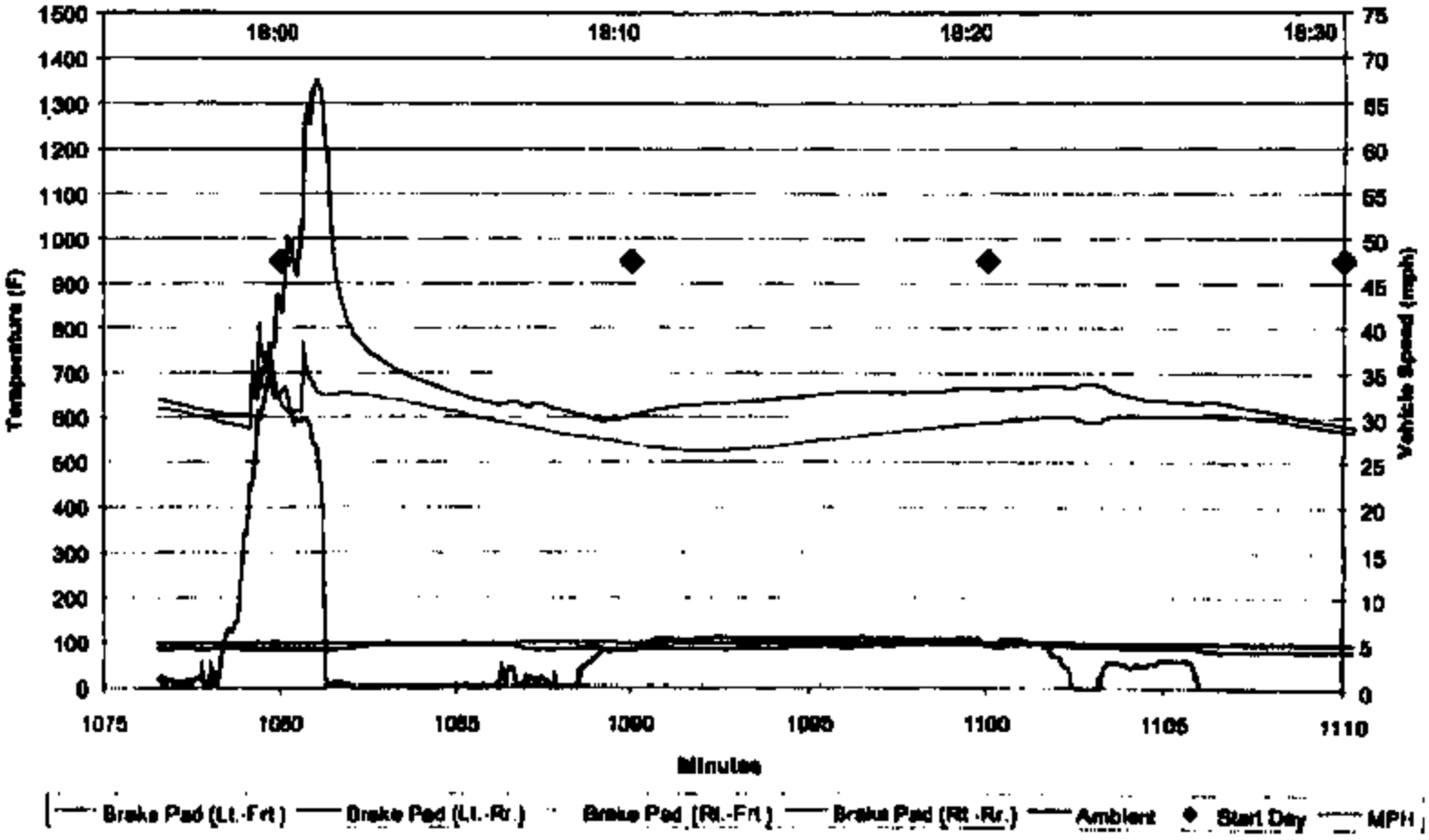
SKF 001023

Truck 47298 - Brake Pad Temperatures Versus Time
Brent Shoffner 10/11/02

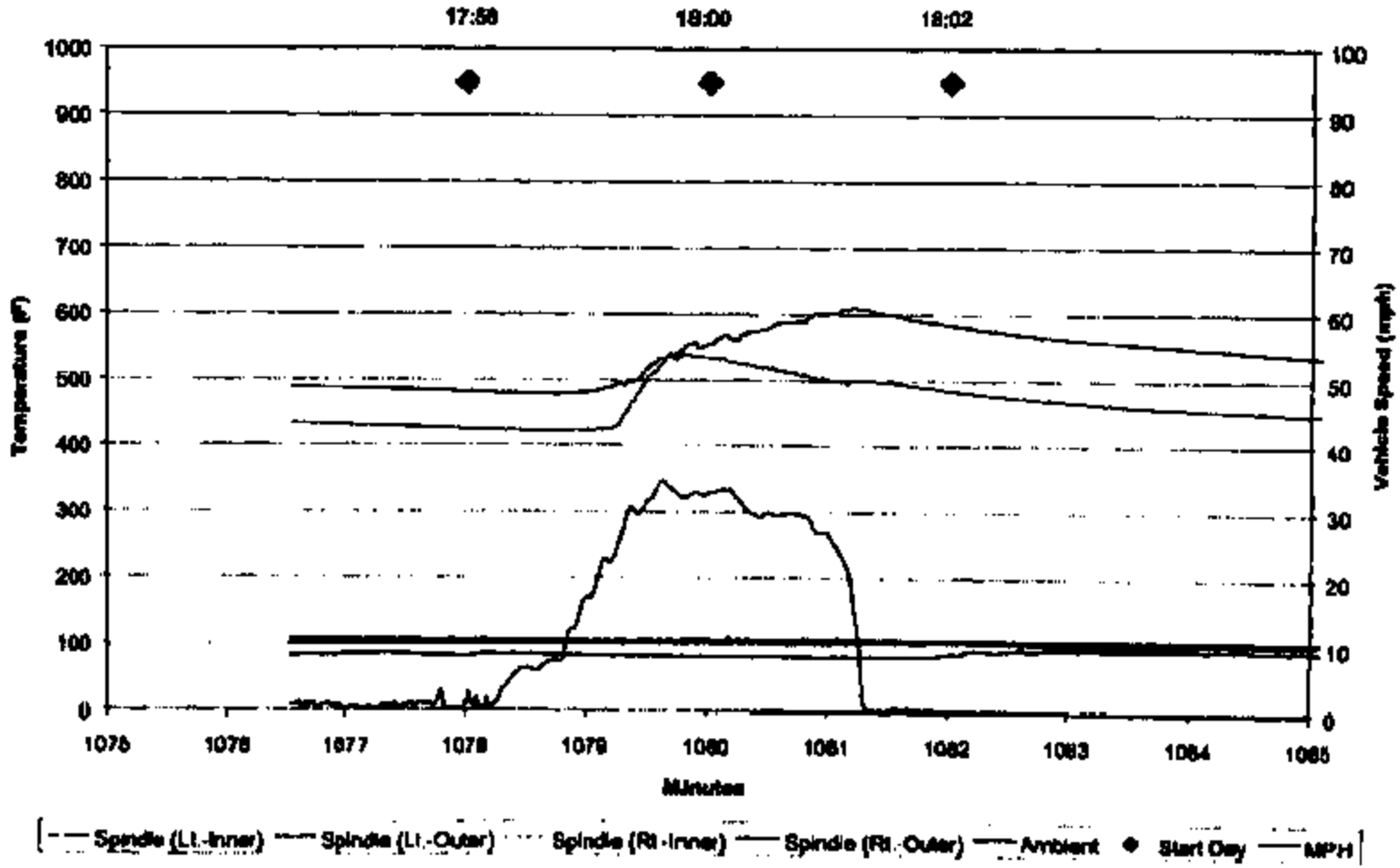



Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 10/11/02
18:00
18:10
18:20
18:30
1000
900
800
700
600
500
400
300
200
100
0
Temperature (F)
100
90
80
70
60
50
40
30
20
10
0
Vehicle Speed (mph)
1075
1080
1085
1090
1095
1100
1105
1110
Minutes
Spindle (Lt.-Inner)
Spindle (Lt.-Outer)
Spindle (Rt.-Inner)
Spindle (Rt.-Outer)
Ambient
Start Day
MPH

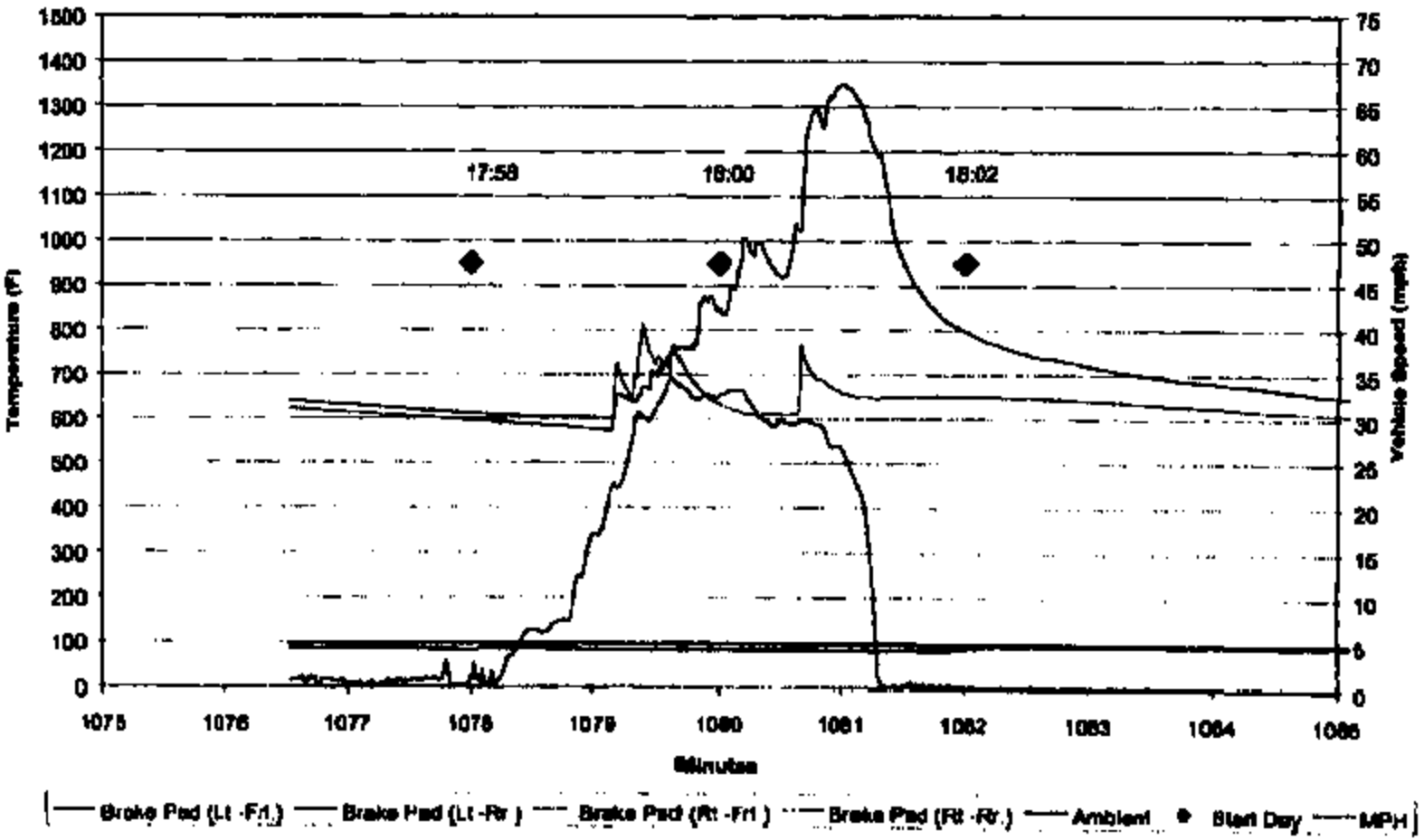
Truck 47298 - Brake Pad Temperatures Versus Time
Brent Shoffner 10/11/02



Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 10/11/02



Truck 47296 - Brake Pad Temperatures Versus Time
Brent Shoffner 10/11/02



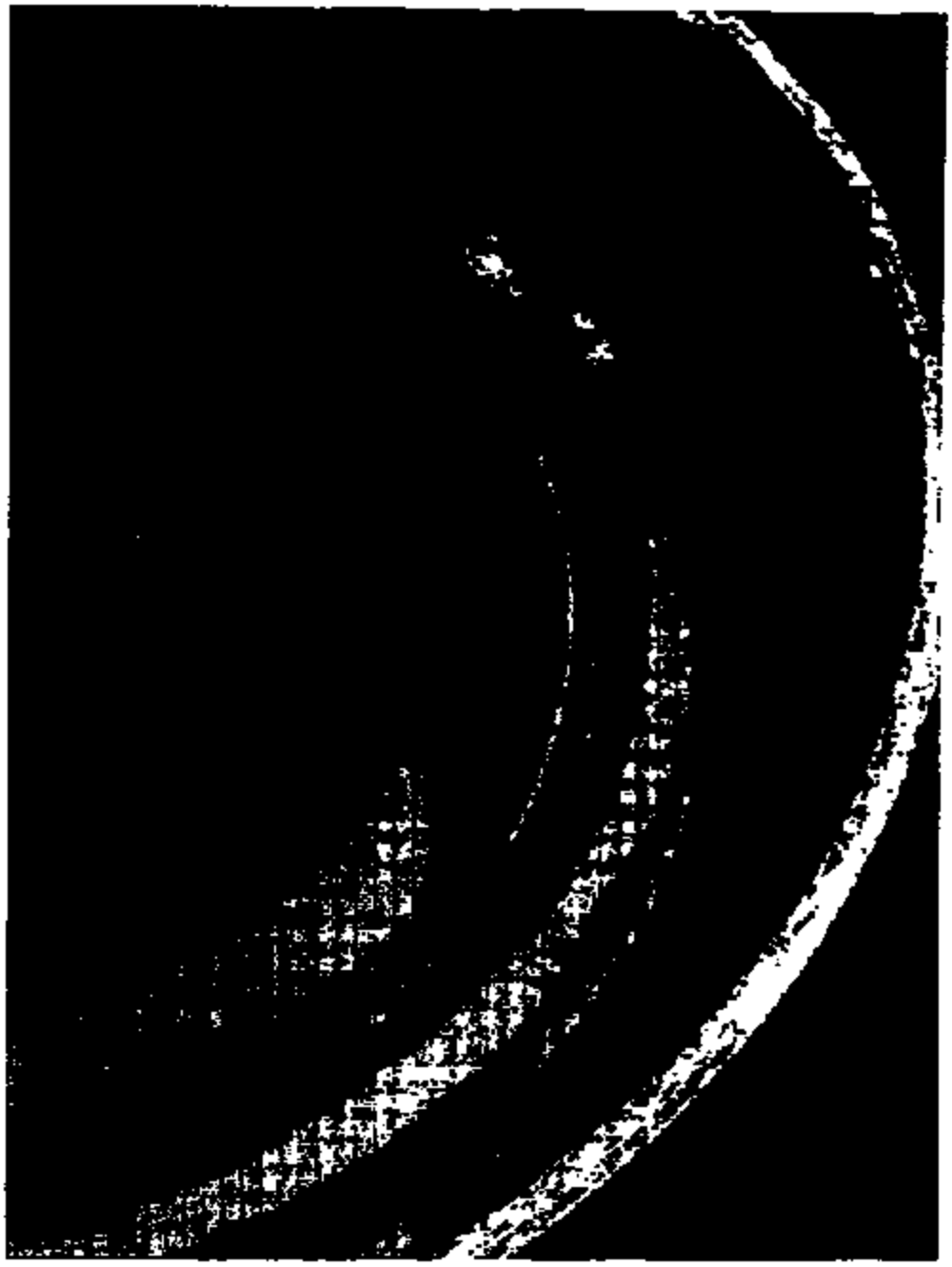
APPENDIX P
Wheel and Hub Cap Photos at the Stop Prior to and after Bearing Roller Ejection

The Indicator of the Heat Sensitive Belt Has Popped Out
Photograph Taken at the Stop Prior to Roller Ejection

SKF 36:030

Temperature Indicators on the Wheel during the Stop between Burn Out of the Bearing Grease and Roller Ejection

Right Front Brake Drum



Wheel and Spindle End after Roller Ejection

Page 4

SKF 03103

Bruce Weeks
10/22/2002 02:24 PM

To: Arno Stubenrauch/SCH/SKF@SKF, Achim Mueller/SCH/SKF@SKF, Michael D Lewis/DET/SKF@SKF, Robert J Bandy/DET/SKF@SKF

cc:

Subject: ACTION: List of THU Database Documents Already Given to ARM, and to Consider Sharing

Gentlemen,

Here is a list of documents from the ARM database that we need to consider whether we will share them with ARM or not. I have also listed below, the reports I am already sure ARM has been given.

Consider whether we give to ARM:

08/05/02 Roller quality due to roller diameter / raceway angle (question Dale Bell) (Juergen Schultheis)
08/07/02 Internal geometry - Alken April/May 1999 (Juergen Schultheis)
08/02/02 Capability Studies: Internal geometry IR (Juergen Schultheis)
08/01/02 Internal Geometry - Luechow Production 98 (Juergen Schultheis)
07/25/02 Seal fit / assembly process (Juergen Schultheis)
07/18/02 Capability bore grinding - parameter K1 (rectangularity side face bore) (Juergen Schultheis)
07/17/02 Roller quality production Galegow (Juergen Schultheis)
07/16/02 Capability of meshing unit in Alken due to axial clearance (Juergen Schultheis)
07/16/02 Scrap analyses CR-Bethlehem - Visit J. Kirch / J. Schultheis (Juergen Schultheis)
07/16/02 THU production Luechow: quality results 1998 (Juergen Schultheis)
07/16/02 Roller quality delivered from SKF Veenendaal (Juergen Schultheis)
07/16/02 Roller quality delivered from Galegow (Juergen Schultheis)

Already given to Chuck Smith at ARM on 07/25/02 (detailed on ARM database under the heading "Reports handed out to Chuck Smith":

07/25/02 Inner ring hardness (incoming inspection) (Juergen Schultheis)
07/25/02 Internal geometry - Alken 98 - 2002 (Juergen Schultheis)
07/25/02 Gage R&R for axial clearance 1998-2002 (Juergen Schultheis)
07/25/02 Manson axial clearance report (Juergen Schultheis)
07/25/02 Missing Marking 7D
07/25/02 Inboard R-Safe Seal cleaning of stock in Alken (due to seal defect discover) (Juergen Schultheis)
07/25/02 THU Process Layout (Juergen Schultheis)
07/25/02 MPR 100% Summary (Juergen Schultheis)
07/25/02 Procedure for checking diamond Rolls (Juergen Schultheis)
07/25/02 Component Traceability System (implemented 01 Aug 02) (Juergen Schultheis)
07/22/02 Apex point for THU application (Juergen Schultheis)
07/22/02 Axial Clearance Procedures (Juergen Schultheis)

Already given to Dale Bell (& Chuck Smith?) at ARM on 01 Aug 2002:

Schweinfurt 186/02 Outer ring spalling
ERC NL02T903e General Visual Observations
ERC ST02T206 Visual Inspection
ERC NL02M904e X-Ray Diffraction Analysis
ERC NL02M902 Analysis of Remaining Grease
ERC NL02M903e SEM Evaluation

ERC NL02M903e Supplment - Bore Corrosion Products Analysis
ERC NL02M49THUe Summary of Findings
Schweinfurt ST02T210 Raceway Qualification Tests (water in bearings)
Schweinfurt ST02T205 Air Leak Tests (aluminum hubcap & spindle)
NATC (no number) dated 08 Aug 2002 (delivered later) Air Leak Test (plastic hubcap & oversize threads)
E-mail from Achim Mueller concerning "Jet Cleaning of THU"
Orpheus calculations on spindle deflection by A.R.J. Reininga and G.J.Dop

Already given to Dale Bell & Chuck Smith on 12-13 Aug 2002:

Schweinfurt ST02T207 Non-Rotation During Assembly
Schweinfurt ST02T211 Stud Replacement by Hammering Out Studs
Schweinfurt ST02T209 Raceway Qualification Test of Damaged Raceways
Schweinfurt ST02T212 Static Water Splash Tests
Schweinfurt Executive Summary about ARM-THU-Incidents A. Stubenrauch

I will be posting this information on the ARM THU database. If anyone is aware of other reports that have been given to ARM, please go to the database on Notes and post a response.

Regards,

Bruce

Schweinfurt telecon 22 Oct 02
Mike Lewis Arno Stubenrauch
Bruce Weeks Armin #?
Bob Bondy
1. Reliability of THU's - Line Haul only
Plunge - infinite
Grease L1 - Calithia 1.1 M, GWZ 2.3 M
Pvg. - 12K Wirbell factured BEACON 0.9 M
Seal - ? Look to Volvo drive seal & BTF-0026 - ERC Calculation
Wear charts - FAX to Arno
2. Orpheus - lost
3. Failure Analysis
2 - from Gibson field - need serial #'s
3 - RQT - 2 fail 1 long runner early Oct
3 - from Aiken - OR spall - field returns 11099 early Oct
10 - from NAR 11099-13899
Need inspection sheets - FAX to Achim - DHL info
050-05299 IBIR spalls - Elgin Sayp OK - Sch sayp
need report - seal defects?
3 - from Aiken - high clearance - OR significant wear late Aug
4. 12 lobe unit - clicker
5. Axial clearance correlation
6. Plan to review returned cyclos
include air leak test
7. List of D/B items

Orpheus 8:30 23 Oct

Michael D Lewis
10/21/2002 04:47 PM

To: Achim Mueller/SCH/SKF@SKF, Robert J Bondy/DET/SKF, Arno Stubenrauch/SCH/SKF@SKF, Bruce Wenke/AMER/SKF@SKF

cc:

Subject: Agenda for today's meeting

Arno,

For today's discussions, I would like to cover the following:

1. Reliability of THU
   - Bearing
   - Seal

   Statement to ARM
2. Mating component discussions
   - Orpheous
   - Measurements of parts
3. Discussion of Failure analysis
   - List of parts
   - Timing
4. Discussion of 6 lobe unit
5. Clearance correlation update Juergen Sebastian & Achim are handling this
6. Over view of plan for returned seals
7. List of database items
   - Appropriate for ARM
   - Sent to ARM already

Discussion

Subject: Reports handed out to Chuck Smith (26-07-02)

Category: Quality

There was a meeting on 26-07-2002 at NATC in Detroit with Chuck Smith (Co-director Aron Mantor)

During that meeting following documents/reports were handed out to Chuck Smith (copy Bob Bondy)

Subject 1: Axial Clearance

Difference in manufacturing and measuring of axial clearance within the channel:

Axialclear_Lue_Alken.dc

Procedure for calibration/calibration of axial clearance measuring equipment installed in THU channel Alken:

axialclear_routine_alken.d

Results of R&R-studies for axial clearance measuring equipment installed in THU channel Alken:

R&R_axialclearance98.p

R&R_axialclearance99.p

R&R_axialclearance00.p

R&R_axialclearance01.p

R&R_axialclearance02.p

Subject 2: 3D-report for THU's with exceeded axial clearance (Monsoon Case):

Monsoon_Report_AxialClearance.

Subject 3: 7 Step Report - Missing marking

7_Stepreport_Missingmarking.

Subject 4: 7 Step Report - Seals

7_Stepreport_Seals.dc

Subject 5: Process Flow of THU Channel Alken / Measuring equipment

THU_ Process Layout Alken .

MPR_100%_summary.d

Subject 6: Product Audit July 2002:

ProductAudR_072002.dc

Subject 7: Internal Geometry 1998 --> 2002:

1998 figures were not available. Lost during organisation change.

Monthly Internal Geometry Results95-(

Due to missing 1998 figures the advantages of diamont dressing rollers were explained as well as the
procedure for the ordering and checking of diamont dressing roller was shown:

schelthels2002-08-09_133451.

Subject 8: Component Traceability System (implemented 1. August 02)

Samples:

Traceability.doc

Subject 9: Inner ring hardness validation (history)

IR hardness_98-2000.x

Subject 10: APEX comparison Luechow - Alken

apex_point.doc

7-Step Corrective Action.

7-Step Initiator/Team Leader: Christopher Jones	**Phone:**(803) 963-8452 **Fax:**(803) 563-8611	**Status:** Closed
Supplier: SKF USA Inc.	**Supplier Code:** 77248	**Issue Date:** 04/08/02
Location: SKF Automotive / Allen 1884 International Pl. Graniteville, SC 29829	**Date of Occurrence:** 01/10/02	**Date Closed:** 07/18/02
Part No.& Description: BTF-0085	**Source of Complaint:** ArvinMeritor	**NC Ticket Number:**
Line Affected: FF-981 Easy Steer non-drive front axle		**Referral Number:** A/02TH/0003

7D Team: Chris Jones - SKF Quality Assurance Manager, Mario Winkler - SKF Channel manager Kevin Cannon SKF Quality Engineer, Mike Lewis - Manager Truck Application Engineering, Bruce Weeks - Project Manager Application Engineering, Robert Bondy - Senior National Account Manager, William J Farrell - Chicago Rawhide - Sales, Roy Cinquegrani - Chicago Rawhide Quality Control Manager, Bill Tubbs - Chicago Rawhide Quality Analyst, David Simms - Chicago Rawhide Senior Heavy Duty Application Engineer

1. Problem Description

ArvinMeritor contacted NATC in Detroit to report early failures concerning BTF-0085 units. Preliminary indication was failures were related to inboard seal flows. Failed units serial numbers, manufacture dates, and the truck mileage are listed below:

Serial No.	Manufacturing Date	Mileage
0312174	10/17/00	109,318
0329009	01/05/01.	57,613
0332652	02/27/01.	60,934
0334502	03/09/01	91,572
0321457	11/13/00.	69,353
0348840	07/24/01	21,093

2. Interim Action / Containment:

1.) All of the current SV-BTFB 4463268 CD R-Seal seal stock were sent to Chicago Rawhide in Elgin, for disassembly, cleaning and sorting. In addition, parts produced in CR Bethlehem that were rejected from Allen stock and sent to Elgin have been scrapped. These parts were not sorted and/or reshipped.

2.) PPAP and purchase seal at new location (Chicago Rawhide - Elgin) Upon approval of the new seal, sorting was discontinued and only new 100% inspected product was used to replace all seals or build new bearings.

7-Step Corrective Action.

3.) Created new procedure and log book for replacing old seals with new ones, and implemented a identification plan for certified stock.

(Reference following Procedure and Log Sheet)

SKF SKF Standard & Practices Automotive Division Work Instruction (WI)	**THU 2.1** **BTF-4065 Steer** **SV-BTFB 446329 CD** **R-Safe Seal** **Rework Procedure**	Section WI 312.1 Page 2 of 7 Issue 1 Date 04-02 Compiled by [illegible] Approved by [illegible] Location SKF Aiken

1.0 ***PURPOSE***

The purpose of this procedure is to provide guidelines for the correct rework of replacing the SV-BTFB 226329 CD inboard seal and the applicable markings required after completion of rework.

2.0 ***SCOPE***

This procedure applies to supervisors, production team members, and anyone associated with the THU 2.1 Channel in SKF Aiken, SC.

3.0 ***DEFINITIONS***

3.1 *Nonconformance: Product or material that does not conform to the Customer requirements or specification.*

3.2 *Scrap: Product or material discarded because of an individual or multiple customer specification / requirement is not met.*

4.0 ***PROCEDURE***

4.1 *Carefully, remove old inboard seal and scrap it.*

4.2 *Clean seal bore verifying no bore tight enters the groove.*

4.3 *Place bearing on channel for insertion of new seal and lone ring.*

4.4 *Remove completed bearing from channel. Place "1 inch yellow dot" on back of bearing flange using paint stick and mark.*

4.5 A.) *If seal is a reworked (inspected) seal, apply a ½ x ½ "X" between the serial number and date code and on one of the machined bosses above the brake print diameter and record the serial number on form SKF-THU 036 to verify rework has been completed.*

B.) If seal is an new seal (new mold). apply a 1/8 x 1/8 "Z" between the serial number and date code and on one of the machined bosses above the brake piston diameter and record the serial number on form SKF-THU 036 to verify rework has been completed

4.6 Visually Inspect

4.7 Pack bearing

6.0 REFERENCES

6.1 Qd IP 465.1 Control of Nonconforming Product

THU 2.1 BTF-0065 SF-BTFB 446329 CD R-SAFE SEAL REWORK SIGN OFF CHECK SHEET

Rework Date:

SERIAL #	A	B	SERIAL #	A	B	SERIAL #	A	B

Verification Signature | Date

SKF-THU 036 (04/2002)

7-Step Corrective Action.

4.) Quarantined all stock in Aiken, Statham Warehouse, and immediate return of all stock at ArvinMeritor for the replacement of old seals.

Total Number Of Bearings Reworked - 6,347
BTF-0065A - 3,347
BTF-0065B - 3,020

Total From all Meritor Facilities - 1442

From Meritor Fletcher - 810
BTF-0065A - 648
BTF-0065B - 162

From Meritor Florence - 632
BTF-0065A - 458
BTF-0065B - 174

Bearings in Aiken: Total 3,429
BTF-0065A - 1,636
BTF-0065B - 1,799

Bearings from Statham Warehouse: Total 1,498
BTF-0065A - 810
BTF-0065B - 688

3. Root Cause:

Inspection of seals produced at CR Bethlehem from the returned Aiken stock showed visible signs of potential leak defects for the following conditions: Unfills, manual knife trim damage flowlines, and soft spots. In conversations with CR Bethlehem staff, they agree that these were major problems that the plant contended with during their production runs and any one of these defects may have caused the seal failures. The 6 seals that were returned from the field had enough wear that any of these defects may have been worn away. There is only 1 seal with remaining evidence of seal defects, which was a unfill (void) on the wiper lip. Due to the fact that all of the defects mentioned may have been worn away and each will be treated as a potential root cause of seal failure.

4. Corrective Actions:

1. Unfills (or voids) occurred on the wiper lip and on the bond tab on the side-wall of the part. There are several potential reasons why this occurred on CR Bethlehem production which are reflected on the Elgin PFMEA. However, it was identified that the root cause for the unfills was the lack of proper clearance in the mold to allow the metal stamping to fit into the mold. This lack of clearance in a nonfunctional portion of the mold did not allow the metal stamping to fully seat in the mold cavity. As the rubber entered the mold cavity to fill out the seal, the proper rubber path was reduced by the unseated metal stamping. In some cases, the force of rubber never overcame this resistance soon enough and the rubber cured up before filling out the seal. This created unfills (voids) on both the wiper lip and on the side-wall of the part. The corrective action was to remove the interference point to allow the metal to seat fully in the mold. This is located in a nonfunctional portion of the mold. There is no change to dimensional data, and this was confirmed with dimensional verification which was included in the PPAP to Aiken.

7-Step Corrective Action.

2. Regarding the potential for Dirty Mold, we concur with the findings from original TER completed by CR Bethlehem on this part number. Elgin follows similar procedures for auditing and inspecting for dirty mold and follows a break in process with mold release to prevent Dirty Mold from causing seal defects. However, there is one addition corrective action. Mold Release used during CR Bethlehem production is acceptable with 490 rubber, however there is a newer technology mold release agent that is available. This product (Chemlease) is used for all 490 rubber during the break in and molding process. This substitute product allows the mold to run cleaner and substantially reduces the potential for this failure to occur.

3. Next, the damaged to the primary lip was caused by manually trimming the part with a knife blade. The need for trimming arouse due to the high picker flash left on the part. The high picker flash is caused by damage to the gate area of the mold, but is controllable by mold release and press parameters. In Elgin production, there has not been any trouble with high picker flash thus far. Regardless, there are 2 corrective actions. One, if any picker flash does occur, the parts will be scrap, instead of reworking with a knife trim. Secondly, if picker flash does become an issue, the corrective action will be to replace any mold cavities with damage to the gate area with replacement mold inserts and re-qualify the mold internally.

4. Flowlines on the contact points is noted on both CR Bethlehem and Elgin production. Re-facing the radial grind on the lands of the mold cavity is a routine maintenance item needed to be completed when the mold arrived in Elgin. This process allows for air to escape the mold as the rubber enters the cavity. In addition, mold release can create flowlines, for which the fore-mentioned changes to mold release and re-facing of the lands helps to control the defect.

5. Verification:

Although each of the defect conditions covered above are controllable as described, each part will be is 100% visually inspected. However, as an additional verification, a 100% functional test will be conducted on all seals. The test (Air Leak Down) will be performed before the assembly process. The Leak Down process will sort out all of the defects listed above and prevents any molding defects from being assembled and shipped. The Leak Down is performed by putting the seal into a fixture that seals at both contact points. Then, air is introduced into the fixture and the test equipment measures the rate of air pressure decay. Any leak path caused by molding defects will be detected by the lack of ability for the seal to contain the air pressure. This leak test simultaneously checks the wiper lip and primary lip of the seal. MSA for Leakdown has validated the effectiveness of the test.

All corrective actions were completed before start of production in Elgin with the exception of the air Leak Down. All seals produced before implementation of Leakdown were 200% inspected to "oil seal" standards which have Zero Allowable defect size or quantity on the sealing surfaces. The Leakdown equipment is complete and will ready for production 4-25-2002. Implementation and training is being completed and from this point forward, all seals will be 100% leak down tested as an added precaution.

UPDATE 5/23/2002

The final action item for 100% leakdown testing was implemented on 4/25/2002. On 4-9/2002 the 1000 piece shipment contained only 100% leakdown tested parts, as well as all other shipments since that date.

7-Step Corrective Action.

7-Step Initiator/Team Leader: Christopher Jones	Phone: (803) 663-9662	Region: Canada
	Fax: (803) 663-9611	Issue Date: 07/29/02
Supplier: SKF USA Inc.	Supplier Code: 77246	Revision Date: 07/29/02
Location: SKF Automotive / Allen 1084 International Pl. Graniteville, SC 29829	Date of Occurrence: 06/04/02	Date Root Cause Identified: 07/2002
Part No & Description: BTF-0062	Date PCA Identified: 06/05/02	Date PCA Implemented: 06/05/02
Source of Complaint: ArvinMeritor	Date PCA Verified: 07/01/02	Date Closed: 07/24/02
Line Affected: THU	NC Ticket Number	Referral Number: ARCZTHU004

8D Team: Chris Jones Quality Assurance Manager, Kevin Cannon Quality Engineer, Mario Winkler Channel Manager, John Thomas Electrical Engineer.

1. Problem Description

Two bearings were returned to Arvin Meritor from the field for warranty analysis. During the investigation it was found that both bearings did not contain any identification marks on the side of the outer ring flange. SKF has visually examined only one of the two bearings and determined that based on the seal installed in the bearing (Freudenburg) it is a BTF 0062 and therefore manufactured before April 6 Th. 2000 when a seal change was introduced. After further investigation it was also found that bearing did not contain the pin marked number placed on the outer ring after heat treatment. This fact means the bearing was produced before March 1 St. 2000 which is when the pin marker was introduced into the channel process as a corrective action. The second bearing has not been seen and therefore not even a rough manufacturing date can be determined.

2. Interim Action / Containment:

Total Bearings in house are 4,186 and the number break down is as follows:

2,982 BTF-0062 A (HUFFCUTS 32)

1,804 BTF-0062 B (HUFFCUTS 34)

*** All bearings with operations conducted outside of the normal channel flow is logged into a rework log book by serial number and this provides an excellent opportunity to verify all markings are present.
All the above bearings have been inspected for bearing marking and found to be in full conformance

7-Step Corrective Action.

3. Root Cause.

During the normal channel process the marking of the bearing on the large outer diameter is the first operation from the final packing station. This means all turning , grinding and assembly operations are complete and in specification, the bearing is fully assembled with exception of the studs and ABS ring

After a detailed investigation it is felt that the bearings were not marked due to fault with the marking machine. The bearings continued through the remaining channel process having the studs and ABS ring fitted and passed visual inspection without the lack of marking being noticed.

Based on the results from visual inspection the below corrective action was implemented on 07/20/00 this will verify every cycle that the marking operation is complete prior to releasing the bearing to the next operation.

4. Corrective Actions:

* Implement in controller (machine logic) that on electrical feedback is given to the plc

(Programable logic controller) verifying the marking operation has been completed on every cycle

Completion Date : 07/20/00.

* Modify channel program logic to eliminate any possibility to manually bypass the marking operation

Completion Date : 08/05/02.

* Implement daily TPM check for stencil condition for damage and wear.

Completion Date : 07/24/02.

* Update PFMEA.

Completion Date : 07/31/02.

5. Verification:

Since the channel logic has been changed a total of 4543 bearings have been produced and verified for their marking. The serial numbers of these bearings have been recorded to ensure full verification.

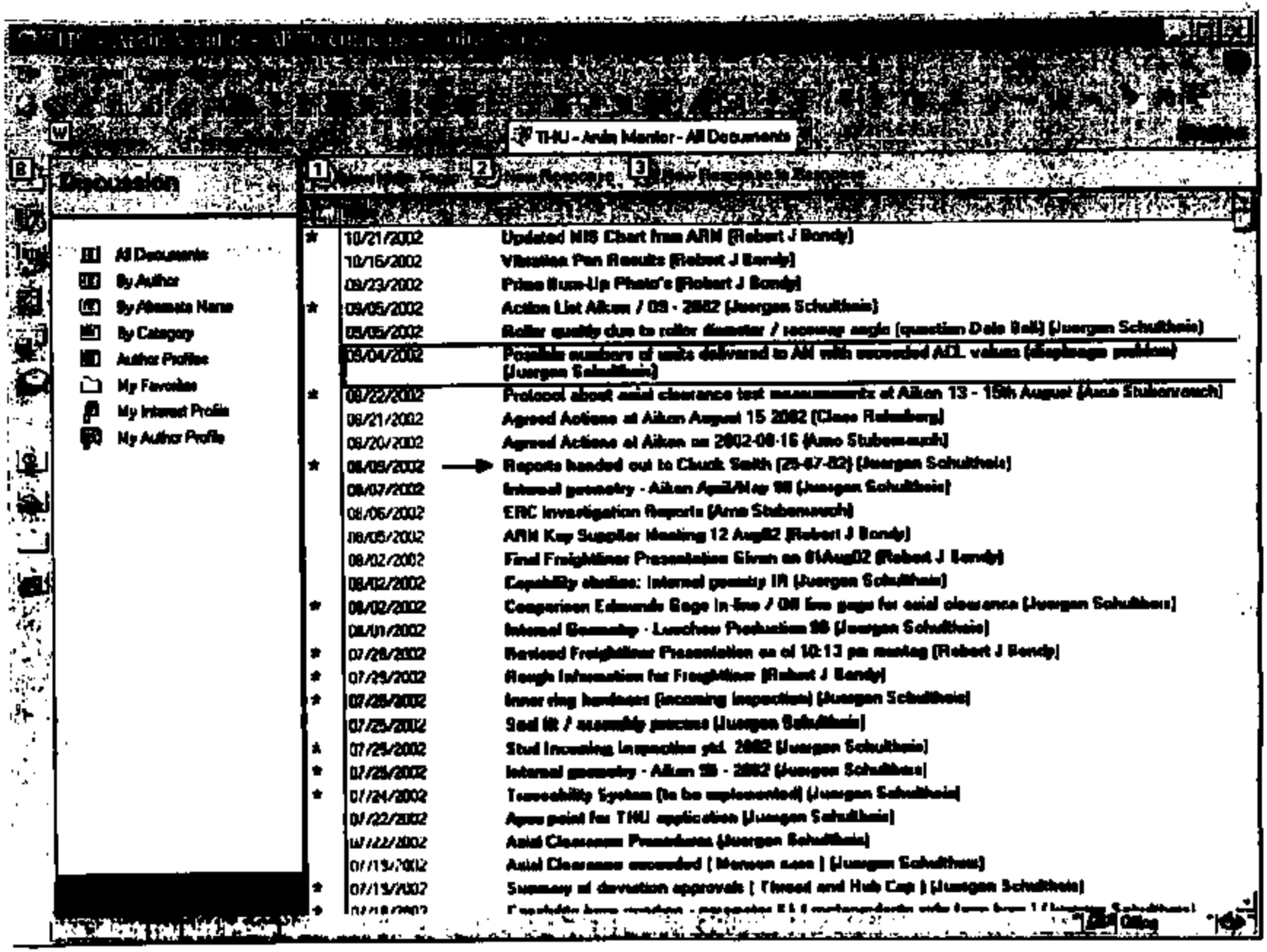
6. Control

The channel program logic can only altered by two trained certified engineers, no operator intervention can occur to remove the verification and bypass over rides currently installed in the system.

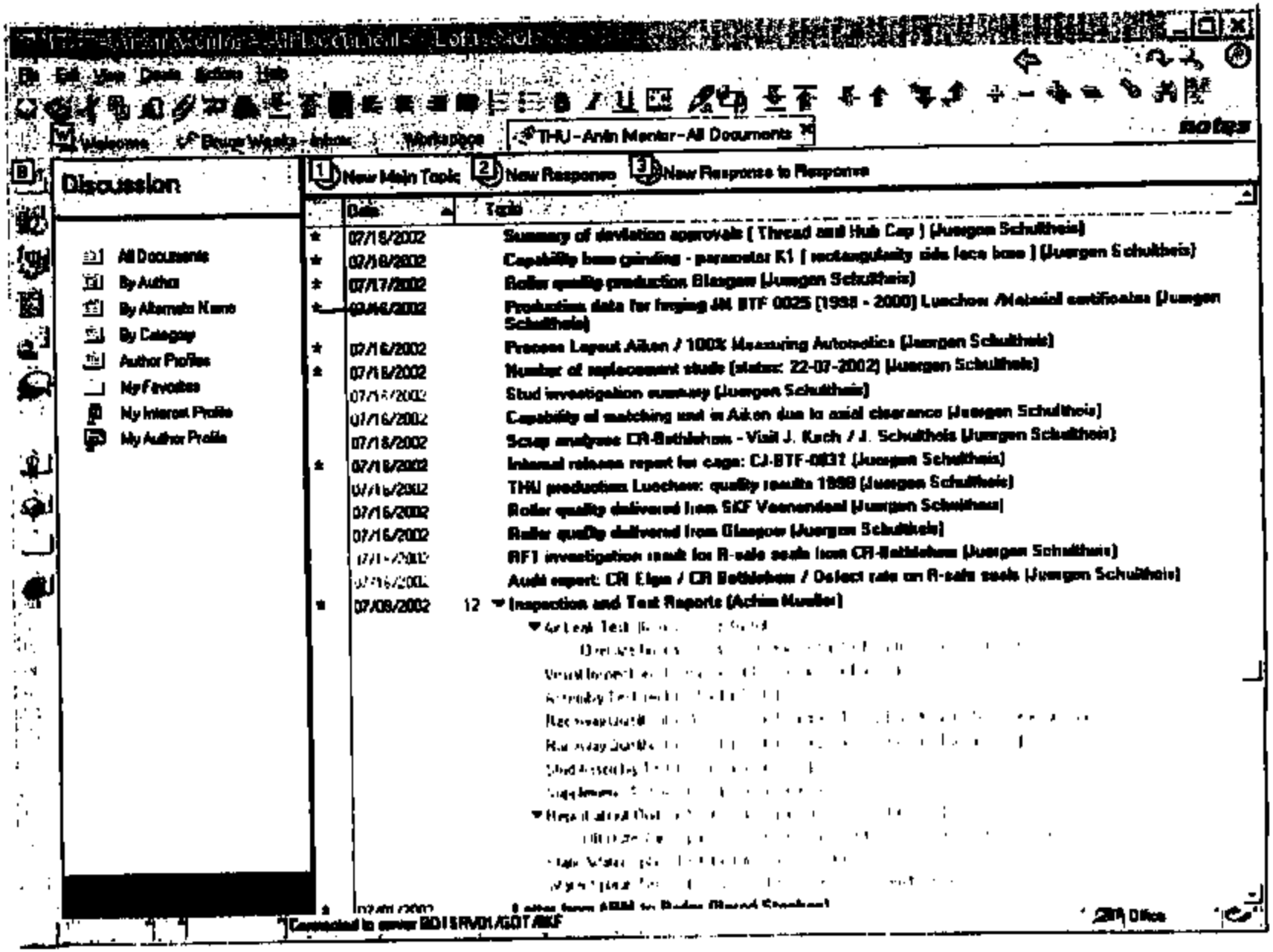
7. Prevention:

The measures outlined in this corrective action report wil be considered permenant.

Chris Jones
Quality Assurance Manager
SKF Automotive Division
Alken.


THU - Anita Mentor - All Documents
Discussion
All Documents
By Author
By Alternate Name
By Category
Author Profiles
My Favorites
My Interest Profile
My Author Profile
10/21/2002 Updated NIS Chart from ARN (Robert J Bondy)
10/16/2002 Vibration Pen Results (Robert J Bondy)
09/23/2002 Prime Run-Up Photo's (Robert J Bondy)
09/05/2002 Action List Aiken / 09 - 2002 (Juergen Schultheis)
09/05/2002 Roller quality due to roller diameter / raceway angle (question Dale Ball) (Juergen Schultheis)
09/04/2002 Possible numbers of units delivered to AH with exceeded AOL values (displacage problem) (Juergen Schultheis)
08/22/2002 Protocol about axial clearance test measurements at Aiken 13 - 15th August (Arno Stubenrauch)
08/21/2002 Agreed Actions at Aiken August 15 2002 (Claes Rabenberg)
08/20/2002 Agreed Actions at Aiken on 2002-08-16 (Arno Stubenrauch)
08/05/2002 Reports handed out to Chuck Smith (29-07-02) (Juergen Schulthels)
08/07/2002 Internal geometry - Aiken April/May 02 (Juergen Schulthels)
08/06/2002 ERC Investigation Reports (Arno Stubenrauch)
08/05/2002 ARN Key Supplier Meeting 12 Aug02 (Robert J Bondy)
08/02/2002 Final Freightliner Presentation Given on 01Aug02 (Robert J Bondy)
08/02/2002 Capability studies: Internal geometry IR (Juergen Schulthels)
08/02/2002 Comparison Edmunds Gage in-line / OR line gage for axial clearance (Juergen Schulthels)
08/01/2002 Internal Geometry - Luncheon Presentation 08 (Juergen Schulthels)
07/26/2002 Revised Freightliner Presentation as of 10:13 pm monday (Robert J Bondy)
07/29/2002 Rough Information for Freightliner (Robert J Bondy)
07/29/2002 Inner ring hardness (incoming inspection) (Juergen Schulthels)
07/25/2002 Seal fit / assembly process (Juergen Schulthels)
07/25/2002 Stud Incoming Inspection std. 2002 (Juergen Schulthels)
07/25/2002 Internal geometry - Aiken 08 - 2002 (Juergen Schulthels)
07/24/2002 Traceability System (to be implemented) (Juergen Schulthels)
07/22/2002 Apex point for THU application (Juergen Schulthels)
07/22/2002 Axial Clearance Procedures (Juergen Schulthels)
07/19/2002 Axial Clearance exceeded (Marwan case) (Juergen Schulthels)
07/19/2002 Summary of deviation approvals (Thread and Hub Cap) (Juergen Schulthels)

SKF 001050



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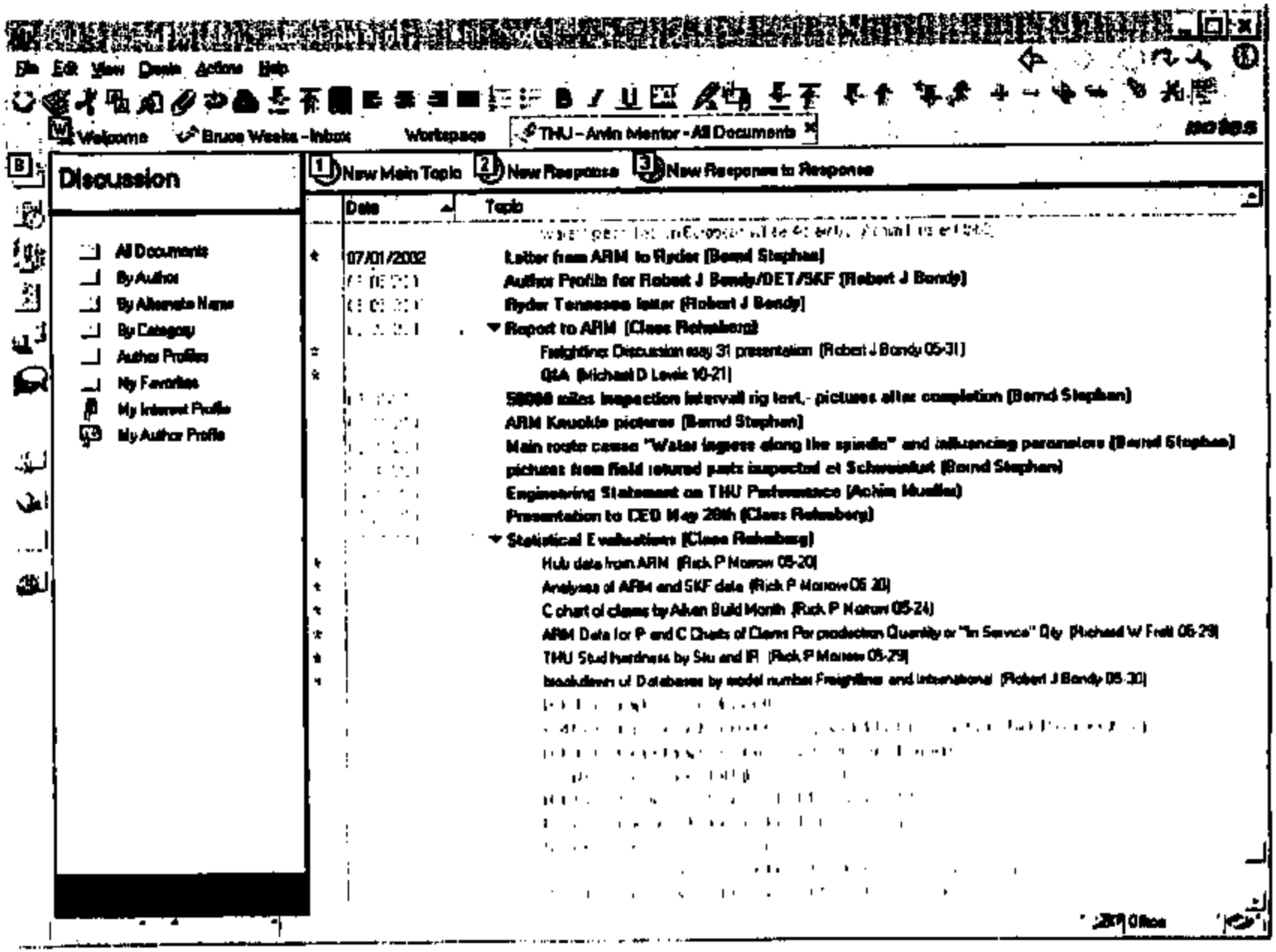
Welcome
Bruce Weeks - Inbox
Workspace
THU - Anin Mentor - All Documents
notes
Discussion
All Documents
By Author
By Alternate Name
By Category
Author Profiles
My Favorites
My Interest Profile
My Author Profile
1 New Main Topic
2 New Response
3 New Response to Response
Date
Topic
07/16/2002 Summary of deviation approvals (Thread and Hub Cap) (Juergen Schultheis)
07/16/2002 Capability base grinding - parameter K1 (rectangularity side face base) (Juergen Schultheis)
07/17/2002 Roller quality production Glasgow (Juergen Schultheis)
07/16/2002 Production data for forging JM BTF 0025 (1998 - 2000) Luechow /Material certificates (Juergen Schultheis)
07/16/2002 Process Layout Aiken / 100% Measuring Automatics (Juergen Schultheis)
07/16/2002 Number of replacement studs (status: 22-07-2002) (Juergen Schultheis)
07/16/2002 Stud investigation summary (Juergen Schultheis)
07/16/2002 Capability of matching unit in Aiken due to axial clearance (Juergen Schultheis)
07/16/2002 Scrap analyses CR-Bethlehem - Visit J. Koch / J. Schultheis (Juergen Schultheis)
07/16/2002 Internal release report for cage: CJ-BTF-0031 (Juergen Schultheis)
07/16/2002 THU production Luechow: quality results 1998 (Juergen Schultheis)
07/16/2002 Roller quality delivered from SKF Veenendaal (Juergen Schultheis)
07/16/2002 Roller quality delivered from Glasgow (Juergen Schultheis)
07/16/2002 RFT investigation result for R-safe seals from CR-Bethlehem (Juergen Schultheis)
07/16/2002 Audit report: CR Elgin / CR Bethlehem / Defect rate on R-safe seals (Juergen Schultheis)
07/09/2002 12 Inspection and Test Reports (Achim Mueller)
Connected to server BDTSRV01/GDT/SKF
Office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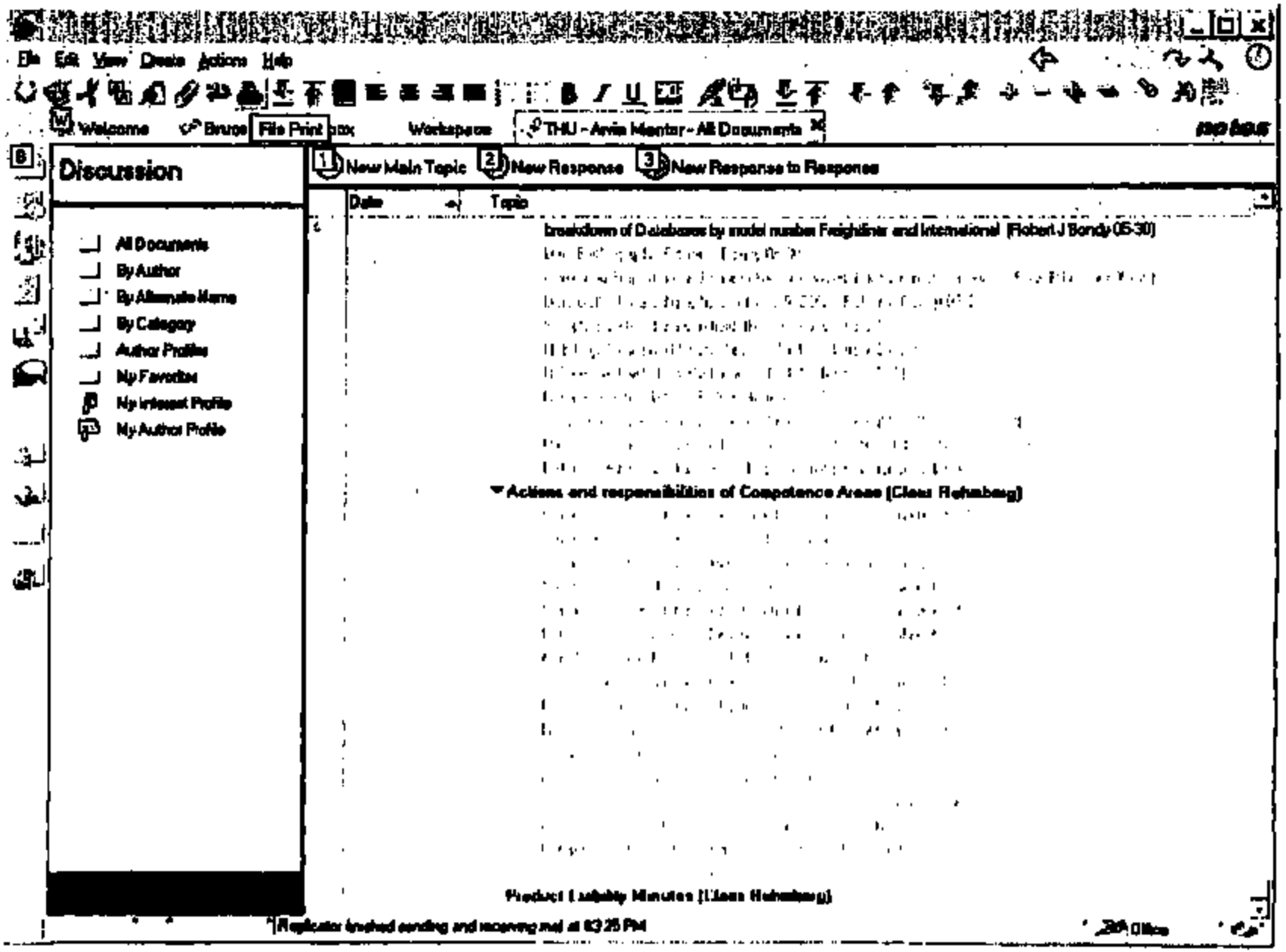
THU - Arvin Mentor - All Documents
Discussion
All Documents
By Author
By Alternate Name
By Category
Author Profiles
My Favorites
My Internet Profile
My Author Profile
1 New Main Topic
2 New Response
3 New Response to Response
Date
Topic
07/01/2002 Letter from ARM to Ryder (Bernd Stephan)
Author Profile for Robert J Bandy/DET/SKF (Robert J Bandy)
Ryder Tennessee letter (Robert J Bandy)
Report to ARM (Class Rehnberg)
Freightliner Discussion may 31 presentation (Robert J Bandy 05-31)
Q&A (Richard D Lewis 10-21)
58000 miles inspection interval rig test,- pictures after completion (Bernd Stephan)
ARM Knuckle pictures (Bernd Stephan)
Main route cause "Water ingress along the spindle" and influencing parameters (Bernd Stephan)
pictures from field returned parts inspected at Schweinfurt (Bernd Stephan)
Engineering Statement on THU Performance (Achim Mueller)
Presentation to CEO May 28th (Claes Rehnberg)
Statistical Evaluations (Claes Rehnberg)
Hub data from ARM (Rick P Morrow 05-20)
Analyses of ARM and SKF data (Rick P Morrow 05-20)
C chart of claims by Arvin Build Month (Rick P Morrow 05-24)
ARM Data for P and C Charts of Claim Per production Quantity or "In Service" Qty (Richard W Frett 05-29)
THU Stud hardness by Stu and IR (Rick P Morrow 05-29)
breakdown of Databases by model number Freightliner and International (Robert J Bandy 05-30)


File Edit View Create Actions Help
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By Author
By Alternate Name
By Category
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My Favorites
My Interest Profile
My Author Profile
1 New Main Topic
2 New Response
3 New Response to Response
Date
Topic
breakdown of Databases by model number Freightliner and International (Robert J Bondy 05-30)
Actions and responsibilities of Competence Areas (Claus Hohnbaeg)
Product Liability Minutes (Claus Hohnbaeg)
Replicator finished sending and receiving mail at 8:25 PM

SKF 001053

Discussion
Main Topic
Juergen
Schulthaus/SCH/SKF
07/16 10:48 AM

Subject: Capability of matching unit in Aiken due to axial clearance

Category: Quality

BTF-0065 AXIAL GAGE REJECT ANALYSIS

Day	Total Parts Produced	No. Of First Time Rejects	First Time Reject Percentage	
10.07.2002	271	18	6,64%	
11.07.2002	290	27	9,31%	
12.07.2002	234	16	6,84%	
Sum	796	61	7,67%	
Average	265	20	7,67%	

Max. Rejected Axle Clearance Value	Min. Rejected Axle Clearance Value
0,090	0,006

Detailed data attached:

axialcap_aiken.xls

Discussion

Main Topic

Jurgen Schulthaie/SKF
07/16 10:25 AM

Subject: Roller quality delivered from Glasgow

Category: Quality

To: Christopher.Jones@skf.com, Jurgen.Schulthaie@skf.com
cc: rwallace@rbcbearings.com
Subject: Re: Quality of conformance for RT 502 L

Gentlemen,

1. From the Glasgow plant, we supplied the 502IIIDB225 roller to SKF Aiken as follows:

Month	Quantity
Dec. 98	476,066
Jan. 99	624,214
Feb. 99	680,314
Mar. 99	803,931
April 99	515,153
May 99	619,238
June 99	828,124
July 99	213,012
Aug. 99	523,153
Sept. 99	470,272
Oct. 99	293,838
Nov. 99	787,417
Dec. 99	111,773

2. Product Audits

During the grinding operation product audits were conducted continuously. If a non conformance was found that product was not used. We are faxing to Chris Jones examples of the summary sheets for our ongoing audits. Backup data including traces are still available for these summaries.

3. Material Certificates

Material certificates were, and are reviewed when the raw material is received. There were no non-conformances.

4. Heat Treat

Every heat of rollers was inspected in the met. lab. and no non-conformances were found.

5. PPAP

The final PPAP for the Aiken Truck Hub including the rollers was March 1998.

Best Regards,

SW1 – HUB TEST May 2002

SKF 001086

SOUTHWEST RESEARCH INSTITUTE™

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October 23, 2002

TO: SKF, Inc.
46815 Port Street
Plymouth, Michigan 48170

ATTENTION: Mr. John Turner

SUBJECT: Southwest Research Institute (SwRI®) Preproposal No. 08-FLRD-289, *"Evaluations of Steering Axle Bearings on a Class 8 Truck"*

I. INTRODUCTION

The Fleet and Field Evaluations Section of Southwest Research Institute (SwRI) is pleased to provide this preproposal in response to a request from SKF, Inc. (SKF) as a follow-on to the program that was just completed. The new program will document the failure mode of a right front conventional wheel bearing and also a right front unitized hub. The program will be conducted on a Class 8 truck operated on the public road system and on the 8.5-mile oval track at the Continental General Proving Grounds.

II. PROGRAM OUTLINE

It is not possible to predict the exact number of miles required to fail the test bearings. However, the probable scenario for the program is shown below:

A. Conventional Wheel Bearing Test

1. Setup the truck to test the conventional wheel end bearing.
2. Conduct mileage accumulation on the public road system until a spindle temperature specified by SKF is achieved.
3. Prepare the truck with camera mounts and vibration sensor to conduct testing of the conventional wheel end at the Continental General Proving Grounds south of Uvalde, Texas. Tow the vehicle to the proving grounds.
4. Conduct mileage accumulation on the 8.5-mile oval track at the Continental General Proving Grounds with out video until a second threshold temperature is achieved.

This preproposal is submitted as a guide and merely represents our estimated time and price to perform the services based upon our general understanding of the program and your needs at this time. The estimated time and price as set forth herein are subject to change. This preproposal shall not constitute an offer for services and is intended for discussion purposes only. Should your company decide to have SwRI conduct this program, SwRI will prepare a formal proposal which will include a statement of work and contract for services.

DETROIT, MICHIGAN (248) 353-2550 • HOUSTON, TEXAS (713) 877-1377 • WASHINGTON, DC (301) 951-6200

5. Conduct mileage accumulation on the 8.5-mile oval track at the Continental General Proving Grounds with video documentation from three cameras.
6. Repair any damage to the truck and/or truck caused by the test program.

B. Unitized Hub Test

1. Install a front axle for a unitized hub and set up the truck to test the unitized hub bearing.
2. Conduct mileage accumulation on the public road system until a spindle temperature specified by SKF is achieved.
3. Conduct mileage accumulation on the 8.5-mile oval track at the Continental General Proving Grounds with out video until a second threshold is achieved.
4. Conduct mileage accumulation on the 8.5-mile oval track at the Continental General Proving Grounds with video documentation from three cameras.
5. Repair any damage to the truck and/or truck caused by the test program.

C. End of Test

1. Remove the ballast and instrumentation from the rig.
2. Return the truck to the leasing company.
3. Write the report.
4. Produce an edited tape at the direction of SKF.

III. TEST PROGRAM DETAILS

A. Test Set-up for the Conventional Wheel End

SwRI will lease a Class 8 tractor with an Arvin-Meritor front steering axle with conventional wheel end (model number FF961) and an antilock brake system (ABS). The tractor front end will be aligned and a 45-foot flat bed trailer will be leased for the program.

The fifth wheel location on the tractor will be adjusted and concrete ballast will be loaded onto to the front of the trailer until the weight on the front tractor axle is approximately 12,000 lbs. This weight will be documented by a public scale used to weigh trucks.

A safety skid shoe will be fabricated and attached to the steering axle, which will support the right front weight of the truck in case the right front wheel comes off the end of the spindle during failure. The wheel-bearing lubcap will be removed allowing the bearing lubricant to leak out. In an effort to prevent the right front wheel from coming off during failure, the spindle jam nut will be removed and replaced by a threaded wheel retainer. The retainer will be fabricated with a conical taper on the inboard side to pilot the I.D. of the outer race if it contacts the retainer.

The right front steering knuckle will be drilled to allow installation of thermocouple plugs, which will sense the temperature of the inboard and outboard ends of the spindle. A brake pad will be drilled at two locations to enable the installation of two thermocouple plugs to sense brake pad temperatures. If both of the spindle temperatures are less than 200°F, the parameters listed below will be recorded every six minutes using a Campbell™23X datalogger. If either of the spindle temperatures are equal to or exceed 200°F, the data acquisition rate will be increased to 1 Hertz.

1. Julian date
2. Military time in hours, minutes, and seconds
3. Ambient temperature (°F)
4. Vehicle speed (mph)
5. Right spindle inner temperature (°F)
6. Right spindle outer temperature (°F)
7. Right brake pad front temperature (°F)
8. Right brake pad rear temperature (°F)

A spindle temperature trigger indicating potential bearing failure will be specified by SKF. At this temperature an alarm will activate and the driver will decelerate the rig, pull to the side of the road and park the rig. The truck will then be driven at reduced speed to SwRI via the public road system.

B. Mileage Accumulation

Depending on the situation the mileage accumulation to produce a bearing failure will be accomplished in the most optimum method: public road system, Continental General Proving Grounds without video, or Continental General Proving Grounds with full video documentation. The primary concern is safety. Secondary criteria are documentation and cost.

1. Public Road System

When spindle temperatures are below the specified threshold, mileage accumulation will be performed on the interstate highways in the San Antonio, Texas area. Drivers will work two 10-hour shifts per day on a seven-day per week basis. It is estimated that 1,000 miles will be accumulated on each full day of operation. Bearing inspections will be performed at intervals of approximately 2,000 miles. The fuel will be #2 diesel and the oil will be commercially available 15W-40 heavy-duty diesel engine oil.

2. Continental General Proving Grounds Without Video

Mileage accumulation will be performed on the Continental General Track with a SwRI driver and observer in the vehicle. This phase will be conducted after the spindle temperatures have achieved the threshold temperature specified for the public road system. This phase will continue until the spindle temperatures reach a second threshold which indicates eminent failure. Note that SwRI will have to rent exclusive use of the 8.5-mile oval track for this phase and that Continental General raised the price for exclusive track use by 37.5% effective 11/1/02.

Transportation from SwRI to and from the proving grounds is included. SwRI will provide for driving time up to 10 hours per day. After the last bearing evaluation program, Continental General told SwRI that for similar vehicle programs, no lane changes would be allowed.

3. Continental General Proving Grounds With Video from Three Cameras

Mileage accumulation will be performed on the Continental General Track with an experienced SwRI driver and observer in the vehicle. This phase will be conducted after the spindle temperatures have achieved the threshold temperature, which would indicate an eminent failure. This phase will continue until a failure occurs. Note that SwRI will be required to rent exclusive use of the 8.5-mile

oval track for this phase. Transportation from SwRI to and from the proving grounds is included. SwRI will provide for driving time up to 10 hours per day.

A SwRI project manager and a video camera person will be present to document this phase. Continental General will require that a liaison person be assigned to the test team. A truck capable of pumping water to extinguish a fire will be on standby with two operators in case of fire.

C. Preparation to Conduct the Conventional Wheel Bearing Evaluation at the Continental General Proving Grounds

A single axis accelerometer will be mounted on the driver's seat bracket in vertical orientation. A flat computer screen will be mounted on the dashboard of the truck, which will display the acceleration rate from the sensor. A video camera will be mounted inside the truck capable of video taping the driver and the vibration display screen. A bracket will be mounted on the running board of the truck to videotape the right front wheel. The truck will be towed to the Continental General Proving Grounds and back to SwRI after completion of the test.

D. Setup to Test the Unitized Hub

It is assumed that SKF will supply a complete front axle assembly for a unitized hub and ABS. SwRI will remove the used front axle for the conventional wheel end test and install the front axle for the unitized hub. SwRI will drill the spindle to facilitate installation of thermocouple plugs to measure inboard and outboard spindle temperatures. The front wheels will be aligned. The same datalogger and program used on the conventional wheel end test will be used for the unitized hub evaluation.

IV. REPORTING

SwRI will send a weekly status of the program in writing via e-mail to SKF. The weekly status will include progress on program and the temperature data. Within 15 working days of the end of the program, SwRI will issue a final report.

V. ESTIMATED PRICE

The following assumptions in addition to those stated in the text have been made to determine the price estimate. If these assumptions are not correct, the price will be modified up or down based on the scope of work or cost of fuel or other non-labor purchases.

The following assumptions were made to develop this cost estimate:

1. Only one front wheel bearing will be on test at a time (Example: right front wheel bearing).
2. A different truck is required for ABS.
3. The conventional wheel end bearing will be tested first while SKF obtains a unitized hub from the field with the desired deflection.
4. It is assumed that SKF will supply a front axle for unitized hubs, the test hubs, and spindles.
5. It is assumed that Continental General will not require further safety training.
6. Continental General raised their prices for exclusive use of the 8.5-mile oval track by 37.5% for all customers.

7. There is no time delay waiting for a test hub, after completion of the conventional wheel end evaluation.
8. For mileage accumulation on the public road system requiring one driver similar to the last program, the price per mile will be calculated as follows:

   Price per mile on the public road system =
   (120%) (average $ per gallon of fuel cost)/(average miles per gallon) + $.92/mile

   The current price of diesel fuel in the San Antonio is about $1.36/gallon
   If this price held constant and the truck and trailer rig got 6 mpg, the assumed price per mile for this preproposal is shown below.

   Assumed price per mile on the public road system =
   ($1.36)(120%)/6 + $.92 = $1.19 per mile

9. SKF will be billed for any repairs to the truck or the test truck due to failure of the test bearings based on the cost of the repairs.
10. The original videotapes will be provided to SKF. If SKF directs SwRI to edit the videotape and produce a summary video, SKF will be billed at the rate of $45/hour for video editing.

The estimated prices to conduct the program are given in Table 1.

Table 1 – Price Estimates

Description of the Task	Number of Units	Price per Unit	Extended Total
Test set-up for the conventional wheel end	1	$7,937	$7,937
Mileage accumulation on the public road system	5,000 miles	$1.19/mile*	$5,950
Preparation to test the conventional wheel bearing at the Continental General Proving Grounds	1	$6,156	$6,156
Mileage accumulation at the Continental General Proving Grounds without video	1 day 10 hrs of driving	$700/day $452/hour	$700 $4,520
Mileage accumulation at the Continental General Proving Grounds with video and complete documentation to failure	1 day 10 hrs of driving	$5,068/day $502/hour	$5,068 $5,020
Test set-up for the unitized hub evaluation	1	$5,000	$5,000
Mileage accumulation on the public road system	20,000 miles	$1.19/mile*	$23,800
Preparation to conduct the unitized hub evaluation at the Continental General Proving Grounds	1	$3,000	$3,000
Mileage accumulation at the Continental General Proving Grounds without video	1 days 10 hrs of driving	$700/day $452/hour	$700 $4520
Mileage accumulation at the Continental General Proving Grounds with video and complete documentation to failure.	1 day 10 hrs of driving	$5,068/day $502/hour	$5,068 $5,020
Rental of the third camera	2	$960	$1,920
End of Test	1	$5,000	$5,000
Total			$89,379

* Actual billing will be based on average miles per gallon and cost of fuel as explained in Section V.B.

VI. CONCLUSION

SwRI appreciates the opportunity to provide this preproposal for SKF and looks forward to meeting your testing needs. If you have any questions or require further information, please contact Larry Eckhardt by telephone at (210) 522-2980 or Brent Shoffner at (210) 522-6986 or by fax at (210) 681-5344.

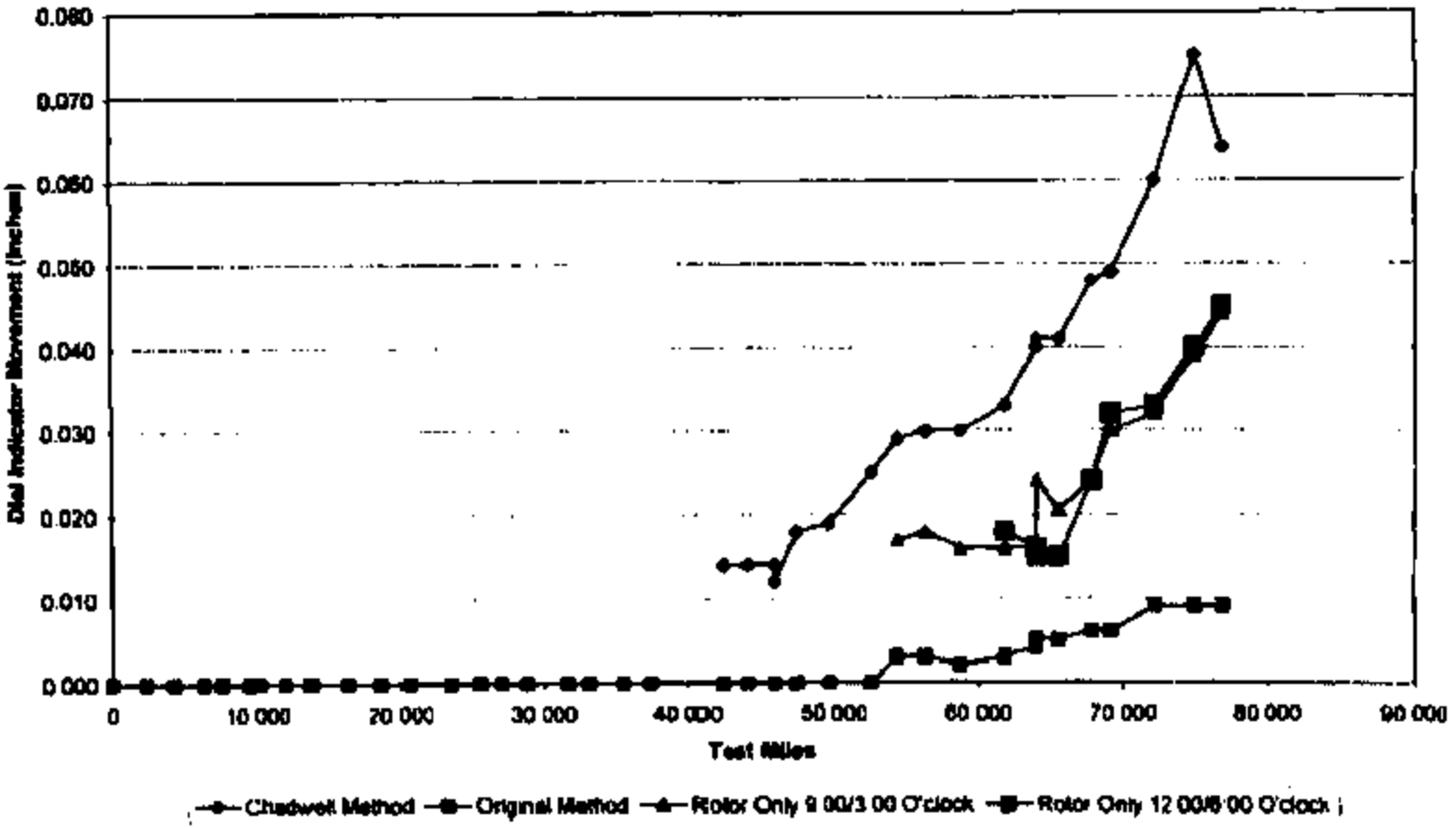
Submitted by:

Brent A. Shoffner

Brent Shoffner
Senior Research Engineer
Fleet and Field Evaluations Section

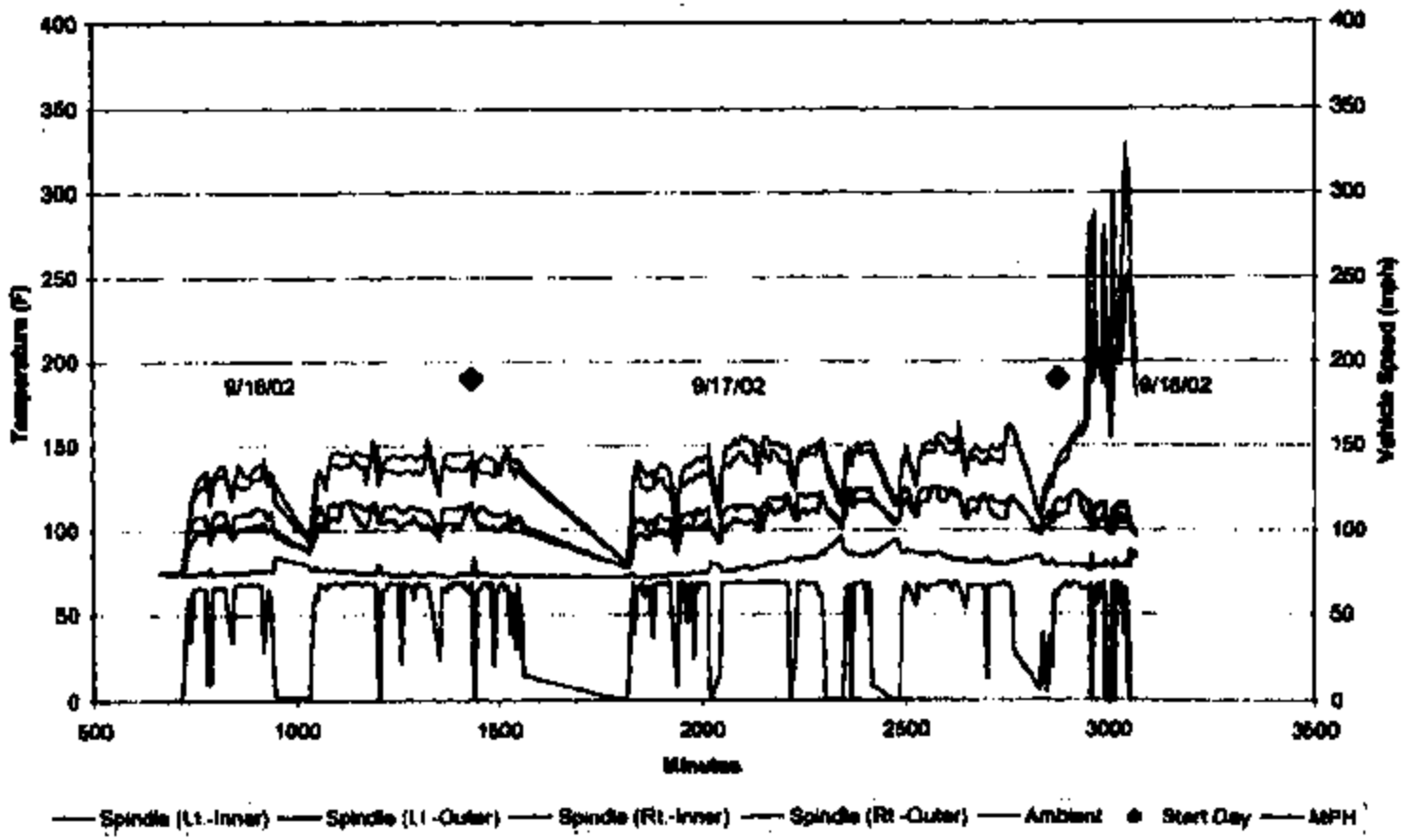
BAS/clm
cc: Lee Grant, SwRI
Steve Marty, SwRI
Larry Eckhardt, SwRI
Kevin Brunner, SwRI
Troy Nagy, SwRI
Norm Pattenaude, SwRI
James Chadwell, SwRI
Russell Watson, SwRI

SKF Bearing Evaluation Program
Right Front Bearing
Brent Shoffner 9/15/02



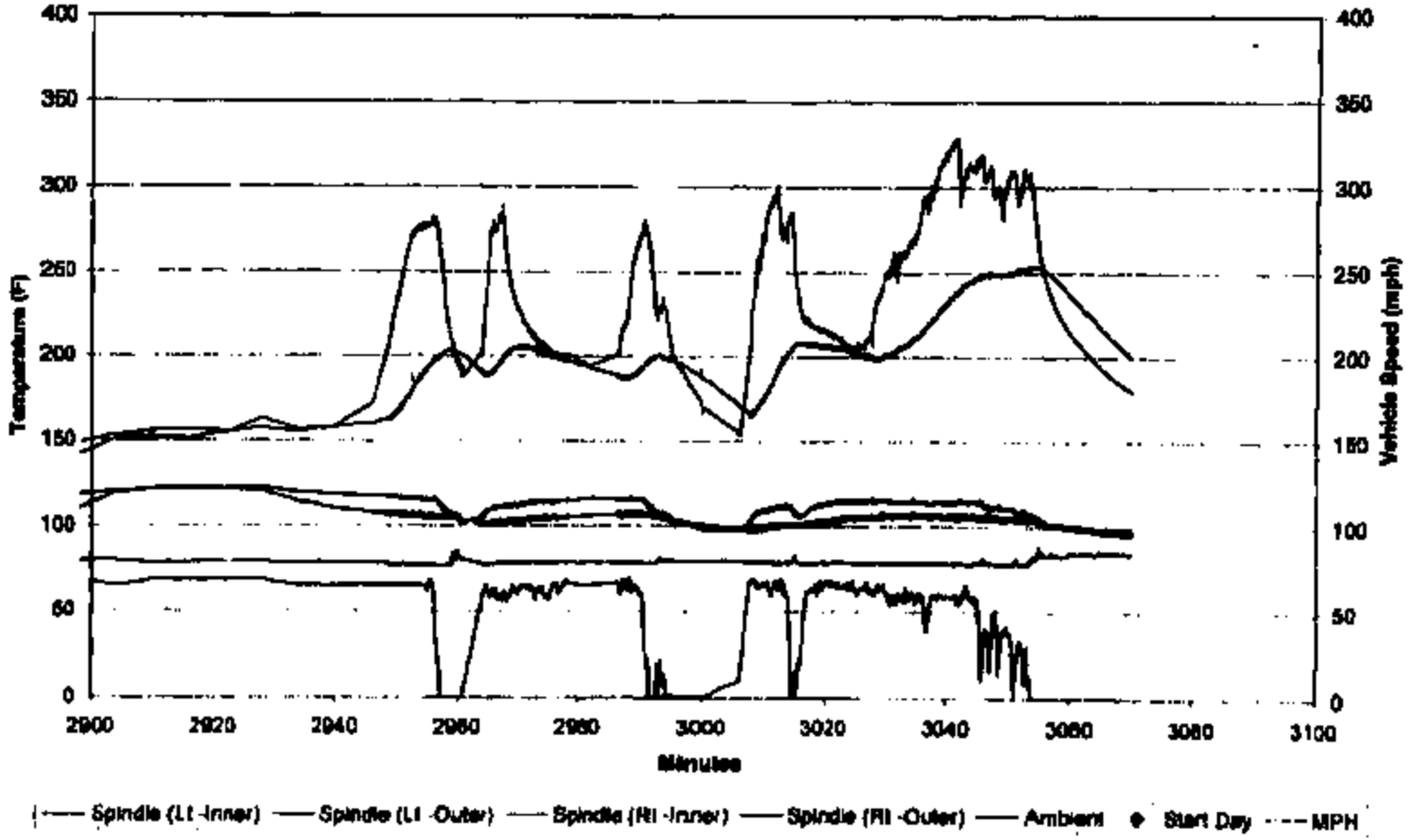
SKF 001093

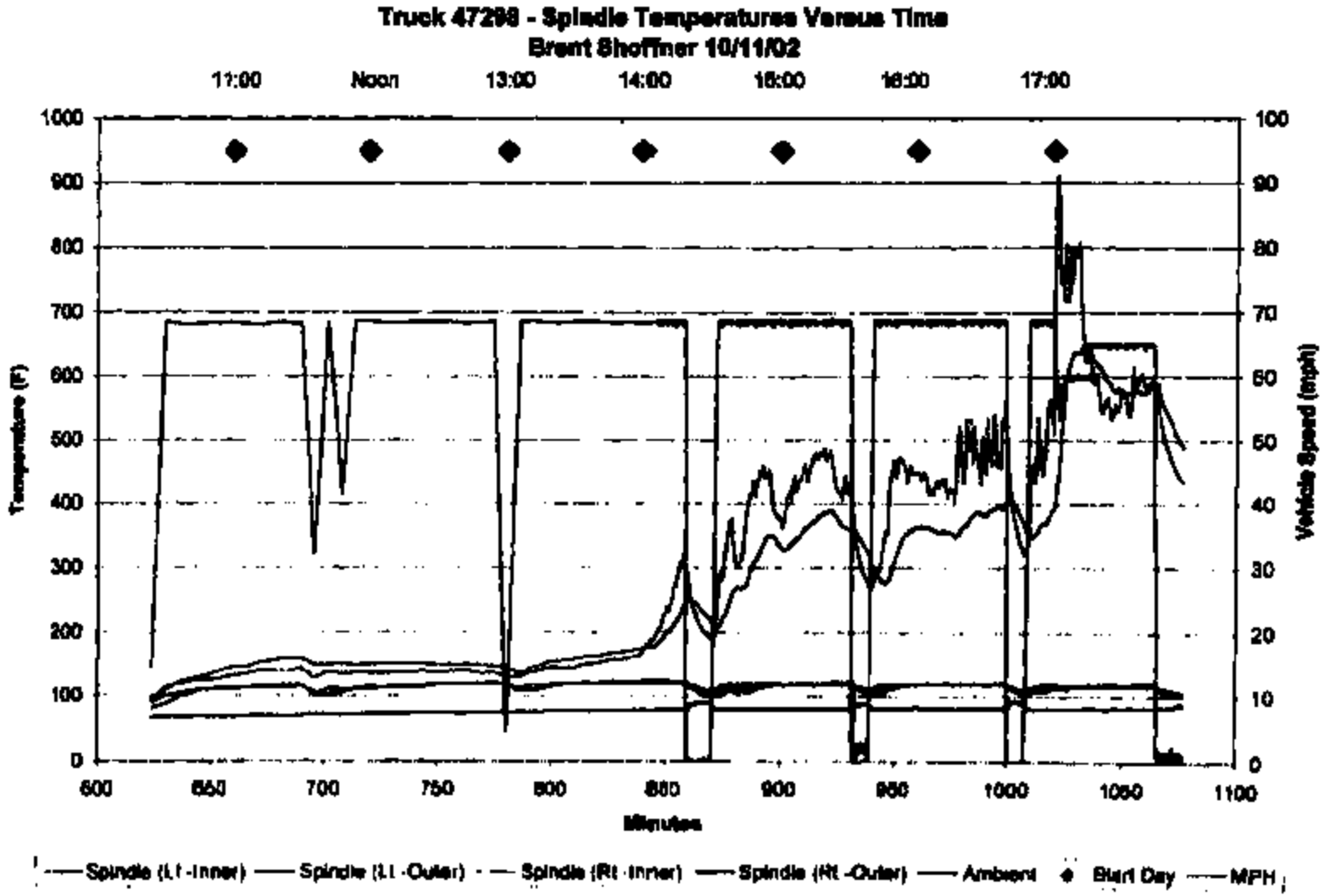
Truck 47288 - Spindle Temperatures Versus Time
Brent Shoffner 09/18/02



SKF 0010960

Truck 47296 - Spindle Temperatures Versus Time
Brent Shoffner 09/18/02




Truck 47298 - Spindle Temperatures Versus Time
Brent Shoffner 10/11/02
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Minutes
Spindle (Lf -Inner)
Spindle (Lf -Outer)
Spindle (Rt -Inner)
Spindle (Rt -Outer)
Ambient
Start Day
MPH

SKF 001096

SOUTHWEST RESEARCH INSTITUTE™

6220 CULEBRA ROAD • POST OFFICE DRAWER 28510 • SAN ANTONIO, TEXAS 78228-0510, USA • WWW.SWRI.ORG

November 13, 2002

TO: SKF, Inc.
46815 Port Street
Plymouth, Michigan 48170

ATTENTION: Mr. John Turner

SUBJECT: Southwest Research Institute (SwRI®) Preproposal No. 08-FLRD-289A, *"Evaluations of Steering Axle Bearings on a Class 8 Truck"*

I. INTRODUCTION

The Fleet and Field Evaluations Section of Southwest Research Institute (SwRI) is pleased to provide this preproposal in response to a request from SKF, Inc. (SKF) as a follow-on to the program that was just completed. The new program will document the failure mode of a right front conventional wheel bearing and also a right front unitized hub. The program will be conducted on a Class 8 truck operated on the public road system and on the 8.5-mile oval track at the Continental General Proving Grounds.

II. PROGRAM OUTLINE

It is not possible to predict the exact number of miles required to fail the test bearings. However, the probable scenario for the program is shown below:

A. Conventional Wheel Bearing Test

1. Setup the truck to test the conventional wheel end bearing.
2. Prepare the truck with camera mounts to conduct testing of the conventional wheel end at the Continental General Proving Grounds south of Uvalde, Texas. Tow the vehicle to the proving grounds.
3. Conduct mileage accumulation on the 8.5-mile oval track at the Continental General Proving Grounds with out video until a threshold temperature specified by SKF is achieved.

This preproposal is submitted as a guide and merely represents our estimated time and price to perform the services based upon our general understanding of the program and your needs at this time. The estimated time and price as set forth herein are subject to change. This preproposal shall not constitute an offer for services and is intended for discussion purposes only. Should your company decide to have SwRI conduct this program, SwRI will prepare a formal proposal which will include a statement of work and contract for services.

4. Conduct mileage accumulation on the 8.5-mile oval track at the Continental General Proving Grounds with video documentation from three cameras.
5. Repair any damage to the truck and/or track caused by the test program.

B. Unitized Hub Test

1. Install a front axle for a unitized hub and set up the truck to test the unitized hub bearing.
2. Conduct mileage accumulation on the public road system until a spindle temperature specified by SKF is achieved.
3. Conduct mileage accumulation on the 8.5-mile oval track at the Continental General Proving Grounds with out video until a second threshold is achieved.
4. Conduct mileage accumulation on the 8.5-mile oval track at the Continental General Proving Grounds with video documentation from three cameras.
5. Repair any damage to the truck and/or track caused by the test program.

C. End of Test

1. Remove the ballast and instrumentation from the rig.
2. Return the truck to the leasing company.
3. Write the report.
4. Produce an edited tape at the direction of SKF.

III. TEST PROGRAM DETAILS

A. Test Set-up for the Conventional Wheel End

SwRI will lease a Class 8 tractor with an Arvin-Meritor front steering axle with conventional wheel end (model number FF961) and an antilock brake system (ABS). The tractor will be a 1997 Freightliner Model FLD 1200 64S (VIN 1FUYDSEB8VP711398). The tractor front end will be aligned and a 45-foot flat bed trailer will be leased for the program.

The fifth wheel location on the tractor will be adjusted and concrete ballast will be loaded onto to the front of the trailer until the weight on the front tractor axle is approximately 12,000 lbs. This weight will be documented by a public scale used to weigh trucks.

A safety skid shoe will be fabricated and attached to the steering axle, which will support the right front weight of the truck in case the right front wheel comes off the end of the spindle during failure. The wheel-bearing hubcap will be removed allowing the bearing lubricant to leak out. In an effort to prevent the right front wheel from coming off during failure, the spindle jam nut will be removed and replaced by a threaded wheel retainer. The retainer will be fabricated with a conical taper on the inboard side to pilot the I.D. of the outer race if it contacts the retainer.

The right front steering knuckle will be drilled to allow installation of thermocouple plugs, which will sense the temperature of the inboard and outboard ends of the spindle. A brake pad will be drilled in two locations to enable the installation of two thermocouple plugs to sense brake pad temperatures. If both of the spindle temperatures are less than 200°F, the parameters listed below will be recorded every ten minutes using a Campbell™23X datalogger. If either of the spindle temperatures are equal to or exceed 200°F, the data acquisition rate will be increased to 1 Hertz.

1. Julian date
2. Military time in hours, minutes, and seconds
3. Ambient temperature (°F)
4. Vehicle speed (mph)
5. Right spindle inner temperature (°F)
6. Right spindle outer temperature (°F)
7. Right brake pad front temperature (°F)
8. Right brake pad rear temperature (°F)
9. Left spindle inner temperature (°F) – Unitized hub test only
10. Left spindle outer temperature (°F) – Unitized hub test only
11. left brake pad front temperature (°F) – Unitized hub test only
12. Left brake pad rear temperature (°F) – Unitized hub test only

B. Mileage Accumulation

Depending on the situation, the mileage accumulation to produce a bearing failure will be accomplished in the most optimum method: public road system, Continental General Proving Grounds without video, or Continental General Proving Grounds with full video documentation. The primary concern is safety. Secondary criteria are documentation and cost. No mileage accumulation on the public road system is planned for the conventional wheel bearing evaluation.

1. Public Road System

When spindle temperatures for the unitized hub are below the specified threshold, mileage accumulation will be performed on the interstate highways in the San Antonio, Texas area. Drivers will work two 10-hour shifts per day on a seven-day per week basis. It is estimated that 1,000 miles will be accumulated on each full day of operation. Bearing inspections will be performed at intervals of approximately 2,000 miles.

2. Continental General Proving Grounds Without Video

Mileage accumulation will be performed on the Continental General Track with a SwRI driver and observer in the vehicle. For the unitized hub evaluation this phase will be conducted after the spindle temperatures have achieved the threshold temperature specified for the public road system. This phase will continue until the spindle temperatures reach a second threshold which indicates eminent failure. Note that SwRI will have to rent exclusive use of the 8.5-mile oval track for this phase and that Continental General raised the price for exclusive track use by 37.5% effective 11/1/02.

Transportation from SwRI to and from the proving grounds is included. SwRI will provide for driving time up to 10 hours per day. After the last bearing evaluation program, Continental General told SwRI that for similar vehicle programs, no lane changes would be allowed.

3. Continental General Proving Grounds With Video from Three Cameras

Mileage accumulation will be performed on the Continental General Track with an experienced SwRI driver and observer in the vehicle. This phase will be conducted after the spindle temperatures have achieved the threshold temperature, which would indicate an eminent failure. This phase will continue until a failure occurs. Note that SwRI will be required to rent exclusive use of the 8.5-mile oval track for this phase. Transportation from SwRI to and from the proving grounds is included. SwRI will provide for driving time up to 10 hours per day.

A SwRI project manager and a video camera person will be present to document this phase. Continental General will require that a liaison person be assigned to the test team. A truck capable of pumping water to extinguish a fire will be on standby with two operators in case of fire.

C. Preparation to Conduct the Conventional Wheel Bearing Evaluation at the Continental General Proving Grounds

A video camera will be mounted inside the truck capable of video taping the driver. A bracket will be mounted on the running board of the truck to videotape the right front wheel. The truck will be towed to the Continental General Proving Grounds and back to SwRI after completion of the test.

D. Setup to Test the Unitized Hub

It is assumed that SKF will supply a complete front axle assembly for a unitized hub and ABS. SwRI will remove the used front axle for the conventional wheel end test and install the front axle for the unitized hub. SwRI will drill the right and left spindles to facilitate installation of thermocouple plugs to measure inboard and outboard spindle temperatures. The right and left brake pad temperatures will also be monitored. The left front hub from the previous program will be installed on the new test truck. The front wheels will be aligned. The datalogger program from the completed unitized hub evaluation will be used for this project.

IV. REPORTING

SwRI will send a weekly status of the program in writing via e-mail to SKF. The weekly status will include progress on program and the temperature data. Within 15 working days of the end of the program, SwRI will issue a final report.

V. ESTIMATED PRICE

The following assumptions in addition to those stated in the text have been made to determine the price estimate. If these assumptions are not correct, the price will be modified up or down based on the scope of work or cost of fuel or other non-labor purchases.

The following assumptions were made to develop this cost estimate:

1. Only one front conventional wheel bearing will be on test (Example: right front wheel bearing). However, both the left and right unitized hubs will be monitored during the mileage accumulation on the public road system.
2. A different truck is required for ABS.
3. The conventional wheel end bearing will be tested first while SKF obtains a unitized hub from the field with the desired deflection.
4. It is assumed that SKF will supply a front axle for unitized hubs, the test hubs, and spindles.
5. It is assumed that Continental General will not require further safety training.
6. Continental General raised their prices for exclusive use of the 8.5-mile oval track by 37.5% for all customers.

7. There is no time delay waiting for a test hub, after completion of the conventional wheel end evaluation.
8. For mileage accumulation on the public road system requiring one driver similar to the last program, the price per mile will be calculated as follows:

   Price per mile on the public road system =
   (120%) (average $ per gallon of fuel cost)/(average miles per gallon) + $.92/mile

   The current price of diesel fuel in the San Antonio is about $1.36/gallon
   If this price held constant and the truck and trailer rig got 6 mpg, the assumed price per mile for this preproposal is shown below.

   Assumed price per mile on the public road system =
   ($1.36)(120%)/6 + $.92 = $1.19 per mile

9. SKF will be billed for any repairs to the truck or the test track due to failure of the test bearings based on the cost of the repairs.
10. The original videotapes will be provided to SKF. If SKF directs SwRI to edit the videotape and produce a summary video, SKF will be billed at the rate of $45/hour for video editing.

The estimated prices to conduct the program are given in Table 1

Table 1 – Price Estimates

Description of the Task	Number of Units	Price per Unit	Extended Total
Test set-up for the conventional wheel end	1	$7,937	$7,937
Preparation to test the conventional wheel bearing at the Continental General Proving Grounds	1	$5,281	$5,281
Mileage accumulation at the Continental General Proving Grounds without video	1 day 10 hrs of driving	$700/day $452/hour	$700 $4,520
Mileage accumulation at the Continental General Proving Grounds with video and complete documentation to failure	1 day 10 hrs of driving	$5,068/day $502/hour	$5,068 $5,020
Test set-up for the unitized hub evaluation (Rt. and Lt.)	1	$7,250	$7,250
Mileage accumulation on the public road system	20,000 miles	$1.19/mile*	$23,800
Preparation to conduct the unitized hub evaluation at the Continental General Proving Grounds	1	$3,000	$3,000
Mileage accumulation at the Continental General Proving Grounds without video	1 day 10 hrs of driving	$700/day $452/hour	$700 $4520
Mileage accumulation at the Continental General Proving Grounds with video and complete documentation to failure.	1 day 10 hrs of driving	$5,068/day $502/hour	$5,068 $5,020
Rental of the third camera	2	$960	$1,920
End of Test	1	$5,000	$5,000
Total			$84,804

* Actual billing will be based on average miles per gallon and cost of fuel as explained in Section V.8

VI. CONCLUSION

SwRI appreciates the opportunity to provide this preproposal for SKF and looks forward to meeting your testing needs. If you have any questions or require further information, please contact Larry Eckhardt by telephone at (210) 522-2980 or Brent Shoffner at (210) 522-6986 or by fax at (210) 681-5344.

Submitted by:

Brent A. Shoffner

Brent Shoffner
Senior Research Engineer
Fleet and Field Evaluations Section

BAS/clm
cc: Lee Grant, SwRI
Steve Marty, SwRI
Larry Eckhardt, SwRI
Kevin Brunner, SwRI
Troy Nagy, SwRI
Norm Puttenmide, SwRI
James Chadwell, SwRI
Russell Watson, SwRI

Printout for JOHN S TURNER
11/14/2002

BShoffner@swri.edu on 11/14/2002 03:26:58 PM

To: john.s.turner@skf.com
cc: annette.vanhecke@swri.org, christine.mandiola@swri.org, kevin.brunner@swri.org, larry.eckhardt@swri.org, norman.patterson.de@swri.org, steven.marty@swri.org, troy.raggy@swri.org
Subject: Preproposal 08-FLRD-289A

The attached preproposal, 08-FLRD-289 revision A has the following differences from the original preproposal.

The vibration sensor and screen were eliminated from the program.
The left unitized hub from the previous evaluation will be installed during the unitized hub evaluation phase.
The mileage accumulation on the public road system with the conventional hub has been removed.
The VIN of the test vehicle has been added to the preproposal document.

Brent
(210) 522-6986

08-FLRD-289revA.pr

Customer: BEL INTL/[illegible] Claim #: 0331597 Mileage: _____

Vin#: _____ Hub Serial #: 13901-0331597

Customer Complaint: _____

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >2 grams: yes no Endplay: no yes if so ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

Circular witness marks on inner BRG cone faces: yes no In service date: _____ failed: _____

Comments: _____

Disposition: C.R. SEAL

Root cause: GRINDING SENT TO SKF 5/10/02
RIGHT HAND HUB Sent to SWRI 12 May

Customer: KENWORTH NORTHWEST Claim #: CWA 11068 Mileage: 239,253

Vin#: [illegible] Hub Serial #: 13000-0279171

Customer Complaint: LT HUB NOISY & LOOSE

Complete hub received: yes no Highly progressive incident: yes no Hammer used: yes no

Hub cap threads clean: yes no Wheel off: yes no

I/B seal purge >.5 grams: yes no O/B seal purge >2 grams: yes no Endplay: no yes if so ____

Smooth rotation: yes no seal drag acceptable: yes no Clip ring grooved: yes no

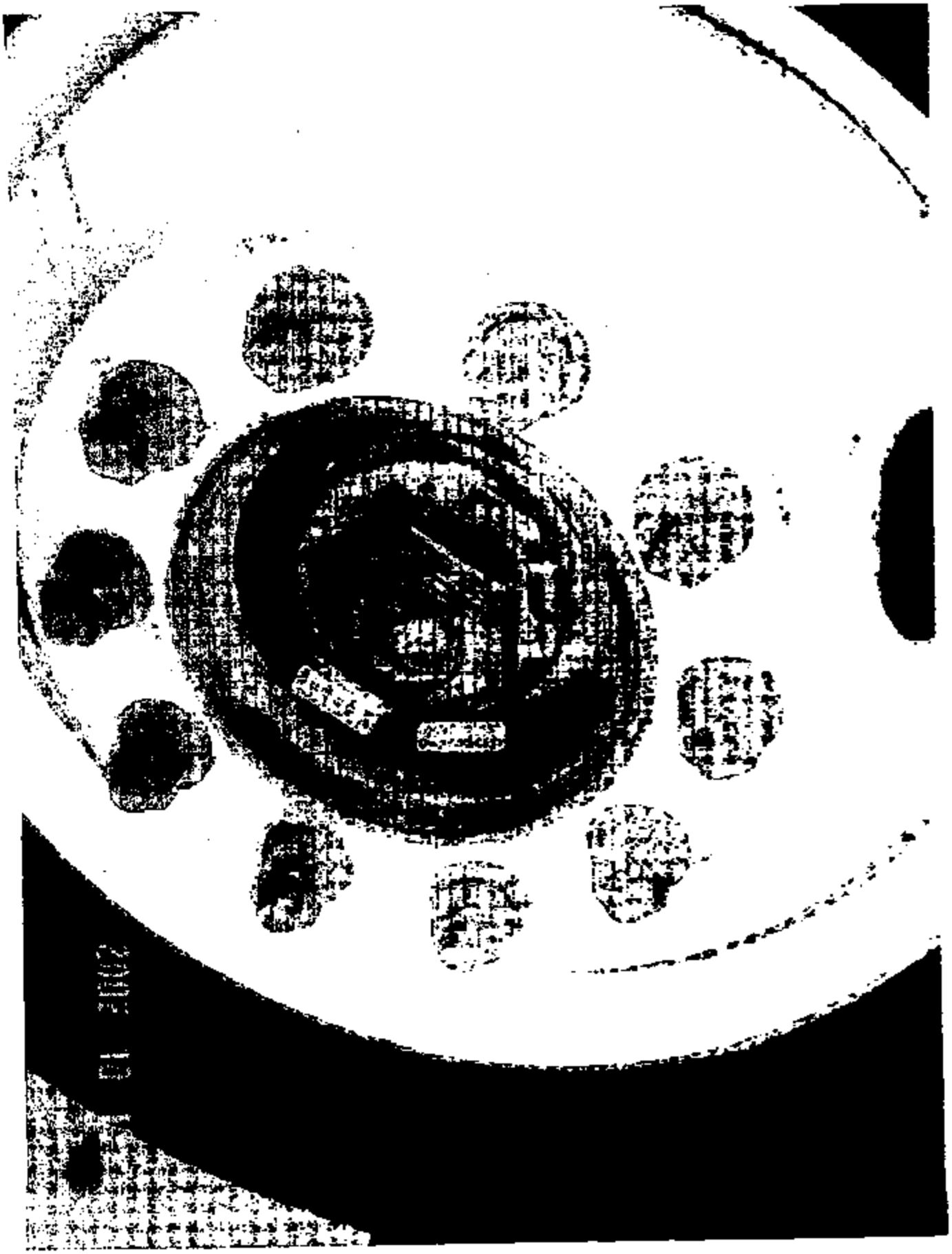
Circular witness marks on inner BRG cone faces: yes no In service date: [illegible] failed: [illegible]

Comments: _____

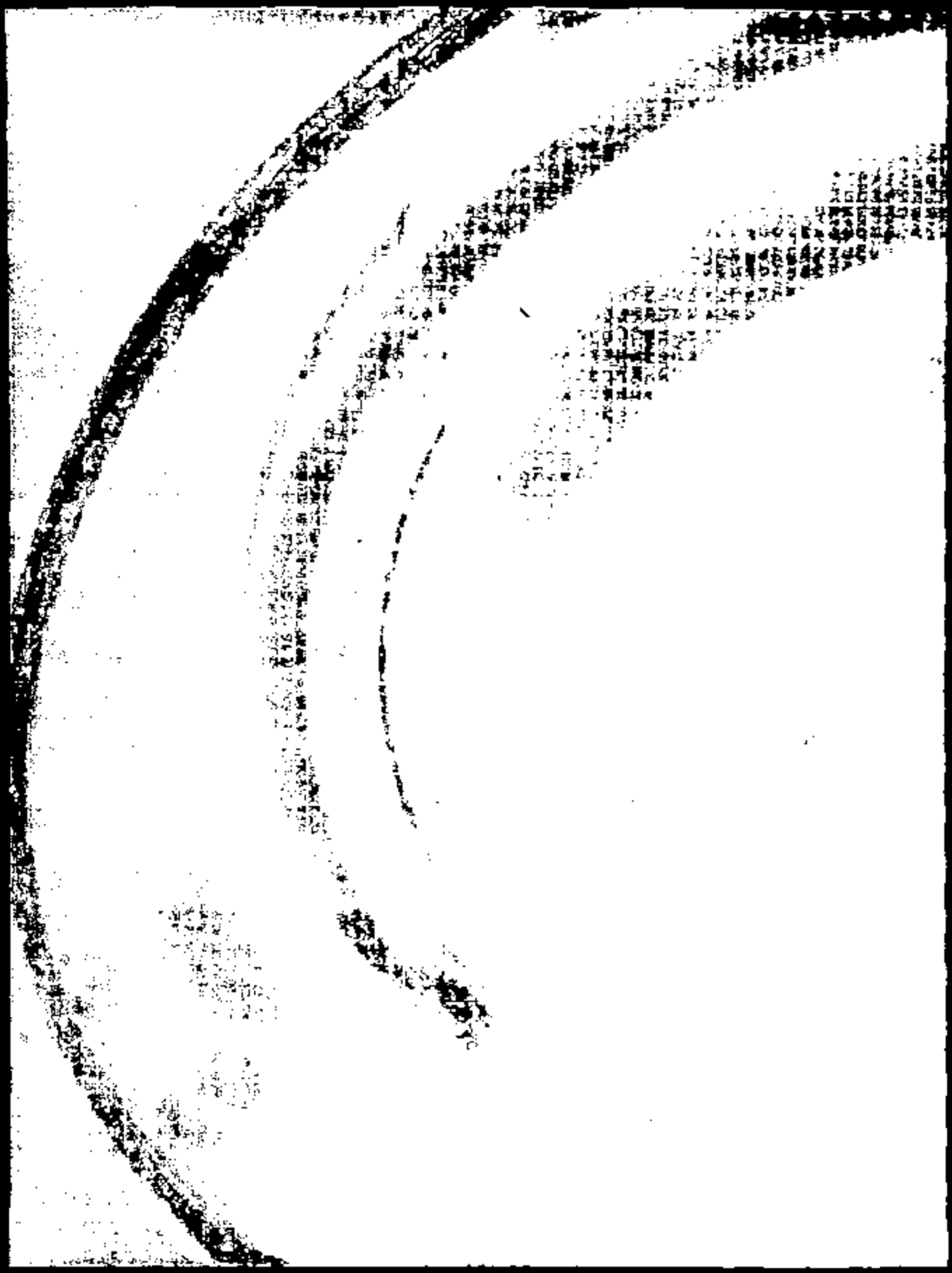
Disposition: C.R. SEAL

Root cause: GRINDING SENT TO SKF 5/10/02
LEFT HUB Sent to SWRI 12 May

SKF 32138



SKF 001106



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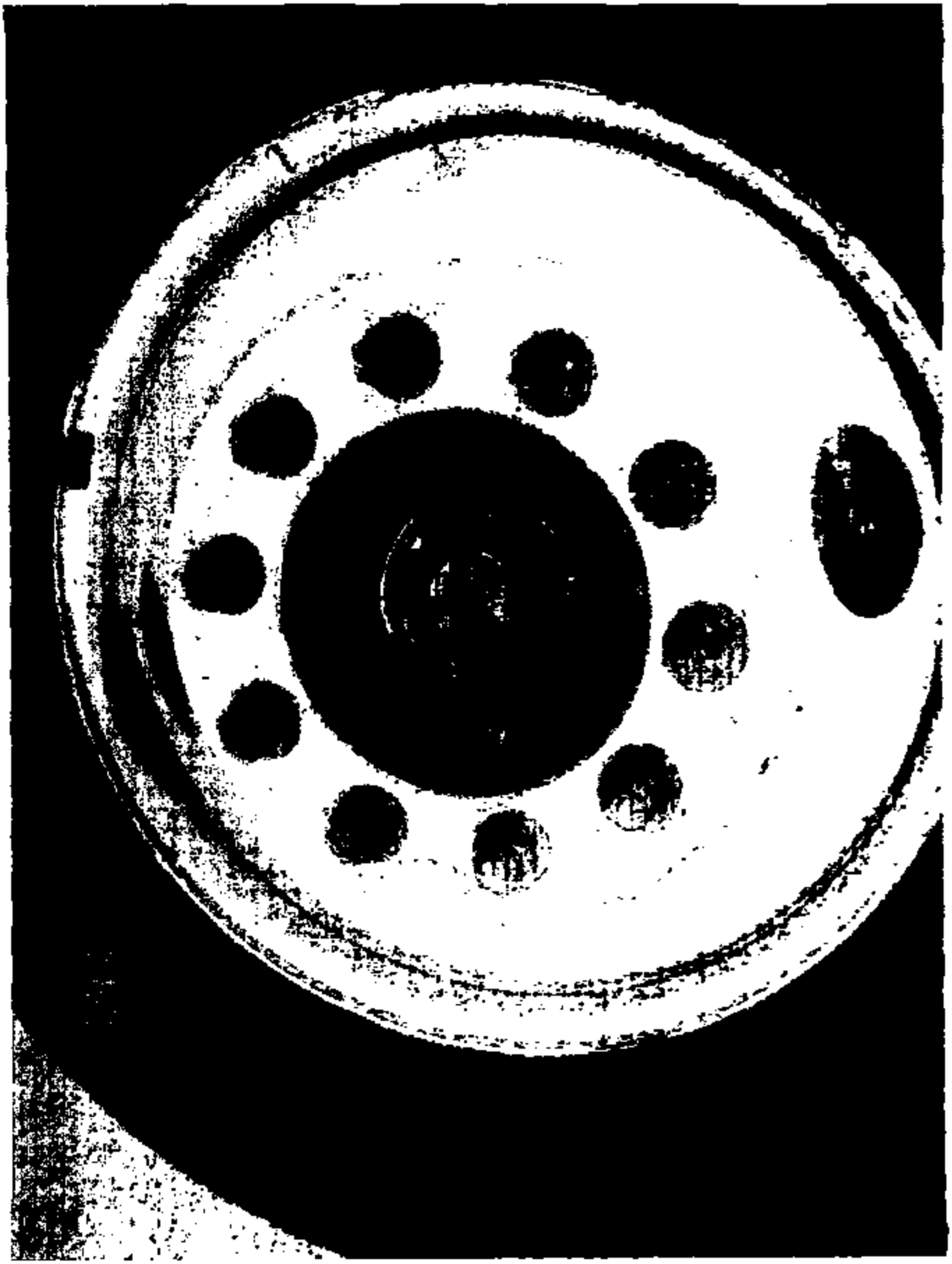
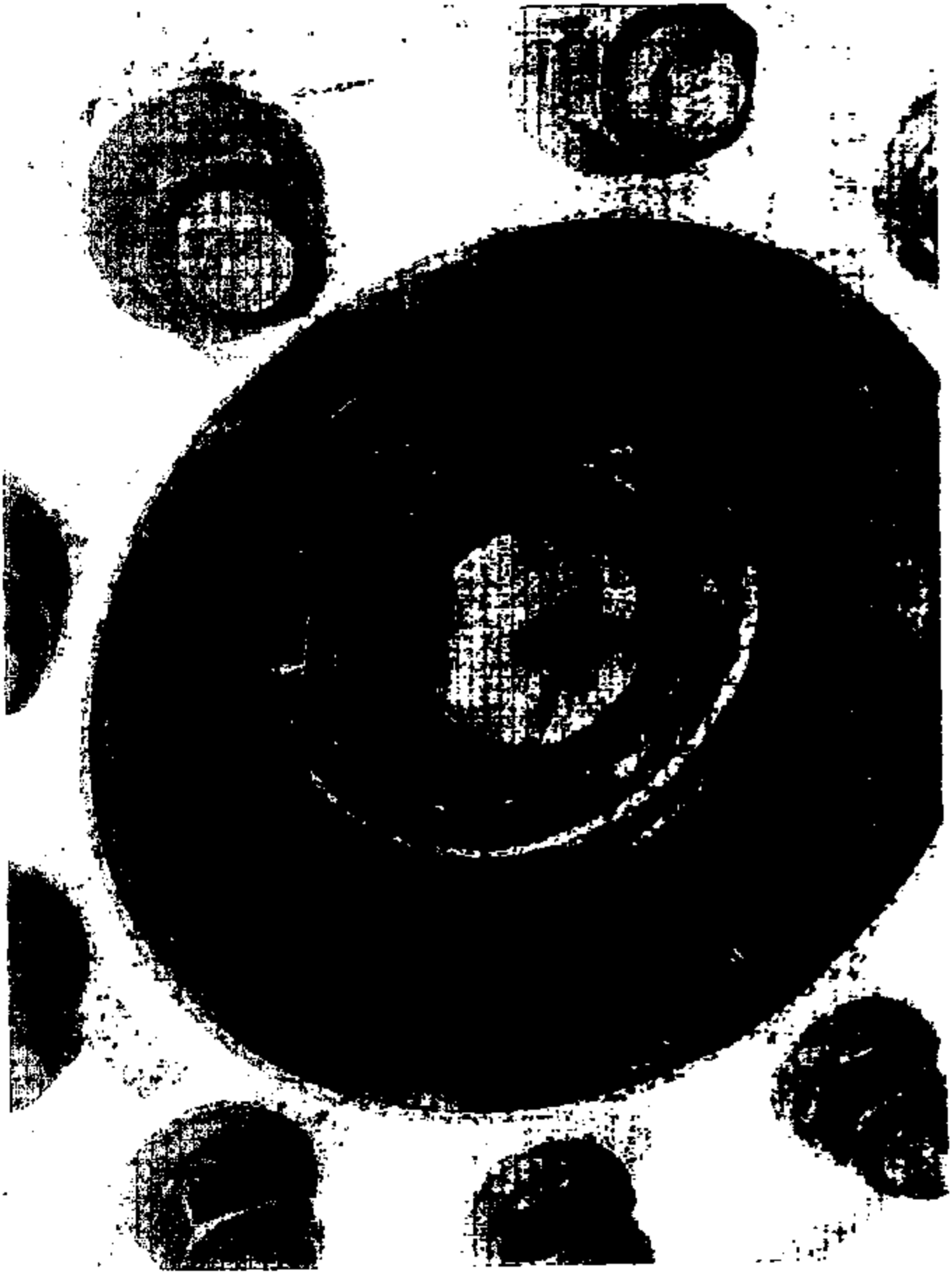
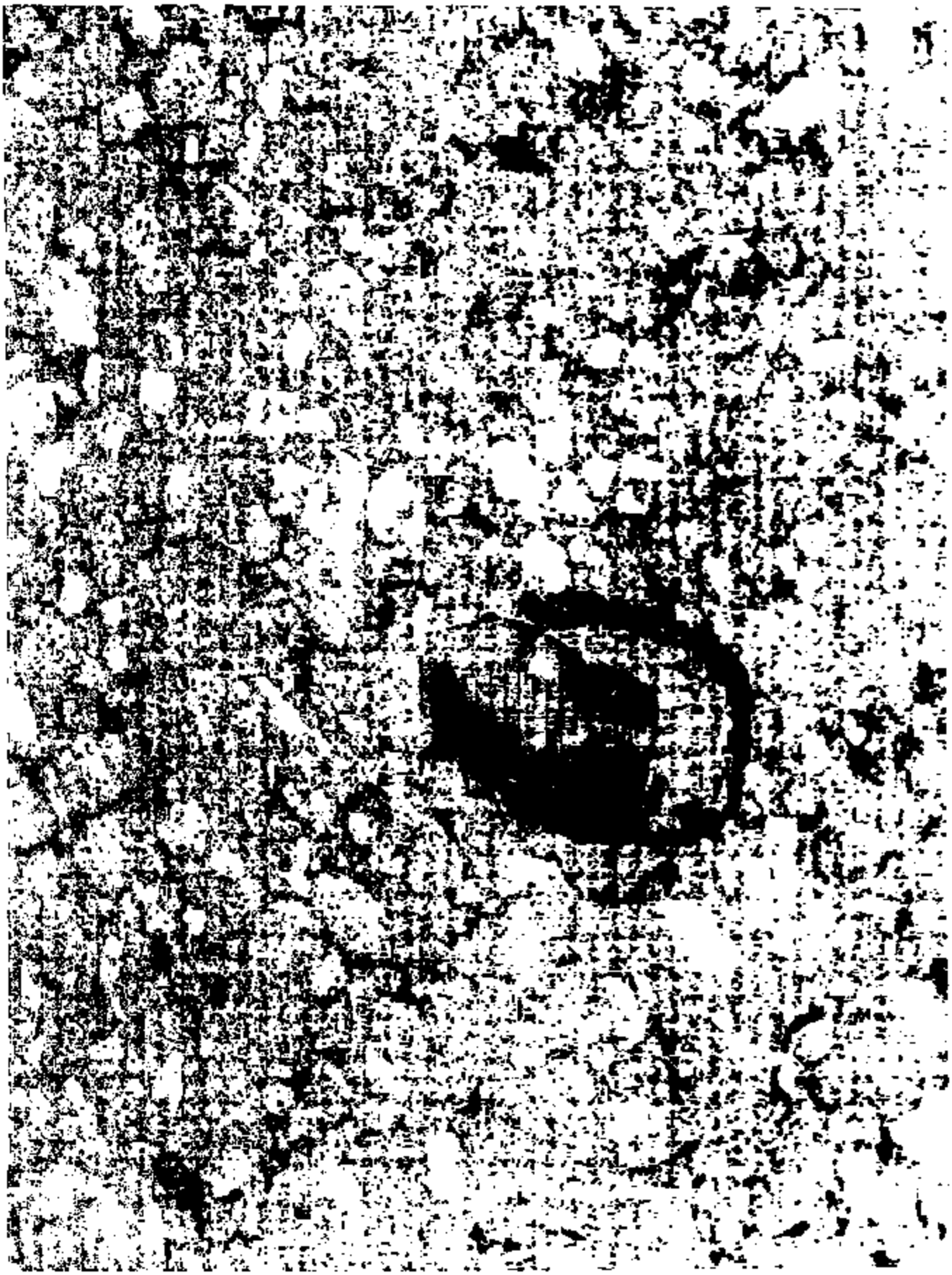


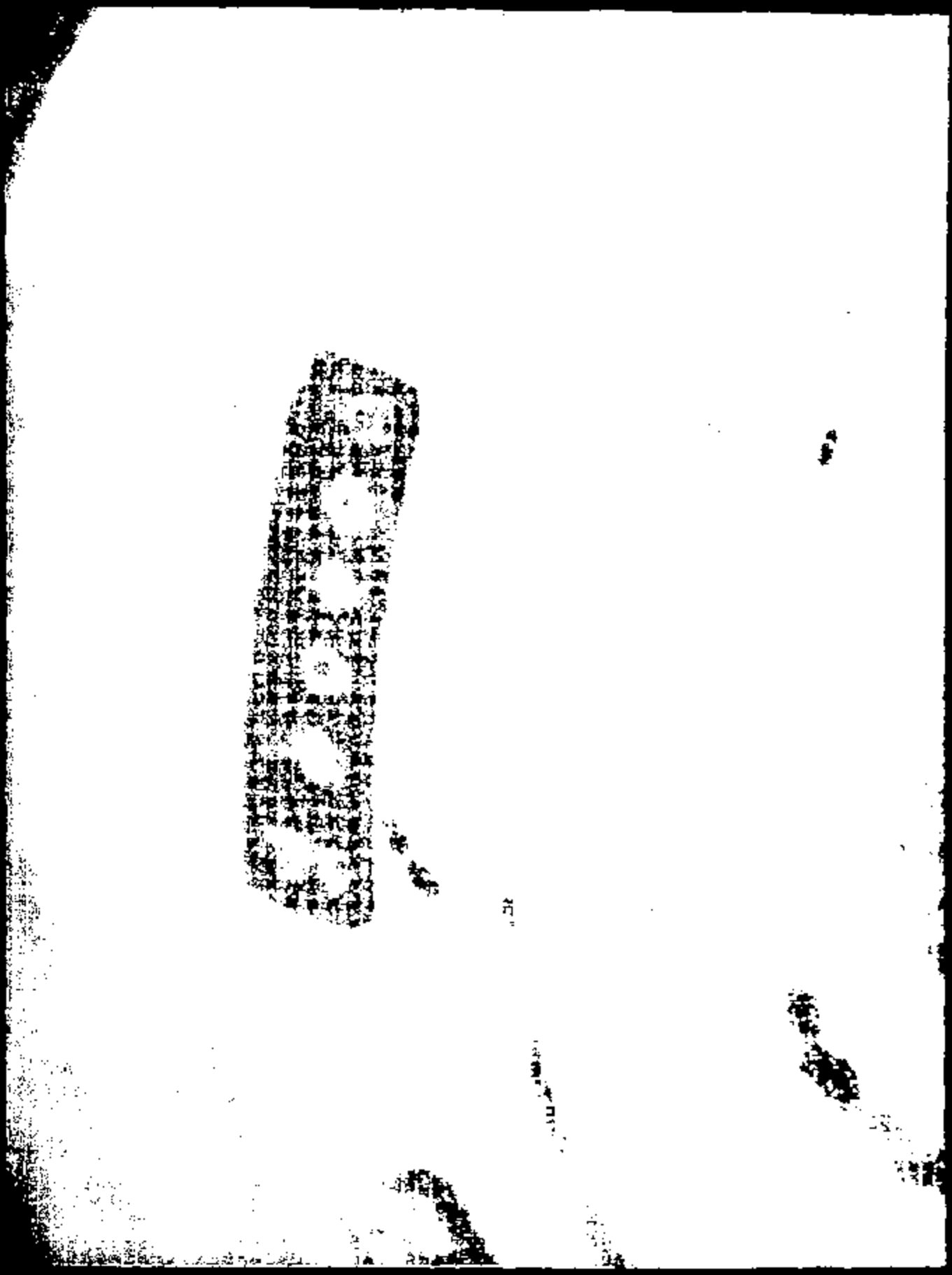
SKF 001109

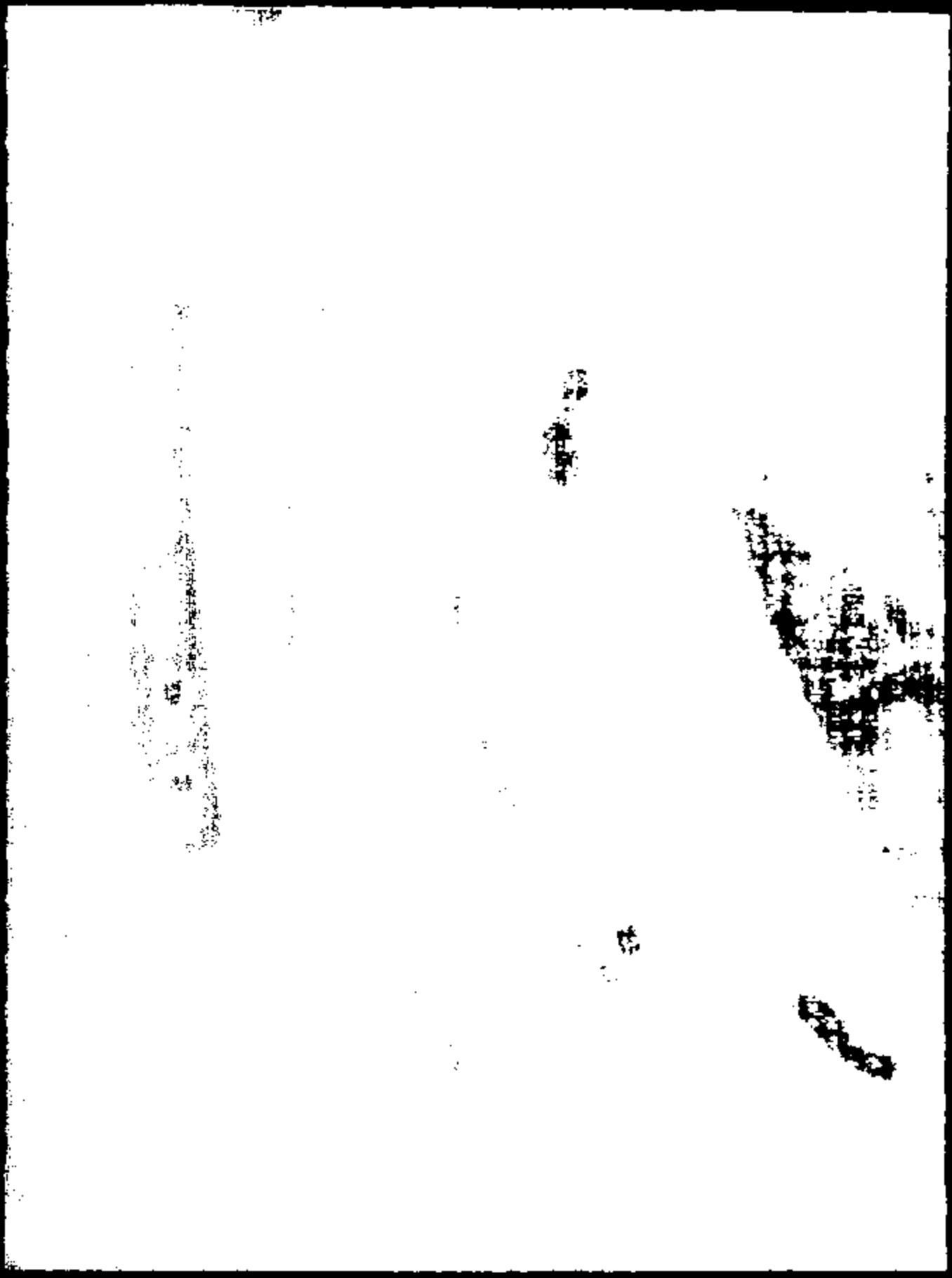


SKF 001110



SKF 001111





Printout for JOHN S TURNER
07/18/2002

BShoffner@swri.edu on 07/17/2002 06:14:47 PM

To: bruce.weeks@SKF.COM, john.s.turner@SKF.COM
cc: russell.watson@swri.org, robert.williams@swri.org, larry.eckhardt@swri.org, james.chadwell@swri.org, gene.dickinson@swri.org, gary.moreland@swri.org, fleetscheduling@swri.org, dons.seledon@swri.org, albert.olveda@swri.org
Subject: SKF Front Bearing Evaluation Program Status - 7/17/02

The bearings have 38,583 test miles as of 4:00 PM 7/16/02.
Please refer to the bearing end play spreadsheet.
Noise continues to be detected at both the left and right front bearings.
James believes that the right side exhibits more noise than last week.
However, no end play has been observed at either bearing.

The temperature strips were installed at 16,347 test miles on both the inside and outside of the hub caps. Since no end play has been exhibited at either bearing, the hub caps have not been removed. None of the 'outside' temperature strip ranges have changed color.

Graphs of the spindle and brake pad temperatures versus time are included in the attached spreadsheet for the test days of 07/10/02 through 07/16/02.

It has been raining more then it should in South Texas.
The daytime ambient temperatures have been in the 85-95F range.
The spindle temperatures have rarely gone over 140F.

John, I need authorization from SKF Purchasing to extend the test beyond 40,957 miles which could be achieved in 3 days.
The current purchase order value of $56K will cover that mileage.
If we have to stop the test to wait for contractual issues, SwRI will incur truck rental charges and probably lose some of our agency drivers.

Brent Shoffner and James Chadwell

Bearing_End_Play.xl 298716.xls

Stone Spindle ⊥ & Ra - 19 Aug 02

SKF 001120

Minutes from Teleconference 27 Jun 2000 @ 2:00
The next follow-up meeting is Wednesday, 09 Aug 1:00 to review the action items

Summary:

Started with 666 claims - 122 were recall: 29 were hub cap; 10 were tone ring issues; 5 are king pin issues; 3 broken studs; 2 policy; 1 fill plug leaking; 1 brake issue; 1 parking brake; 1 slack adjuster. - 403 parts remaining

Of the 403 remaining there were 4 main groups: Bearing Failure, seal leaks, endplay and unknown - 20 for noisy; 7 for run out 5 for hub cracked. The following minutes have been re-formatted to follow these four main categories with corrective actions for each.

From the SKF Database - of the 73 claims we found that 29 were a direct THU issue while the remaining 44 were other issues. From the data available we were only able to cross reference 29 parts between Meritor and SKF's databases.
Can Mike Vielette review SKF database to see if he can determine if the claims we have are elsewhere in the Meritor database (such as a king pin claim)? Tracked 29 parts that correlate between the two databases. SKF to give Meritor a spreadsheet containing the uncorrelated claims information COMPLETE – Jack McKenzie to send these claims to Mike Villette to see if correlations can be made. Mike Villette did add a list of OE VIN and customer claim numbers. **Jack McKenzie to follow up with Mike Vielette.**

Action Items:

BEARING FAILURE

To better understand this classification of failures, SKF needs to look at more parts. Jack Mckenzie to contact Robert (Rosey) Rosenthal to get all warranty parts back. COMPLETE Freightliner has abandoned the procedure of returning product. District Service Reps will be asked to get the parts back through the fleet or the dealer. This has begun to happen. SKF is reviewing parts at Troy approximately every 2 weeks and making disposition there.

Request geographical data input in to database in some fashion. Jack Mckenzie to follow-up with Mike Vielette. Follow-up with Mike 15 Jun, he hasn't had time to get to it yet. Jack McKenzie to follow up with Mike Vielette.

Bruce Weeks to go to Allentown to review all of the recall parts. SKF Germany to review the parts after the initial triage to find out more information.
Allentown visit complete, no excessive endplay was found, visual examination for grease leakage, disassembled and inspected for unusual condition. The majority looked good. Schweinfurt looked at 100+ and found issues with water leakage down spindle from knuckle and into bearing at cone small faces. This is also the source of frozen cones. Suggests better surface finish at bearing back up collar on spindle, or shoulder seal.
European designs use 15-20 microns perpendicularity and 0.8-1.0 micron surface finish of the bearing back-up, depending on size. Our recommendation is 15 micron perpendicularity and 0.6 surface finish. Meritor currently specifies 125 micro-inch (~3 micron) and spindle is a shrink fit into knuckle, perpendicularity number not known.

Bruce Weeks Outer ring grinding error - TER issued 02 Jun to Leuchow. Waiting for Corrective actions. A slight misunderstanding has delayed the answer.
Bruce Weeks to follow up with Luechow.

Bruce Weeks to induce a load of 10000 # to see if he can induce brinnelling to simulate load across rollers if not rotated during torque-up. 17,000# load used, scratches exhibited but not brinnell. Shouldn't brinnell until 45 k according to Beecon. Aiken could not measure any depth. It is safe to assume that non-rotation will not brinnell raceways, however the clearance after run-in issue still exists.

SEAL LEAKS

Bob Bondy - Talk to Paula Oakwood about publishing grease seepage standards with photos. Conversation started with Paula. Similar to TP9683 form. Samples of acceptable/unacceptable seepage taken from recall parts and ready for photography. Photographs are available for review, Bob Bondy has given them to Paula on floppy disc.

Bob Bondy - Talk to Paula Oakwood about communicating the replacement of missing hubcaps. We need to emphasize that the hubcap must be there. Conversation started with Paula. Hubcaps must be replaced if missing. It will be a hard sell to get the field to replace THU's that have had caps missing. We will need to review the OB seal robustness.

Bruce Weeks review the outboard seal design for robustness enhancement.
Schweinfurt and CR asked for recommendations.

A seal team is being formed to look all aspects of seal and seal material design. Investigations will begin with the inboard seal designs and our recent field experience. Results to date:

- Water ingress along spindle is a problem, causing rust in bores and some contaminant ingress at inner ring small side faces. May need shoulder seal arrangement.
- Some issues exist with seal installation cock. Looking into tooling, etc.
- Spindle deflection may be an issue, allowing water to enter by separation of inner rings under load.
- In general, Inboard R-Safe seal seems to be working well except in cold and wet climates.

ENDPLAY

Bruce Weeks - Consider changing wording of the service manual to indicate that no endplay is an acceptable condition. Reviewed and suggestions made 01 Jun. Recommend, "up to 2 grams is acceptable". On the slicker recommend grease purge. SKF to get back to Meritor with a reworded recommendation. Reworded recommendation submitted. **Martin Barila** to send draft copy of reworded manual to Bruce Weeks for review prior to publishing.

Bob Bondy & Martin Barila - Review spindle end sticker wording concerning endplay. Recommend changing the sticker to say, "do not adjust bearing" from "do not adjust bearing endplay". Change Rockwell to Meritor. Reworded sticker on its way to printer.

The above might best be considered distributed in a field service bulletin. We need to look at distribution out of service criteria as a technical bulletin & the technical service Manual.

Bruce Weeks Roller end distress study. Report from Schweinfurt states that these bearings were run with excess clearance. Each bearing is measured at the factory for slight pre-load condition. Hence the cause is from excess clearance due to low clamp load/no rotation at torque-up.

Bob Bondy – To find out if SKF has a documented a position to Monitor regarding the rotation of wheel ends while the hub is being torqued down. None was found in our files. SKF to consider final recommendation for torque-up procedure. Arden is currently rotating during torque up to 150-250 ft-lbs, then loosening, then torquing to 700 ft-lbs. Bruce Weeks to draft torque up procedure. SKF prefers continuous rotation during a single step torque-up. However we recognize the need to work with Arden to develop a procedure that they can work with. Arden is currently looking at a torque-up machine that rotates as it tightens. Bruce Weeks to supply number of rotations required to seat bearings properly.

UNKNOWN

Jack Mckenzie - Mike Villette to add OE claim number, VIN, Dealer location to the database and send to Bruce Weeks. Bruce Weeks to break the information down geographically and to further look for correlations with SKF's database. Bruce will also try to identify high probability fleets or locations. Fleet/dealer info is insufficient to determine target fleet for visit. Geographical data not yet available from Mike Violette.

SKF to receive a Database by month by OEM % of Sales by OEM vs. claims/sales will be evaluated.

FF-891 Sales per quarter

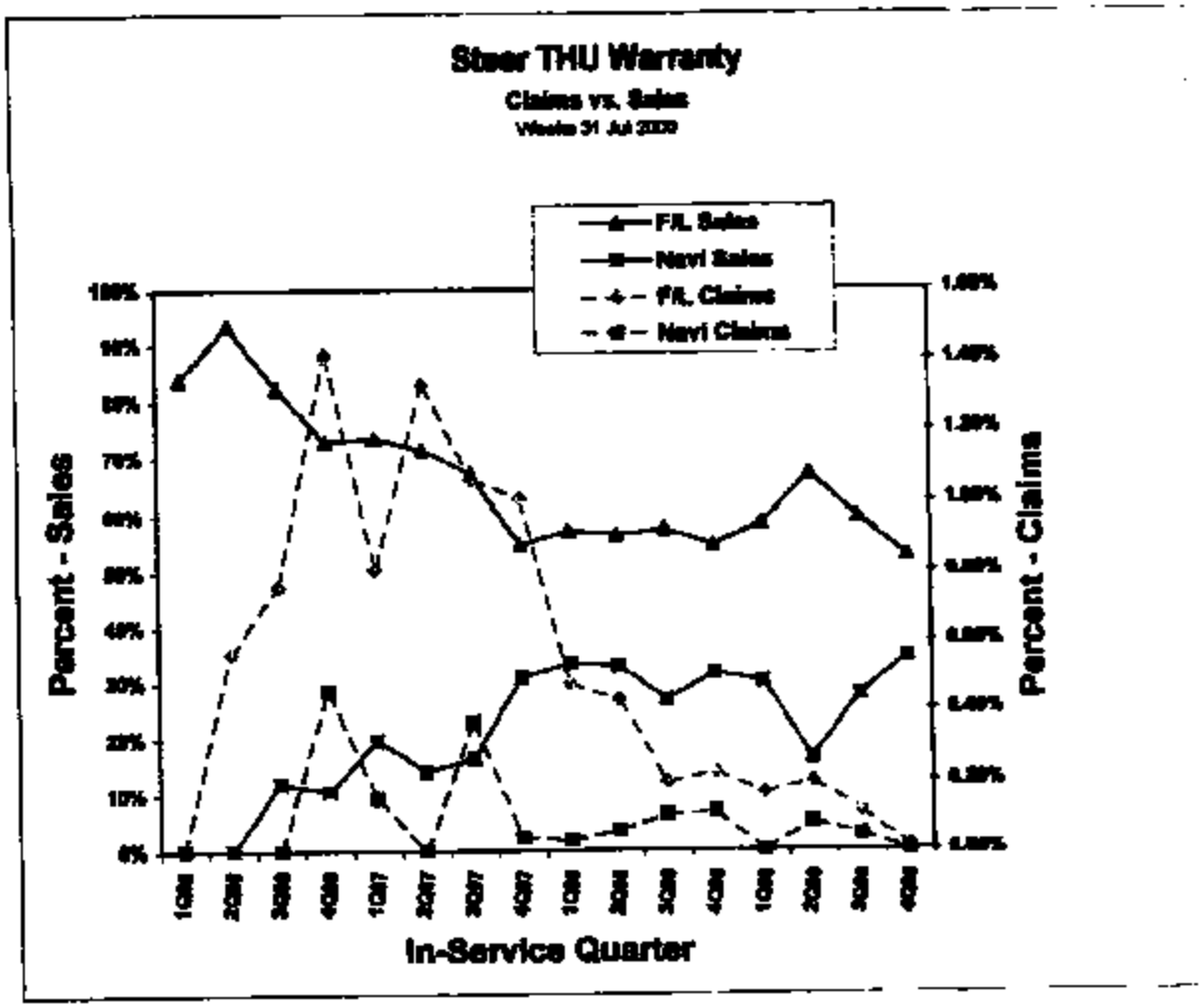
	1996				1997				1998				1999				Totals	Percent
OEM/Qtr	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4		
Frtlnr	186	667	2103	1498	2466	3858	4427	4464	5442	5680	6071	6185	6424	6528	6786	6868	78875	60.66%
Navistar			314	216	661	794	1697	2308	3173	3347	3643	3688	4035	2391	4084	4514	35869	28.38%
Mack			18	96	28	438	486	721	433	587	1080	872	880	1284	884	484	8362	6.61%
Peterbilt			82	76	116	132	168	83	96	82	163	137	187	276	96	127	1713	1.35%
West Str			2			1	26	5	2			3	4		1	5	47	0.04%
Volvo			14	26	15	106	360	248	272	307	338	236	531	677	721	987	4758	3.76%
Kenwrth	36	62	66	128	68	96	67	84	96	88	127	175	43	92	84	94	1275	1.01%
																	126798	

THU Warranty Claims per quarter

	1996				1997				1998				1999				Totals	Percent
OEM/Qtr	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4		
Frtlnr		5	16	21	26	52	47	46	26	24	12	14	14	19	10	1	326	83.38%
Navistar				1	1		4	1	1	2	3	4		3	3		21	5.37%
Mack					2	1	3			1	1		1				9	2.30%
Peterbilt				1	3	7	3	1		2							17	4.35%
West Str																	0	0.00%
Volvo													1			1	2	0.51%
Kenwrth			3		1	1			7		1			1	3		16	4.09%
																	391	

THU Warranty Claims vs. Sales, Percent

	1996				1997				1998				1999			
	1Q96	2Q96	3Q96	4Q96	1Q97	2Q97	3Q97	4Q97	1Q98	2Q98	3Q98	4Q98	1Q99	2Q99	3Q99	4Q99
F/L Claims	0.08	0.59	0.74	1.41	0.81	1.32	1.08	1.01	0.48	0.43	0.20	0.23	0.17	0.20	3.11	2.91
Navi Claims			0.00	0.48	0.18	0.00	0.37	0.04	0.03	0.08	0.11	0.11	0.08	0.08	3.08	3.00
F/L Sales	83.90	95.47	82.24	73.09	73.72	71.49	67.25	54.98	57.42	56.68	57.54	54.88	58.81	67.14	58.66	53.08
Navi Sales	0.08	0.08	12.28	10.77	18.74	14.48	16.61	30.88	33.44	32.61	28.88	31.62	30.14	16.57	27.78	34.88



Bruce Weeks to contact R. Rosenthal to find out if a visit is worthwhile at Okanogan transport so that more information on their application can be evaluated. - Okanogan had several claims.
7 Total trucks with FF-981's
10 claims – 1 is a repeat.
They are not buying any more trucks with FF-981's, they are not a Meritor fleet user. A visit is moot.

MISCELLANEOUS

Bruce Weeks / Bill Savacool to Review all GWZ field test samples in the field through Jack Worrall. Knight w/o 19 Jun, HO Wolding w/o 12 Jun. Phone Mails have been exchanged. Knight parts will be retrieved and inspected. After one year we do not expect to see anything more than infant failures and seal issues. Bearing design issues would not show up for 2-3 years more. Jack McKenzie to follow up with Jack Worrall on return of Knight and Transphos test parts for SKF review.

- **Fretting Corrosion Issues**

Mike Lewis to forward a report on the best anti fretting compound that SKF recommends. Jack Mckenzie to talk to Meritor Chemists to identify the residuals on the bearing bore spindle. Molykote D is recommended by SKF. Mike Lewis to provide a name and contact at Dow Corning. Meritor to provide a cost only study. Asheville has request in system AVE-618. Must be cost justified on a warranty reduction cost/unit basis for seizing to spindle.

Bruce Weeks identify worst-case parts for further analysis during triage in Allentown for fretting. Parts are in NATC for SCH review 06-09 Jun. Samples are being taken for analysis. Tim Chu is following through SKF Chem Lab. Need to be certain that anti-fretting compounds are compatible with GW-Z.

Bob Bondy to provide a shoulder seal quote for the steer axle. Contacted Schweinfurt – waiting for reply. $ 1.29 + installation ballpark price given. Bob Bondy to complete price quote with installation cost.

- **Wheel Guard Issues**

Jack Mckenzie to find out if wheel guards were installed on Freightliner cracked hubs; is the material still available? Did the field representative look at the parts? Jack Mckenzie to work with Tony Moore - Julian date codes can be obtained off of the hubs. Jack McKenzie to follow up with Freightliner on VIN's to see how these trucks were equipped from them. Only one of the 5 claims were verified by Meritor personnel. Accuride recommends re-torques at 50-100 miles and every 10,000 miles thereafter.

- **Hub Cap Issues**

Martin Barile - Consider marking the hubcap to say, " Torque to 350 ft lbs". Drawing changed, tooling to be changed. Underway now.

- **Other Issues**

Bruce Weeks to compare and contrast RVI vs. FF981 application configuration
Testing was done at the Bosch Proving Grounds. Issues were:

- **Calithea grease egress from the R-Safe seal, which was solved by reducing the amount and increasing the stiffness of the grease by using Paragon EP2. They also went back to the F-NOK IB seal for now. GW-Z is approved for use.**
- **Water ingress through hub cap O-Ring solved by better handling at installation.**

Differences are:

FF-981	**RVI**
13,200 # load rating	**6 metric tonne**
Full flange wheel mounting	**Small flange with wheel/brake adapter**
Drum brake	**Disc brake (90%)**
Bore size 65 mm	**70 mm**
Outboard seal	**No outboard seal**
Screw in hub cap	**Hub cap retained by wheel adapter**
GW-Z	**Paragon EP2 (lead base)**
IB seal more protected	**IB seal more exposed to elements**

- **Stamped Tone Ring**

M. Barila to send model of redesigned knuckle to B. Weeks for Schweinfurt review.

B. Weeks to obtain model of hub with stamped tone ring to M. Barila. - **COMPLETE**

Minutes from Teleconference 26 Jun 2000 @ 2:00
The next follow-up meeting is Tuesday, 27 July 2:00 to review the action items

Summary:

Started with 588 claims - 122 were recall: 29 were hub cap; 10 were tone ring issues; 5 are king pin issues; 3 broken studs; 2 policy; 1 fill plug leaking; 1 brake issue; 1 parking brake; 1 slack adjuster. - 403 parts remaining

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Action Items:

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spindle deflection

Bruce Weeks Outer ring grinding error - TER issued 02 Jun to Leuchow. Waiting for Corrective actions. **Bruce Weeks to follow up with Luechow.**

Bruce Weeks to submit the corrective Action to Wayne Hagar on parts (2 each) that were identified to have un-hardened raceways. **COMPLETE** - Submitted to Wayne 30 May.

Bruce Weeks to induce a load of 10000 # to see if he can induce brinnelling to simulate load across rollers if not rotated during torque-up. 17,000# load used, scratches exhibited but not brinnell. Shouldn't brinnell until 45 k according to Beacon. Allen could not measure any depth. It is safe to assume that non-rotation will not brinnell raceways, however the clearance after run-in issue still exists.

SEAL LEAKS

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UNKNOWN

Bruce Weeks - to revise infant failures and break down by in service quarter
Complete – See separate graph. Trend lines for infant failures tend to follow all claims

Jack Mckenzie - Mike Villette to add OE claim number, VIN, Dealer location to the database and send to Bruce Weeks. Bruce Weeks to break the information down geographically and to further look for correlations with SKF's database. Bruce will also try to identify high probability fleets or locations. Fleet/dealer info is insufficient to determine target fleet for visit. Geographical data not yet available from Mike Vialette.

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FF-001 Sales per quarter

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OEM/Qtr	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4		
Peterbilt	195	867	2102	1466	2488	3928	4457	4484	5442	6890	6071	5166	6484	6926	4788	6808	76575	60.88%
Navistar			314	216	851	794	1050	2505	3173	3943	3943	3588	4556	2251	4084	4514	33980	26.58%
Mack			16	95	26	459	446	731	439	997	1080	977	880	1384	898	484	8382	6.61%
Pitbit			58	75	116	139	139	96	96	66	103	137	161	278	96	122	1713	1.36%
West Sty			2			1	24	5	2			3	4		1	5	47	0.04%
Volvo			16	28	16	106	388	946	272	357	335	288	581	672	721	907	4768	3.79%
Kenwth	36	49	66	109	60	94	60	84	56	66	129	176	43	88	84	84	1278	1.01%
																	125733	

TRU Warranty Claims per quarter

	1996				1997				1998				1999				Totals	Percent
OEM/Qtr	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4		
Peterbilt		5	15	27	29	58	47	45	29	24	15	14	14	19	10	1	328	83.38%
Navistar				1	1		4	5	1	2	3	4		2	2		21	5.37%
Mack					2	1	3			1	1		1				9	2.30%
Pitbit				1	3	7	3	1		2							17	4.35%
West Sty																	0	0.00%
Volvo													1			1	2	0.51%
Kenwth			3		1	1			7		1			1	2		16	4.09%
																	391	

Plot PL & Navi on graph

Bruce Weeks to contact R. Rosenthal to find out if a visit is worthwhile at Okanogan transport so that more information on their application can be evaluated. - Okanogan had several claims. E-mail request 29 May – 06 Jun no response yet.
Bruce Weeks to Follow-up. May not be worthwhile, as Okanogan may not have any more trucks with FF-981's. 23 Jun no response yet. Bruce Weeks to follow up, is Okanogan a fleet we should be testing at? Denny Metcher - Fld Rep @ Okanogan
7 trucks in 1997 Waste of our time to visit - They won't buy anymore

MISCELLANEOUS

Bruce Weeks / Bill Savacool to Review all GWZ field test samples in the field through Jack Worrall. Knight w/o 19 Jun, HO Wolding w/o 12 Jun. Phone Mails have been exchanged. Knight parts will be retrieved and inspected. After one year we do not expect to see anything more than infant failures and seal issues. Bearing design issues would not show up for 2-3 years more. Bruce Weeks to e-mail request to Jack McKenzie to retrieve test hubs from Transphoe as well.

- **Fretting Corrosion Issues**

Mike Lewis to forward a report on the best anti fretting compound that SKF recommends. Jack McKenzie to talk to Meritor Chemists to identify the residuals on the bearing bore spindle. Molykote D is recommended by SKF. Mike Lewis to provide a name and contact at Dow Corning. Meritor to provide a cost only study. Asheville has request in system AVE-518.
$ must justify - cost/unit for sticking issue
Bruce Weeks identify worst-case parts for further analysis during triage in Allentown for fretting. Parts are in NATC for SCH review 06-08 Jun. Samples are being taken for analysis. Tim Chu is following through SKF Chem Lab. Need to push - Degradation of grease by fretting compound - & never siege [illegible] & GWZ

Bob Bondy to provide a shoulder seal quote for the steer axle. Contacted Schweinfurt - waiting for reply. $ 1.29 + installation ballpark price given. Bob Bondy to complete price quote with installation cost.

- **Wheel Guard Issues**

Jack McKenzie to find out if wheel guards were installed on Freightliner cracked hubs; is the material still available? Did the field representative look at the parts? Jack McKenzie to work with Tony Moore - Julian date codes can be obtained off of the hubs. Jack McKenzie to follow up with Freightliner on VIN's to see how these trucks were equipped from them. A meeting at Accuride by SKF and Meritor is scheduled for 12 Jul at 11:00 AM.
No word from Jack yet - only one of 5 were confirmed by minor reps —

- **Hub Cap Issues**

Martin Barila - Consider marking the hubcap to say, " Torque to 350 ft.lbs". Drawing changed, tooling to be changed.

underway now —

- **Other Issues**

Bruce Weeks to compare and contrast RVI vs. FF981 application configuration
Testing was done at the Bosch Proving Grounds. Issues were:

- **Calithea grease egress from the R-Safe seal, which was solved by reducing the amount and increasing the stiffness of the grease by using Paragon EP2. They also went back to the F-NOK IB seal for now. GW-Z is approved for use.**
- **Water ingress through hub cap O-Ring solved by better handling at installation.**

Differences are:

FF-981	**RVI**
13,200 # load rating	**8 metric tonne**
Full flange wheel mounting	**Small flange with wheel/brake adapter**
Drum brake	**Disc brake (90%)**
Bore size 65 mm	**70 mm**
Outboard seal	**No outboard seal**
Screw in hub cap	**Hub cap retained by wheel adapter**
Paragon EP2 (lead base)	**GW-Z**
IB seal more protected	**IB seal more exposed to elements**

- **Stamped Tone Ring**

M. Barila to send model of redesigned knuckle to B. Weeks for Schweinfurt review

B. Weeks to obtain model of hub with stamped tone ring to M. Barila. - **COMPLETE**

"Dancing" with knuckle suppliers

08 Jan 2000 Minutes
23 Jan 2000
update of A/I

Summary: 2000

The next follow-up meeting is Tuesday, July 27 from 2:00 - 4:30 to review the action items Teleconference.

Started with 588 claims - 122 were recall: 29 were hub cap; 10 were lone ring issues; 5 are king pin issues; 3 broken studs; 2 policy; 1 fill plug leaking; 1 brake issue; 1 parking brake; 1 slack adjuster. - 403 parts remaining

Of the 403 remaining there were 4 main groups: Bearing Failure, seal leaks, end play and unknown - 20 for noisy; 7 for run out 5 for hub cracked.

From the SKF Database - of the 73 claims we found that 29 were a direct THU issue while the remaining 44 were other issues. From the data available we were only able to cross reference ~~15~~ 29 parts between Meritor and SKF's databases.
Can Mike Villette review SKF database to see if he can determine if the claims we have are elsewhere in the Meritor database (such as a king pin claim)? Tracked 29 parts that correlate between the two databases. SKF to give Meritor a spreadsheet containing the uncorrelated claims information– Jack McKenzie to send these claims to Mike Villette to see if correlations can be made. Mike Villette did add a list of OE VIN and customer claim numbers.

Action Items:

- **Further Analysis of the Database**

Bruce Weeks - to revise infant failures and break down by in service quarter
Complete – See separate graph. Trend lines for infant failures tend to follow all claims

Jack Mckenzie - Mike Villette add OE claim number, VIN, Dealer location to the data base and send to Bruce Weeks. Bruce Weeks to break the information down geographically and to further look for correlation's with SKF's database. Bruce will also try to identify high probability fleets or locations.
Request geographical data input in to database in some fashion. Jack Mckenzie to follow-up with Mike Villette. Follow-up with Mike 15 Jun, he hasn't had time to get to it yet.

- **Further investigation**

To better understand these various classifications of failures, we need to look at more parts Jack Mckenzie to contact Bill Poznak to see if there are any Navistar claims with parts. Poznak indicated that warranty parts are forwarded to Fort Wayne. At that warranty review, the disposition is not made – they simply forward the claim to Meritor within 2-3 days. There aren't a lot of Navistar claims. There is no value for SKF to go to Navistar. Parts are on their way to Troy from Navistar, SKF to review when they arrive.

SKF to receive a Database by month by OEM % of Sales by OEM vs claims/sales will be evaluated. Need the volume/quarter for each OEM. Follow-up with Mike 15 Jun, he hasn't had time to get to it yet.

Jack Mckenzie to contact Robert (Rosey) Rosenthal to get all warranty parts back . Complete – Freightliner has abandoned the procedure of returning product. District Service Reps will be asked to get the parts back through the fleet or the dealer. Average for all claims is they are paid within 48 days. All dealers agree to keep the parts for at least 30 days to get paid.

Jack Mckenzie to find out if wheel guards were installed on Freightliner cracked hubs; is the material still available? Did the field representative look at the parts? Jack Mckenzie to work with Tony Moore - Julian date codes can be obtained off of the hubs.

Bruce Weeks to go to Allentown to review all of the recall parts. SKF Germany to review the parts after the initial triage to find out more information.
Allentown visit complete, parts are at NATC, SCH coming to review 06-08 Jun. See separate notes. Evaluated 230 parts - returned 106 to NATC that had mileages noted plus 27 other pieces were sent back for further investigation – no excessive endplay was found, visual examination for grease leakage, disassembled and inspected for unusual condition. The majority looked good. Pieces at NATC are being reviewed by Schweinfurt personnel. Schweinfurt looked at 100+ and found issues with water leakage down spindle from knuckle and into bearing at cone small faces. This is also the source of frozen cones. Suggests better surface finish at bearing back up collar on spindle or shoulder seal.

Bruce Weeks to contact R. Rosenthal to find out if a visit is worthwhile at Okanogan transport so that more information on their application can be evaluated. - Okanogan had several claims. E-mail request 29 May – 06 Jun no response yet.
Bruce Weeks to Follow-up. May not be worth while as Okanogan may not have any more trucks with FF-881's. 23 Jun no response yet.

Bruce Weeks / Bill Savacool to Review all GWZ field test samples in the field through Jack Worrall. Knight w/o 19 Jun, HO Welding w/o 12 Jun. Phone Mails have been exchanged. Knight parts will be retrieved and inspected. After one year we do not expect to see anything more than infant failures and seal issues. Bearing design issues would not show up for 2-3 years more.

- Causes and Corrective Actions Required

Bruce Weeks Roller end distress study to be followed up with Leuchow to determine root cause with corrective action. Rollers measured by Glasgow found to be mid within spec. Inner ring measured in Allen found to be OK to print. Dimensionally, parts are in specification. There is concern that the parts had some wear at the high end. Flange – ok , Roller ok but had wear, We're progressing with the analysis. May be from excess clearance from low clamp load/no rotation at torque-up. Schweinfurt has parts in their labs for further analysis.

Bruce Weeks Outer ring grinding error - corrective action required from Leuchow. TER to be issued. TER issued 02 Jun. Waiting for Corrective actions.

Bruce Weeks to submit the corrective Action to Wayne Hagar on parts (2 each) that were identified to have un-hardened raceways. Submitted to Wayne 30 May.

- Fretting Corrosion Issues

Mike Lewis to forward a report on the best anti fretting compound that SKF recommends. Jack Mclenzie to talk to Meritor Chemists to identify the residuals on the bearing bore spindle. Molykoyte D is recommended by SKF. Mike Lewis to provide a name and contact at Dow Corning. Meritor to provide a cost only study.

Bruce Weeks identify worst case parts for further analysis during triage in Allentown for fretting. Parts are in NATC for SCH review 06-08 Jun. Samples are being taken for analysis.

Bob Bondy to provide a shoulder seal quote for the steer axle. . Contacted Schweinfurt – waiting for reply. $ 1.29 + installation ballpark price given.

- Field Education

Bob Bondy - Talk to Paula Oakwood about publishing grease seepage standards with photos. Conversation started with Paula. Similar to TP9683 form. Samples of acceptable/unacceptable seepage taken from recall parts and ready for photography.

Bob Bondy - Talk to Paula Oakwood about communicating the replacement of missing hub caps. We need to emphasize that the hub cap must be there. Conversation started with Paula. Hub caps must be replaced if missing.

Bruce Weeks - Consider changing wording of the service manual to indicate that no end play is an acceptable condition. Reviewed and suggestions made 01 Jun. Recommend "up to 2 grams is acceptable". On the sticker recommend grease purge. SKF to get back to Meritor with a reworded recommendation. Reworded recommendation submitted.

Bob Bondy & Martin Barila - Review spindle end sticker wording concerning end play. Not completed. Recommend changing the sticker to say "do not adjust bearing" from "do not adjust bearing endplay". Change Rockwell to Meritor

The above might best be considered distributed in a field service bulletin. We need to look at distribution out of service criteria as a technical bulletin & the technical service Manual.

- Miscellaneous

Martin Barila - Consider marking the hub cap to say " torque to 350 ft.lbs"

Bruce Weeks to compare and contrast RVI vs. FF981 application configuration
Not complete. Bob Bondy has some information.

Bruce Weeks review the outboard seal design for robustness enhancement.
Not complete. Schweinfurt and CR asked for recommendations.

Bruce Weeks to induce a load of 10000 # to see if he can induce brinnelling

17,000# load used, scratches exhibited but not brinnell, parts are on their way to Alken for measurement of depth. Shouldn't brinnell until 45 k according to Beacon. Alken could not measure any depth, NATC will use shadow graph.

Bob Bondy – To find out if SKF has a documented a position to Meritor regarding the rotation of wheel ends while the hub is being torqued down.
Meritor has Revised shop instructions to read that the hub is to be rotated while being torqued down to 100 ft-lbs. Then loosened, and torqued to final spec. This is because their torquing equipment works better if starting from 0 torque. SKF to consider final recommendation for torque-up procedure.

7-Step Corrective Action.

7-Step Initiator/Team Leader: Christopher Jones	**Phone:**(803) 663-8652 **Fax:**(803) 663-8611	**Status** Closed
Supplier: SKF USA Inc.	**Supplier Code:** 77249	**Issue Date** 04/09/02
Location: SKF Automotive / Aiken 1084 International Pl. Graniteville, SC 29829	**Date of Occurrence:** 01/10/02	**Date Closed** 07/18/02
Part No.& Description: BTF-0065	**Source of Complaint:** ArvinMeritor	**NIC Ticket Number**
Line Affected: FF-961 Easy Steer non-drive front axle		**Referral Number:** AK0ZTHU003

7D Team: Chris Jones - SKF Quality Assurance Manager, Mario Winkler - SKF Channel manager Kevin Cannon SKF Quality Engineer, Mike Lewis - Manager Truck Application Engineering, Bruce Weeks - Project Manager Application Engineering, Robert Bondy - Senior National Account Manager. William J Farrell - Chicago Rawhide – Sales, Roy Cinqurgrani - Chicago Rawhide Quality Control Manager, Bill Tubbs - Chicago Rawhide Quality Analyst, David Simms - Chicago Rawhide Senior Heavy Duty Application Engineer

1. Problem Description

ArvinMeritor contacted NATC in Detroit to report early failures concerning BTF-0065 units. Preliminary indication was failures were related to inboard seal flaws. Failed units serial numbers, manufacture dates, and the truck mileage are listed below:

Serial No.	Manufacturing Date	Mileage
0312174	10/17/00	109,318
0326003	01/05/01.	57,613
0332652	02/27/01.	60,934
0334602	03/09/01.	91,572
0321457	11/13/00.	69,353
0346640	07/24/01	21,093

2. Interim Action / Containment:

1.) All of the current SV-BTFB 4463269 CD R-Safe seal stock were sent to Chicago Rawhide in Elgin, for disassembly, cleaning and sorting. In addition, parts produced in CR Bethlehem that were rejected from Aiken stock and sent to Elgin have been scrapped. These parts were not sorted and/or reshipped.

2.) PPAP and purchase seal at new location (Chicago Rawhide - Elgin). Upon approval of the new seal, sorting was discontinued and only new 100% inspected product was used to replace all seals or build new bearings.

7-Step Corrective Action.

2. Regarding the potential for Dirty Mold, we concur with the findings from original TER completed by CR Bethlehem on this part number. Elgin follows similar procedures for auditing and inspecting for dirty mold and follows a break in process with mold release to prevent Dirty Mold from causing seal defects. However, there is one addition corrective action. Michum Mold Release used during CR Bethlehem production is acceptable with 490 rubber, however there is a newer technology mold release agent that is available. This product (Chemtrend) is used for all 490 rubber during the break in and molding process. This substitute product allows the mold to run cleaner and substantially reduces the potential for this failure to occur.

3. Next, the damaged to the primary lip was caused by manually trimming the part with a knife blade. The need for trimming arouse due to the high picker flash left on the part. The high picker flash is caused by damage to the gate area of the mold, but is controllable by mold release and press parameters. In Elgin production, there has not been any trouble with high picker flash thus far. Regardless, there are 2 corrective actions. One, if any picker flash does occur, the parts will be scrap, instead of reworking with a knife trim. Secondly, if picker flash does become an issue, the corrective action will be to replace any mold cavities with damage to the gate area with replacement mold inserts and re-qualify the mold internally.

4. Flowlines on the contact points is noted on both CR Bethlehem and Elgin production. Re-facing the radial grind on the lands of the mold cavity is a routine maintenance item needed to be completed when the mold arrived in Elgin. This process allows for air to escape the mold as the rubber enters the cavity. In addition, mold release can create flowlines, for which, the fore-mentioned changes to mold release and re-facing of the lands helps to control this defects.

6. Verification:

Although each of the defect conditions covered above are controllable as described, each part will be is 100% visually inspected. However, as an additional verification, a 100% functional test will be conducted on all seals. The test (Air Leak Down) will be performed before the assembly process. The Leak Down process will sort out all of the defects listed above and prevents any molding defects from being assembled and shipped. The Leak Down is performed by putting the seal into a fixture that seals at both contact points. Then, air is introduced into the fixture and the test equipment measures the rate of air pressure decay. Any leak path caused by molding defects will be detected by the lack of ability for the seal to contain the air pressure. This leak test simultaneously checks the wiper lip and primary lip of the seal. MSA for Leakdown has validated the effectiveness of the test.

All corrective actions were completed before start of production in Elgin with the exception of the air Leak Down. All seals produced before implementation of Leakdown were 200% inspected to "oil seal" standards which have Zero Allowable defect size or quantity on the sealing surfaces. The Leakdown equipment is complete and will ready for production 4-25-2002. Implementation and training is being completed and from this point forward, all seals will be 100% leak down tested as an added precaution.

UPDATE 5/23/2002

The final action item for 100% leakdown testing was implemented on 4/25/2002. On 4/30/2002, the 1000 piece shipment contained only 100% leakdown tested parts, as well as all other shipments since that date.

UPDATE 07/18/02

Attribute Gage R&R Study - This is a pass fail MSA using known good and bad parts.

7-Step Corrective Action,

4.) Quarantined all stock in Aiken, Statham Warehouse, and immediate return of all stock at ArvinMeritor for the replacement of old seals.

Total Number Of Bearings Reworked - 6,367
BTF-0065A - 3,347
BTF-0065B - 3,020

Total From all Meritor Facilities - 1442

From Meritor Fletcher - 810
BTF-0065A - 648
BTF-0065B - 162

From Meritor Florence - 632
BTF-0065A - 459
BTF-0065B - 173

Bearings in Aiken: Total 3,429
BTF-0065A - 1,630
BTF-0065B - 1,799

Bearings from Statum Warehouse: Total 1,496
BTF-0065A - 810
BTF-0065B - 686

3. Root Cause:

Inspection of seals produced at CR Bethlehem from the returned Aiken stock showed visible signs of potential leak defects for the following conditions: Unfills, manual knife trim damage, flowlines, and soft spots. In conversations with CR Bethlehem staff, they agree that these were major problems that the plant contended with during their production runs and any one of these defects may have caused the seal failures. The 6 seals that were returned from the field had enough wear that any of these defects may have been worn away. There is only 1 seal with remaining evidence of seal defects, which was a unfill (void) on the wiper lip. Due to the fact that all of the defects mentioned may have been worn away and each will be treated as a potential root cause of seal failure.

4. Corrective Actions:

1. Unfills (or voids) occurred on the wiper lip and on the bond tab on the side-wall of the part. There are several potential reasons why this occurred on CR Bethlehem production which are reflected on the Elgin PFMEA. However, it was identified that the root cause for the unfills was the lack of proper clearance in the mold to allow the metal stamping to fit into the mold. This lack of clearance in a nonfunctional portion of the mold did not allow the metal stamping to fully seat in the mold cavity. As the rubber entered the mold cavity to fill out the seal, the proper rubber path was reduced by the unseated metal stamping. In some cases, the force of rubber never overcame this resistance soon enough and the rubber cured up before filling out the seal. This created unfills (voids) on both the wiper lip and on the side-wall of the part. The corrective action was to remove the interference point to allow the metal to seat fully in the mold. This is located in a nonfunctional portion of the mold. There is no change to dimensional data, and this was confirmed with dimensional verification which was included in the PPAP to Aiken.

7-Step Corrective Action.

3.) Created new procedure and log book for replacing old seals with new ones, and implemented a identification plan for certified stock.

(Reference following Procedure and Log Sheet)

SKF Standard & Practices Automotive Division Work Instruction (WI)	**THU 2.1** **BTF-0065 Steer** **SV-BTFB 446329 CD** **R-Safe Seal** **Rework Procedure**	Section WI 312.1 Page 2(2) Issue 1 Date 04/02 Compiled by klc Approved by cbj Location SKF Aiken

1.0 PURPOSE

The purpose of this procedure is to provide guidelines for the correct rework of replacing the SV-BTFB 226329 CD inboard seal and the applicable makings required after completion of rework.

2.0 SCOPE

This procedure applies to supervisors, production team members, and anyone assisting within the THU 2.1 Channel in SKF Aiken, SC.

3.0 DEFINITIONS

3.1 Nonconformance: Product or material that does not conform to the Customer requirements or specification.

3.2 Scrap: Product or material discarded because of an individual or multiple customer specification / requirement is not met.

4.0 PROCEDURE

4.1 Carefully, remove old inboard seal and scrap it.

4.2 Clean seal bore verifying no bore tight enters the grease.

4.3 Place bearing on channel for insertion of new seal and tone ring

4.4 Remove completed bearing from channel. Place "1 inch yellow dot" on back of bearing flange using paint stick and mask.

4.5 A.) If seal is a reworked (inspected) seal, apply a $\frac{1}{4}$ x $\frac{1}{4}$ "X" between the serial number and date code and on one of the machined bosses above the brake pilot diameter and record the serial number on form SKF-THU 036 to verify rework has been completed.

B.) If seal is an new seal (new mold), apply a 1/8 x 1/4 "Z" between the serial number and date code and on one of the machined bosses above the brake pilot diameter and record the serial number on form SKF-THU 036 to verify rework has been completed.

4.6 Visually Inspect

4.7 Pack bearing

6.0 REFERENCES

6.1 Qd IP 465.1 Control of Nonconforming Product

THU 2.1 BTF-0065 SF-BTFB 446329 CD R-SAFE SEAL REWORK SIGN OFF CHECK SHEET

Rework Date:

SERIAL #	A	B	SERIAL #	A	B	SERIAL #	A	B

Verification Signature: **Date:**

SKF-THU 036 (04/2002)

7-Step Corrective Action.

7-Step Initiator/Team Leader: Christopher Jones	Phone:(803) 663-8662	Status: Closed.
	Fax:(803) 663-8611	Issue Date:08/14/02
Supplier: SKF USA Inc.	Supplier Code: 77248	Revision Date:
Location: SKF Automotive / Aiken	Date of Occurrence:	Date Root Cause Identified:
1064 International Pl.	08/09/02	08/15/02
Graniteville, SC 29829		
Part No.& Description:	Date PCA Identified:	Date PCA Implemented:
BTF-0085	08/16/02.	08/17/02.
Source of Complaint:	Date PCA Verified:	Date Closed:
Arvin Meritor	08/30/02	08/30/02
Line Affected:	DMN 17482.	Referral Number:
THU		AK02THU006

8D Team: Chris Jones Quality Assurance Manager, Kevin Cannon Quality Engineer, Mario Winkler Channel Manager, John Thomas Electrical Engineer.

1. **Problem Description**

Six HFFU 00 TS 32 (BTF 0085) bearings were returned from Arvin Meritor Ashville plant for excessive end play. The bearing serial numbers were as follows :-

21202 - 0391304 Manufacturing Date July 31 St.
21202 - 0391386 Manufacturing Date July 31 St.
21202 - 0391428 Manufacturing Date July 31 St.
12202 - 0376217 Manufacturing Date May 2 ND. Recorded end play at Meritor - 0.001"
12202 - 0376204 Manufacturing Date May 2 ND. Recorded end play at Meritor - 0.001"
12202 - 0376313 Manufacturing Date May 2 ND. Recorded end play at Meritor - 0.001"

2. **Interim Action / Containment:**

The functionality of the axial clearance gage was verified using the masters and found to be functioning correctly. From 08/09/02 all bearings delivered have had each serial number verified against the axial clearance value stored in the central channel computer. No defects were found.

3. **Root Cause.**

On Tuesday August 13 Th. six master bearings were assembled and delivered to Ashville to determine end play vs clamp force with bearings with known axial clearance. The bearings were manufactured using the normal assembly process but had the studs and ABS ring removed, the results are below.

7-Step Corrective Action.

The channel program logic can only altered by two trained certified engineers, no operator intervention can occur to remove the verification and bypass over rides currently installed in the system.

7. Prevention:

The measures outlined in this corrective action report will be considered permanent.

Chris Jones

Quality Assurance Manager
SKF Automotive Division
Aiken.

Root Cause Of Manufacture:

An Axial Clearance Gage problem was noticed in January of 1999. During the initial malfunctioning of the gage, the units in which the gage classified as low axial clearance were adjusted by replacing nominal size inner rings with smaller diameters to increase the axial clearance value. This is a normal SKF practice, if there is an axial clearance rejection; inner rings are replaced accordingly to adjust the axial clearance to within the required specification and re-gaged. Since the axial clearance gage diaphragm was not applying the proper load and nominal inner rings were replaced with smaller ones, the combination resulted in units having excessive axial clearance values, which were classified as acceptable by the gage.

Root Cause Of Non Detection:

The gage continued to provide similar readings of clearance without a noticeable change after 25 to 30 consecutive parts were gaged. The malfunction on the gage was attributed to a failure of the diaphragm material; the diaphragm is used to provide the load in checking the axial clearance. The load is necessary in order to properly seat the inner ring bearing assemblies prior to making an axial clearance check. The proper load to be applied is 300 Newton's.

Interim Action / Containment:

Identifying the root cause was not immediate, therefore a decision was made to quarantine 2,000 bearings based on the Edmunds Axial Clearance Gage Data Base, which stores up to 5,760 consecutive readings. This quantity was chosen as being a conservative number based on the timing of the gage malfunction as determined from the recorded data. To provide full protection against any potential erroneous readings, the quarantined quantity was chosen based on all the values that were stored in the gage data file, and how they varied to one another.

After replacing the first diaphragm, part masters were made with known values that were utilized to verify gage repeatability and provide assurance that the gage was functioning properly if problems occurred. Over a period of about nine months, two additional diaphragms were replaced. This resulted in a redesign request to Edmunds Gages and establishing a regular scheduled TPM to change the diaphragm.

The 2,000 quarantined bearings were later re-gaged utilizing a newly designed manual off-line gage. However, there were some differences between the two gages:

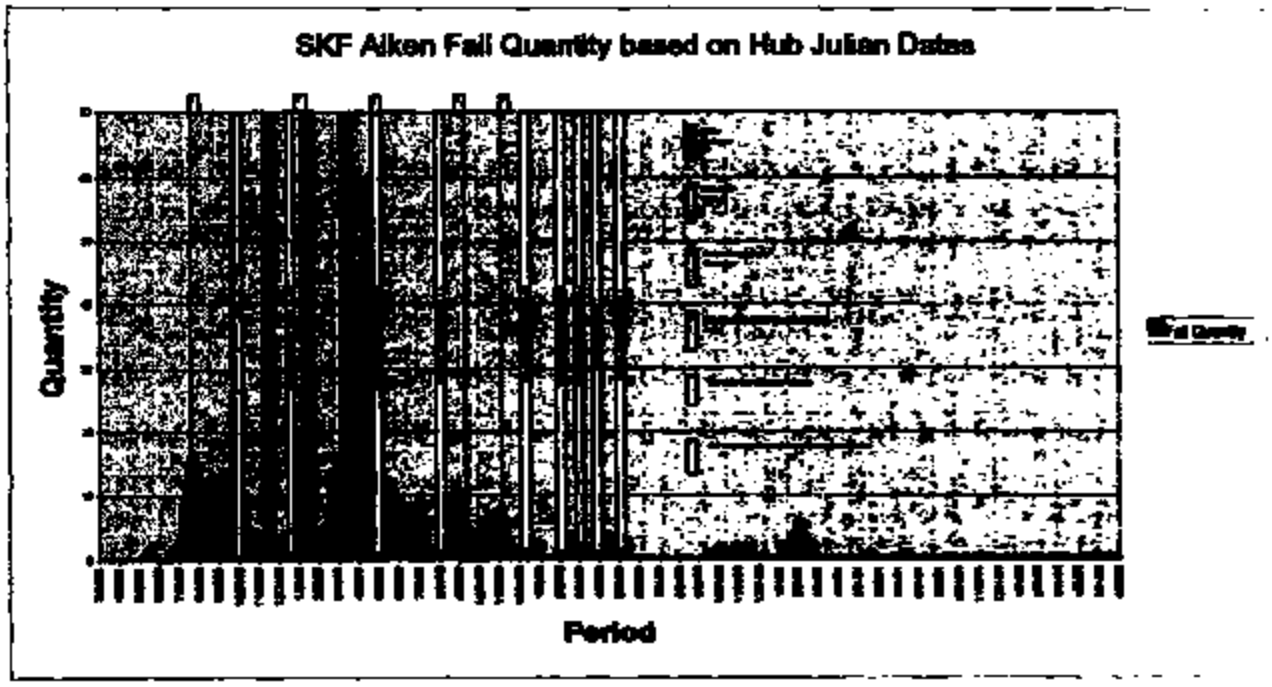
1) The off-line gage measured statically instead of dynamically;
2) The off-line gage did not rotate the bearing;
3) The off-line gage measured axial clearance after complete assembly of bearing (grease/seals) where as the on-line gage measured with only the inner rings installed.

Correlation studies were conducted between the two gages, which indicated at that time that the off-line gage was capable of detecting outliers.

The shipment of the 2000 quarantined bearings was delayed for about 10 months from their manufacture due to the time required to manufacture the manual gage and perform gage R&R testing. This accounts for the wide range of in-service dates for the vehicles involved.

Further investigation revealed additional problems and corrective actions concerning the axial Clearance gage (see following detailed list and attached chart):

- October 31, 1998 – Axial Clearance Gage air leak found
  Corrective Action – Repaired Leak (October 31, 1998)
- January 21, 1999 – Axial Clearance Gage Diaphragm failure
  Corrective Action – Replaced Diaphragm and quarantined approximately 2,000 bearings (January 21, 1999)
- May 31, 1999 - Axial Clearance Gage Diaphragm failure
  Corrective Action – Replaced Diaphragm (May 31, 1999)
- August 20, 1999 – Bearing wobbles when rotated
  Corrective Action – Axial Clearance Gage upper and lower bearings were replaced (August 20, 1999)
- **October 6, 1999 - Changed Mounting of Diaphragm to reduce wear**
- January 7, 2000 - Axial Clearance Failure
  Corrective Action – Replaced Diaphragm (January 7, 2000)
- February 29, 2000 - Axial Clearance Gage Diaphragm replaced
  Corrective Action – Replaced Diaphragm (February 29, 2000)
- **March 31, 2000 - Axial Clearance Gage retrofitted with new cylinder design replacing diaphragm.**
- April 27, 2000 –Centering Ball broke off of lower tooling
  Corrective Action – Aligned Shaft (April 27, 2000)
- **June 6, 2000 - Axial Clearance Gage upper and lower bearings were replaced**



Additional Interim Corrective Actions:

1. Requested Edmunds Gage for complete on site evaluation of axial clearance gage for re-design of gage to eliminate issue.

2. Replace diaphragm every three months to ensure no material failure occurred, while complete gage design was being investigated.

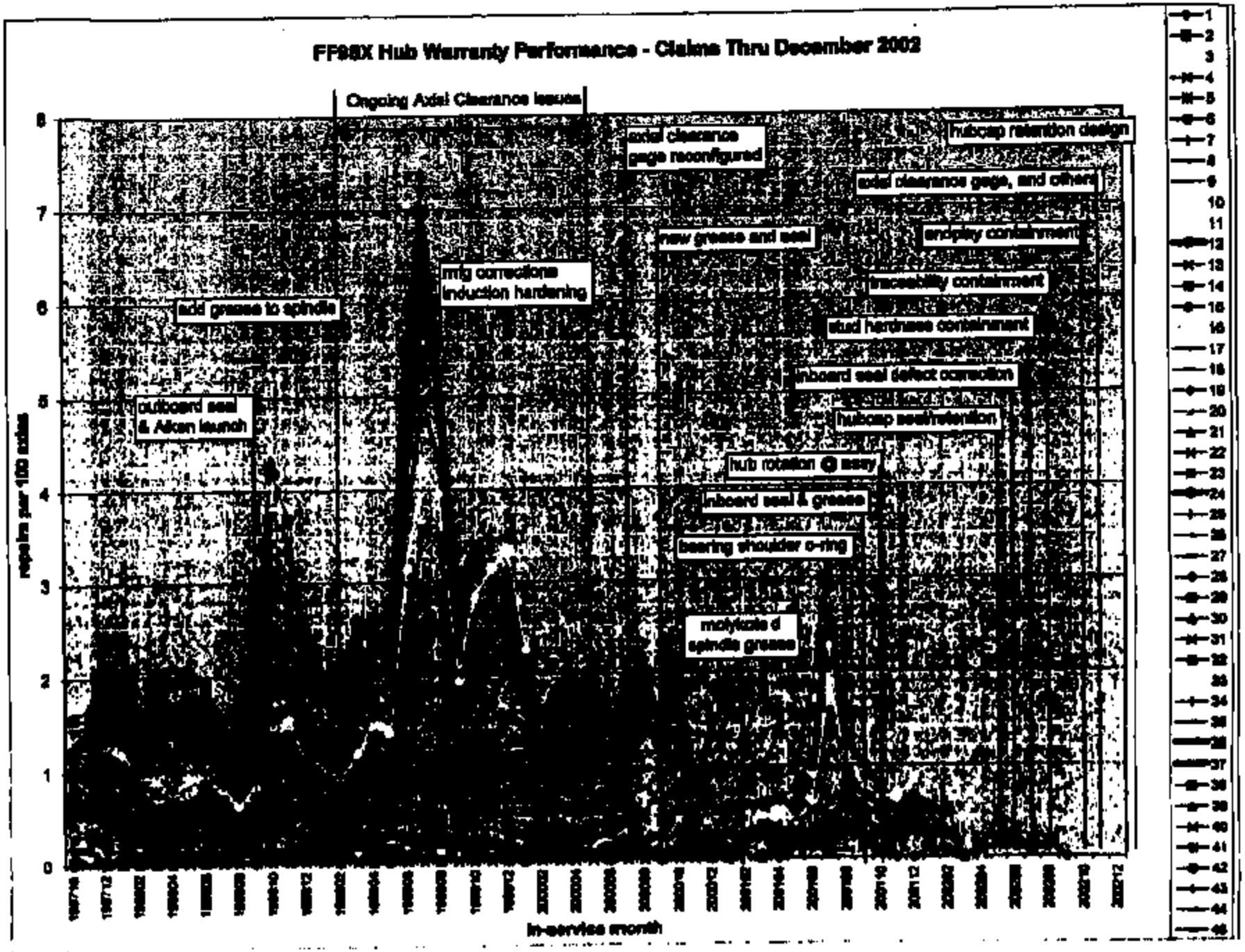
3. Create two hub assemblies to be used as masters and verify the on-line gage repeatability on a regular basis.

Corrective Actions:

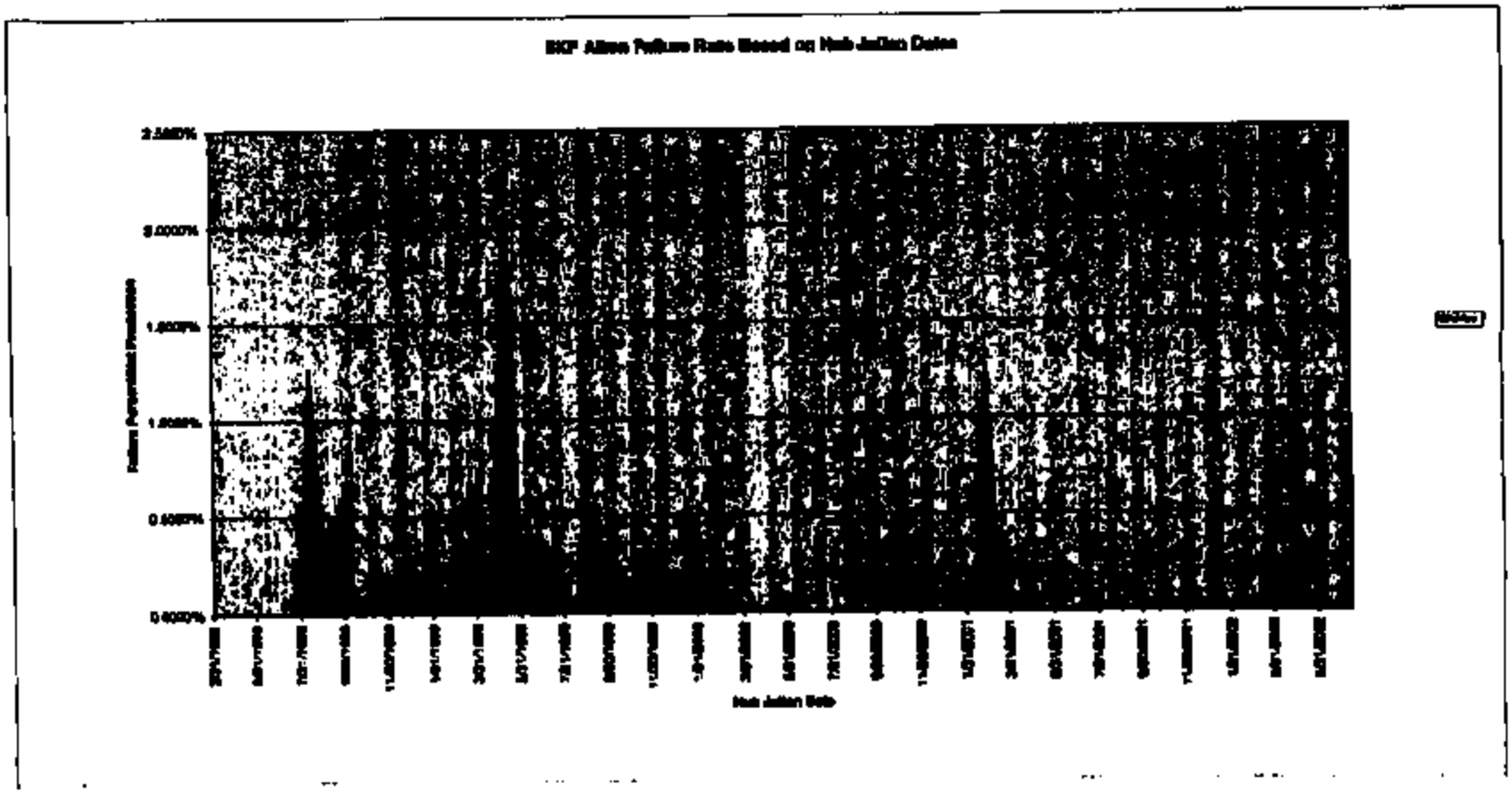
1. Redesign gage and fabricate parts by Edmunds Gage.
   Completion Date: February 2000.

2. Retrofit gage with new special cylinder.
   Completion Date: March 2000.

3. Implement three masters to perform validation checks at the beginning of each shift and chart results on form SKF THU-0034.
   Completion Date: October 2001

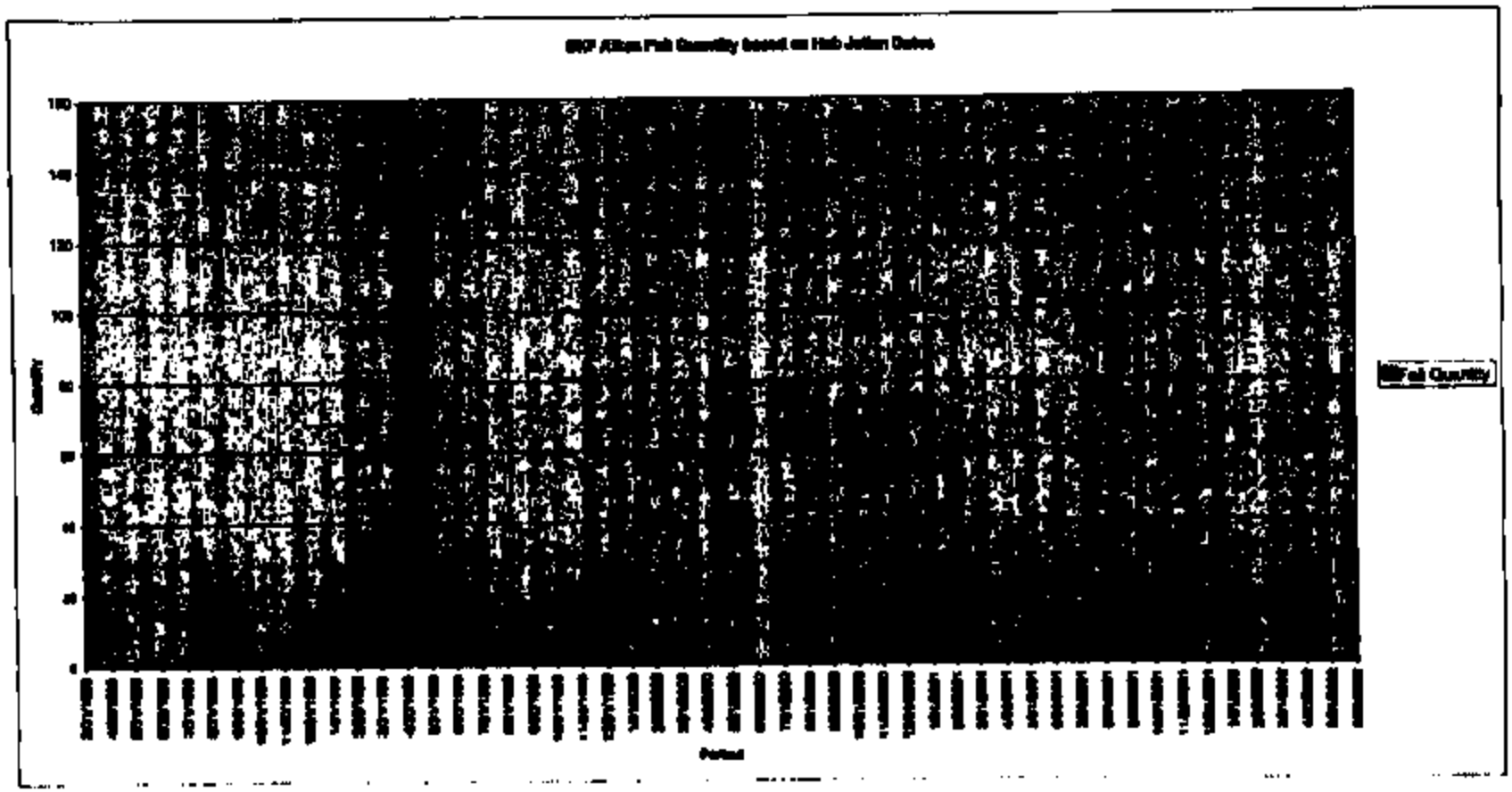

FF98X Hub Warranty Performance - Claims Thru December 2002
Ongoing Axial Clearance Issues
axial clearance gage reconfigured
hubcap retention design
axial clearance gage, and others
new grease and seal
endplay containment
mfg corrections induction hardening
traceability containment
add grease to spindle
stud hardness containment
inboard seal defect correction
outboard seal & Aiken launch
hubcap seal/retention
hub rotation @ assy
inboard seal & grease
bearing shoulder o-ring
molykote d spindle grease
repairs per 100 axles
in-service month

SKF 001154



Units = 584

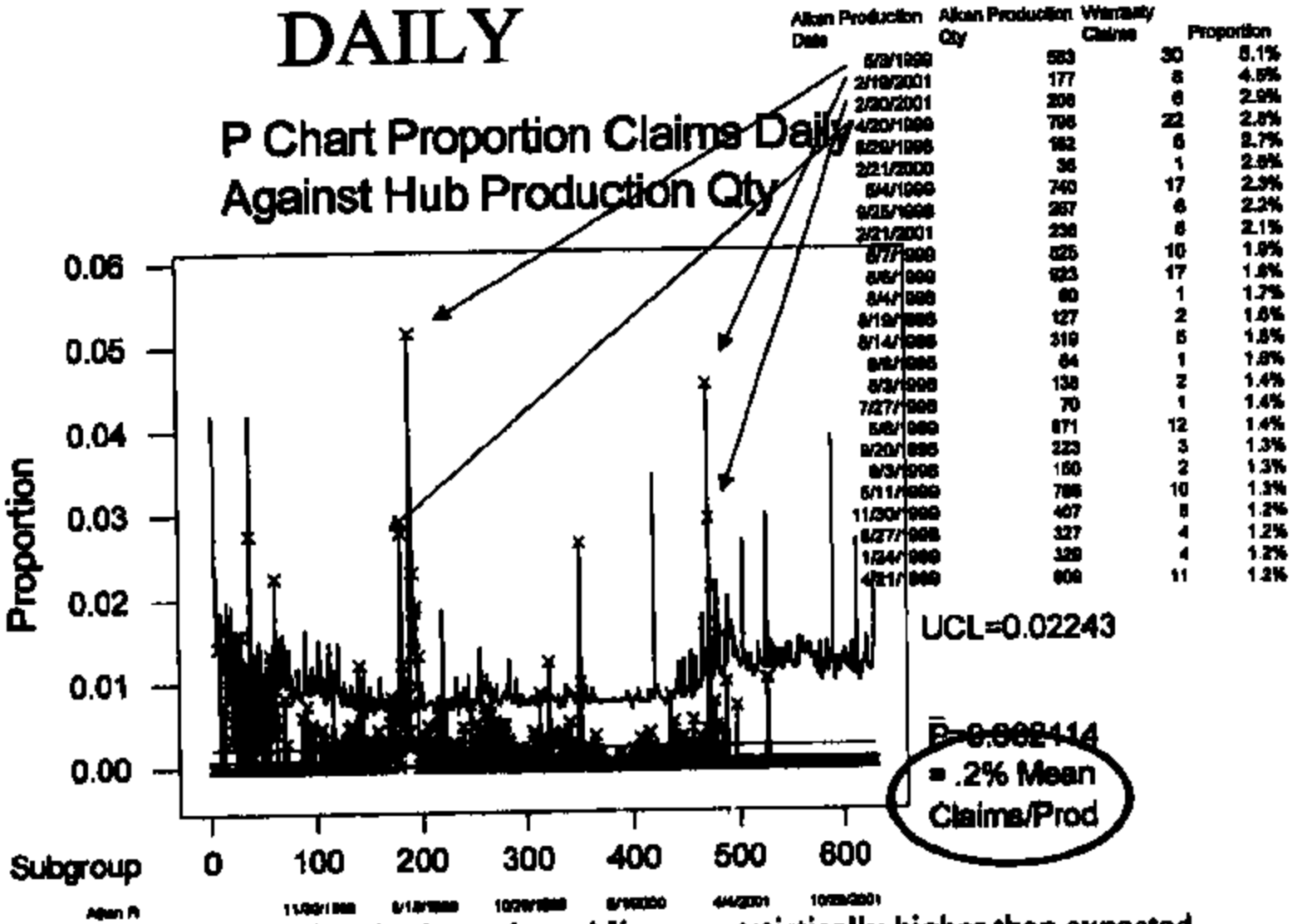
11/21/2002



Units = 164

11/20/2002

DAILY



Allen Production Date	Allen Production Qty	Warranty Claims	Proportion
5/3/1999	583	30	5.1%
2/19/2001	177	8	4.5%
2/20/2001	206	6	2.9%
4/20/1999	706	22	2.8%
8/29/1999	162	6	3.7%
2/21/2000	36	1	2.8%
5/4/1999	740	17	2.3%
9/25/1999	267	6	2.2%
2/21/2001	236	5	2.1%
8/7/1999	525	10	1.9%
8/6/1999	933	17	1.8%
8/4/1999	60	1	1.7%
8/19/1999	127	2	1.6%
8/14/1999	319	5	1.6%
8/2/1999	64	1	1.6%
5/3/1999	138	2	1.4%
7/27/1999	70	1	1.4%
5/6/1999	871	12	1.4%
8/20/1999	223	3	1.3%
8/3/1999	150	2	1.3%
5/11/1999	786	10	1.3%
11/30/1999	407	5	1.2%
8/27/1999	327	4	1.2%
1/24/1999	328	4	1.2%
4/21/1999	909	11	1.2%

Claim values are the x's. x's above the red line are statistically higher than expected.
Immature data likely excludes future claims against year 2000 and other dates

SKF 001157

Michael D Lewis
12/19/2002 05:23 PM

To: Bernd Stephan/SCH/SKF@SKF, Arno Stubenrauch/SCH/SKF@SKF, Tore Johansone/GHQ/SOT/SKF@SKF
cc: Christopher Jones/AMER/SKF@SKF, Robert J Bondy/DET/SKF, William J Ferrell/ELG/SKF@SKF, Edward F Cotter/AMER/SKF@SKF, Mike A May/GLA/SKF@SKF, Richard W Frett/ELG/SKF@SKF, Douglas G Kearney/GLA/SKF@SKF
Subject: Questions/Open issues

As requested by Bill Ferrell, here is a list of the open issues which come to mind - I'm sure I've missed some of the detail regarding Chuck and Dale's questions, but you get the general idea. Also, if I knew where the responsibility of various things resides, I've tried to list it. Somethings are unclear.

1. P.O. for Phase 2 of Southwest Research Institute hub unit testing - B. Stephan

2. Studs out of specification hardness (too hard) (Purchasing/M. Lewis/A. Stubenrauch)
   - Number of parts effected
     - Stud lots quantified
   - Safety defect ? Long term corrosion effects on studs
     - SKF in spec stud bending test show 2.5 times better life than maximum hardness studs
       - Need new "field condition" parts for testing (from Ingersoll)
         - 460 vickers (max deviated hardness)
         - 10.9 stud at max hardess needed for testing
   - Need Purchase Order for outside bending testing
   - Need SFK position on out of specification studs
   - Engineering justification of case depth specification for studs

3. Soft studs (service issue)
   - Number of parts to be serviced (lots affected)
   - Get enough service studs to make changes
   - Define how studs are to be changed (Dealers/procedures/tools)
   - Letter to Doug Brown (ARM) regarding rotating studs and what to do about them - (Bondy/Frett)
     - Letter to be used to notify OE of potential issue

4. Peak return period parts:

Start-up
- Field activity defined
  - How to accomplish inspection ?
  - Train & equip OE's with vibration checker ?
- Root causes addressed ? (Not sure we can ever get this answered)

Poorly honed parts
- Field Activity defined
  - How to accomplish inspection ?
  - Train & equip OE's with vibration checker ?
- Final 8D (Jones)
  - Number of parts effected
  - Root cause defined
  - Corrective action defined

R-safe
- Field Activity defined

Robert H Edwards
11/21/2002 10:05 AM

To: Michael D Lewis/DET/SKF@SKF, Achim Mueller/SCH/SKF@SKF, Arno Stubenrauch/SCH/SKF@SKF, Bernd Stephan/SCH/SKF@SKF
cc: Edward F Collet/AMER/SKF@SKF, Christopher Jones/AMER/SKF@SKF, Mike A May/GLA/SKF@SKF, Robert S Fleming/AKN/SKF@SKF, John K Thomas/AKN/SKF@SKF, Marcus A Jakob/AKN/SKF@SKF, George F Wiseman/AMER/SKF@SKF
Subject: THU 2.1 OR Honing Problem History

The attached file is a summary of all work orders for THU 2.1, Operation 70 (Outer Ring Honing) which have been registered in our computerized maintenance management system (AP/Pro). Relative to the findings of the business unit regarding un-honed or poorly honed raceways, analysis of the history leads to three areas of concern.

1. On several occasions in 1999, records show that parts came out of the chucks. Although this occurred in both stations, the problem was more prevalent on station 1 in which the inboard raceway is honed. The part is located and clamped on the flange and oriented with flange face down, ABS seat diameter - up. The force of the stone on the part in this configuration (relative to outboard raceway) causes more of a moment, which increases the likelihood of a part being thrown from the chuck. During the time this problem existed, it is conceivable that the stone pressure could have been lowered to help decrease the likelihood of the part being released from the chuck. Modifications to the chucks took place in December 1999 to help resolve this issue. This event has occurred since the modification of the chucks, however less frequently. This is attributed to swarf buildup in the chuck.

2. On November 14, 2000, a work order was logged into AP/Pro indicating a problem whereby a part could be placed in station 2 (outboard raceway) and subsequently unloaded without ever honing the part. The exact reason for this and when it first occurred is unknown at this time, however, the work order indicates that the control logic was modified to avoid it from happening again.

3. Another problem which occurred, was the failure of the stone broken/worn out sensor. AP/Pro shows this occurred on May 14, 1999. Failure of the sensor could result in some parts honed with too low stone pressure or even non-contact. A stone index counter was implemented in June 1999 which stops the machine upon expiration requiring the operator to re-position and re-clamp the stone thus ensuring proper stone pressure. The operator should also inspect the last part to ensure that it was properly honed.

While the information above may correlate to some degree the findings from the business unit, it is not entirely clear that this is the sole cause of the spikes on April 20 and May 3. Further investigation regarding the above concerns is ongoing at this time. Please let me know if you have questions.

Best regards,
-Bob

thist1_Op70_workhistory.txt

thu21_op70_workhistory

SKF AIKEN
Work historyr

Date: 11/18/2002

End date	Wo. No.	Maint.object key	WO name
09/12/1998	10735.00	THU-OP070	NO RED RINSE
09/16/1998	10456.00	THU-OP070	STATION 1 CRASH
09/16/1998	10460.00	THU-OP070	need to grind station 1 spindle ch
09/17/1998	10955.00	THU-OP070	STATION 1 STONE INDEX
09/18/1998	10942.00	THU-OP070	NO RIB PRESSER
09/22/1998	11078.00	THU-OP070	part thrown out
09/22/1998	11083.00	THU-OP070	stoneholder clamp is broken
09/22/1998	11085.00	THU-OP070	guide rod scarred
09/24/1998	11086.00	THU-OP070	please make washer for guiderod.
10/09/1998	10673.00	THU-OP070	supfina repair
10/12/1998	11508.00	THU-OP070	REPLACE CLAMPING SLEEVE
10/16/1998	11674.00	THU-OP070	WILL NOT GO INTO AUTO CYCLE
10/18/1998	11694.00	THU-OP070	THE ELEVATOR WAS STUCK IN DOWN
10/28/1998	12015.00	THU-OP070	REPLACE BLUES
10/31/1998	12033.00	THU-OP070	REPLACE SPEITH COUPLING
10/31/1998	12043.00	THU-OP070	CHANGE ANGLE
11/03/1998	12102.00	THU-OP070	ELEVATOR OVER TRAVELED
01/15/1999	11673.00	THU-OP070	HONER IS COMPLETELY INOPERABLE
02/06/1999	13680.00	THU-OP070	STA#2 STAYS IN CYCLE
02/18/1999	13885.00	THU-OP070	ROTATING ASSEMBLY BROKEN
02/19/1999	13910.00	THU-OP070	CRASHED PART STA 1
02/28/1999	13937.00	THU-OP070	MAKE 2 KEYS
03/11/1999	14189.00	THU-OP070	STA #2 HYDRAULIC LEAK ON ROTARY ACT
03/22/1999	14437.00	THU-OP070	STA.#2 INDICATING STONE INDEXER CLA
04/14/1999	14902.00	THU-OP070	THE GANTRY CRASHED INTO THE DOOR
04/16/1999	14991.00	THU-OP070	MACHINE WOULD GO INTO E-STOP
04/17/1999	15033.00	THU-OP070	THE DOOR THAT WAS CRASHED WAS STUCK
04/22/1999	15119.00	THU-OP070	Y1 OPEN GRIPPER FAULT
04/23/1999	15163.00	THU-OP070	THE DOOR WAS STUCK AGEIN
04/27/1999	15178.00	THU-OP070	CLAMPER INDEX ON STATION 1 NEED TO
04/27/1999	15188.00	THU-OP070	CLAMPER INDEX STATION 1 NEED
05/03/1999	15273.00	THU-OP070	DOOR TO STATION 2 WILL NOT OPEN.
05/07/1999	15501.00	THU-OP070	PART CAME OUT OF THE CHUCK
05/10/1999	15540.00	THU-OP070	THE Y1 WOULDNT RETRACT
05/14/1999	15616.00	THU-OP070	STA. #2 STONE INDICATOR NOT WORKING
05/17/1999	15651.00	THU-OP070	THREW A PART STA#1
05/19/1999	15571.00	THU-OP070	STATION ONE CLAMPER INDEX OUT OF
06/16/1999	16062.00	THU-OP070	WOULDNT CLAMP
06/18/1999	15271.00	THU-OP070	DOOR ON STATION 2 WILL NOT CLOSE
06/18/1999	16078.00	THU-OP070	ADDED PART COUNTER FOR STONE CHANGE
06/19/1999	17423.00	THU-OP070	STA 2 PART THROWN OUT
06/24/1999	17545.00	THU-OP070	THREW A PART OUT OF CHUCK STA 2
06/25/1999	17584.00	THU-OP070	STA 1 HYDRAULIC LEAK ON STONE INDEX
06/30/1999	17785.00	THU-OP070	THREW A PART FROM STA 1
06/31/1999	17784.00	THU-OP070	
09/01/1999	17861.00	THU-OP070	STA 2 STONES WEARING UNEVEN
09/13/1999	17779.00	THU-OP070	
10/18/1999	19434.00	THU-OP070	STA. 1 PART STARTED TO COME OUT OF
10/18/1999	19450.00	THU-OP070	THREW A PART
10/20/1999	19519.00	THU-OP070	threw a part out of chuck
10/21/1999	19502.00	THU-OP070	THREW PART OUT
10/21/1999	19503.00	THU-OP070	SPACER FOR INDEXER ARM
10/25/1999	19528.00	THU-OP070	part coming out of chuck
12/01/1999	20955.00	THU-OP070	DOOR CLOSED FAULT
12/14/1999	21282.00	THU-OP070	STA. 1 AND 2 GANTRY DOORS WON'T CLO

0

End date	Wo. No.	Maint.object key	WO name
12/14/1999	21311.00	THU-OP070	DOOR WAS NOT MAKING THE SENSOR
01/06/2000	21793.00	THU-OP070	STA 2 BAD HONE ON RACE
01/14/2000	22050.00	THU-OP070	STA 1 TOOLHOLDER HIT THE PART
04/25/2000	25226.00	THU-OP070	STONE INDEXER WON'T UNCLAMP
06/15/2000	26331.00	THU-OP070	SPLASH GUARD DOOR FAULT
06/15/2000	26532.00	THU-OP070	STA 1 STOP IN CYCLE NO FAULT
06/20/2000	26651.00	THU-OP070	STA 2 SIDE DOOR INTERLOCK OUT OF LI
07/14/2000	27220.00	THU-OP070	modify vertical guard door assembli
08/31/2000	28751.00	THU-OP070	MODIFY VERTICAL GANTRY DOORS
11/14/2000	31024.00	THU-OP070	OUTBOARD RACE NOT HONED
11/15/2000	31063.00	THU-OP070	STA 2 STONE INDEXER SPRAYING HYDR.
01/16/2001	32585.00	THU-OP070	HYDRAULIC LEAK
02/08/2001	33164.00	THU-OP070	STA 2 INDEXING SHAFT BROKE
02/23/2001	33573.00	THU-OP070	CYCLE COUNT UNEVEN
02/23/2001	33584.00	THU-OP070	STA #1 THREW A PART
03/01/2001	33695.00	THU-OP070	STA 1 THREW A PART
03/07/2001	33818.00	THU-OP070	STA 1 THREW A PART
04/06/2001	34503.00	THU-OP070	ST. #1 CHUCK NOT INDICATING CLOSED
06/01/2001	35683.00	THU-OP070	STA 1 STOPPING IN CYCLE
06/14/2001	35972.00	THU-OP070	INSTALL CO2 TANK ON HONER .
09/26/2001	37798.00	THU-OP070	Station 2 threw a part
02/20/2002	40597.00	THU-OP070	MONTHLY TPM FORM IP430.5.870C[10/01
03/05/2002	39062.00	THU-OP070	ADJUST STATION 2 INDEX ARM
03/27/2002	42896.00	THU-OP070	Find Honing oil leak.....
04/12/2002	41609.00	THU-OP070	MONTHLY TPM FORM IP430.5.870C[10/01
06/23/2002	40596.00	THU-OP070	6 MONTH TPM FORM IP430.5.870D[01/02
06/26/2002	39060.00	THU-OP070	Check drawbar and clamping unit
07/02/2002	43408.00	THU-OP070	MONTHLY TPM FORM IP430.5.870C[10/01
07/03/2002	39061.00	THU-OP070	ADJUST AIR BLOWOFF
07/03/2002	46680.00	THU-OP070	MONTHLY TPM FORM IP430.5.870C[10/01
09/06/2002	46721.00	THU-OP070	MONTHLY TPM FORM IP430.5.870C[10/01
10/09/2002	49593.00	THU-OP070	MONTHLY TPM FORM IP430.5.870C[10/01

Printed for: MICHAEL LEWIS
04/03/2002, 07:57:54 PM, 1

Michael D Lewis
04/02/2002 08:55 PM

To: Tom Johnstone/GHQ/GOT/SKF, Claes Rehnberg/GHQ/GOT/SKF, Juergen Schaffstatz/SCH/SKF, Bernd Stephan/SCH/SKF, Matthias Haupt/SCH/SKF, William J Ferrell/ELG/SKF, Timothy D Gilbert/KOP/SKF, Richard W Frett/ELG/SKF, Arno Stubenrauch/SCH/SKF,

cc:

Subject: ArvinMeritor Steer THU2 background

To all:

I am issuing this email as a summary of our current situation with regard to the ArvinMeritor Steer THU2s. If I have left anyone off the distribution list, please forward this to them.

Last week (March 25th), we were informed by ArvinMeritor that the performance of the steer unit was unacceptable and given 30 days to come up with a comprehensive plan to fix the problem. During the last week the situation has become more urgent due to increasing frequency of wheel end issues. Fleets and OE's are now asking ARM to replace units now in the field.

The major issue is what ARM has termed "highly progressive incidents". These are units which have deteriorated to the point where a wheel comes off or is very close to coming off. At the end of the 2001, there were 49 of these incidents. By the end of March 2002, there were 117 incidents. Of the 117 incidents wheels came off 17 trucks. So far, only property damages have been associated with these incidents. However, there have been several cases where drivers have lost control of the vehicle and the out come could have been much worse. Of these 117 incidents, 22 are with parts of Luechow manufacture.

Conventional wheel ends in the USA are typically oil lubricated. Oil lubricated wheel ends which have a seal or bearing problem, generally show an oil leak at the inboard seal. The THU is grease lubricated. We currently have a unit which does not believe as other units on the market - if the THU seal leaks, it typically allows contaminates in, not oil/grease out. There are no visual indicators that a THU has a problem. If wheel end problems go undetected, one of two things happens: 1. The driver eventually notices something wrong (poor handling, brake drag, etc) and pulls over, or 2. Eventually the wheel comes off. Detection, therefore, is critical.

ARM currently has over 3000 claims in their database. ArvinMeritor is reporting a failure rate near 2% for the steer units produced in 1997 (the most mature data) and the failure rates seem to increase for later production years (although this data is immature). As of Dec. 2001, SKF had looked at over 500 units returned from the field. From this analysis, we have what we believe are two major root causes (account for over 75% of valid returns):

Seal ingress leaks
Unhardened raceways (addressed and no longer an issue)

Of these, seals remain unexplained and only somewhat corrected. We currently have 3 issues with seals.

1. Freudenberg seal/Luechow production - the seal does not last 100% through the warranty period, while the target is the life of the truck.
2. Freudenberg seal/Alliance production - the seal seems to fail at a greater rate than the Luechow production.
3. R-Gale seal/Alliance production - The seals molded at Bethlehem for the last 2 years have molding defects which cause shortened life.

Below is some graphical data showing our analysis (by production year) of the parts we have looked at

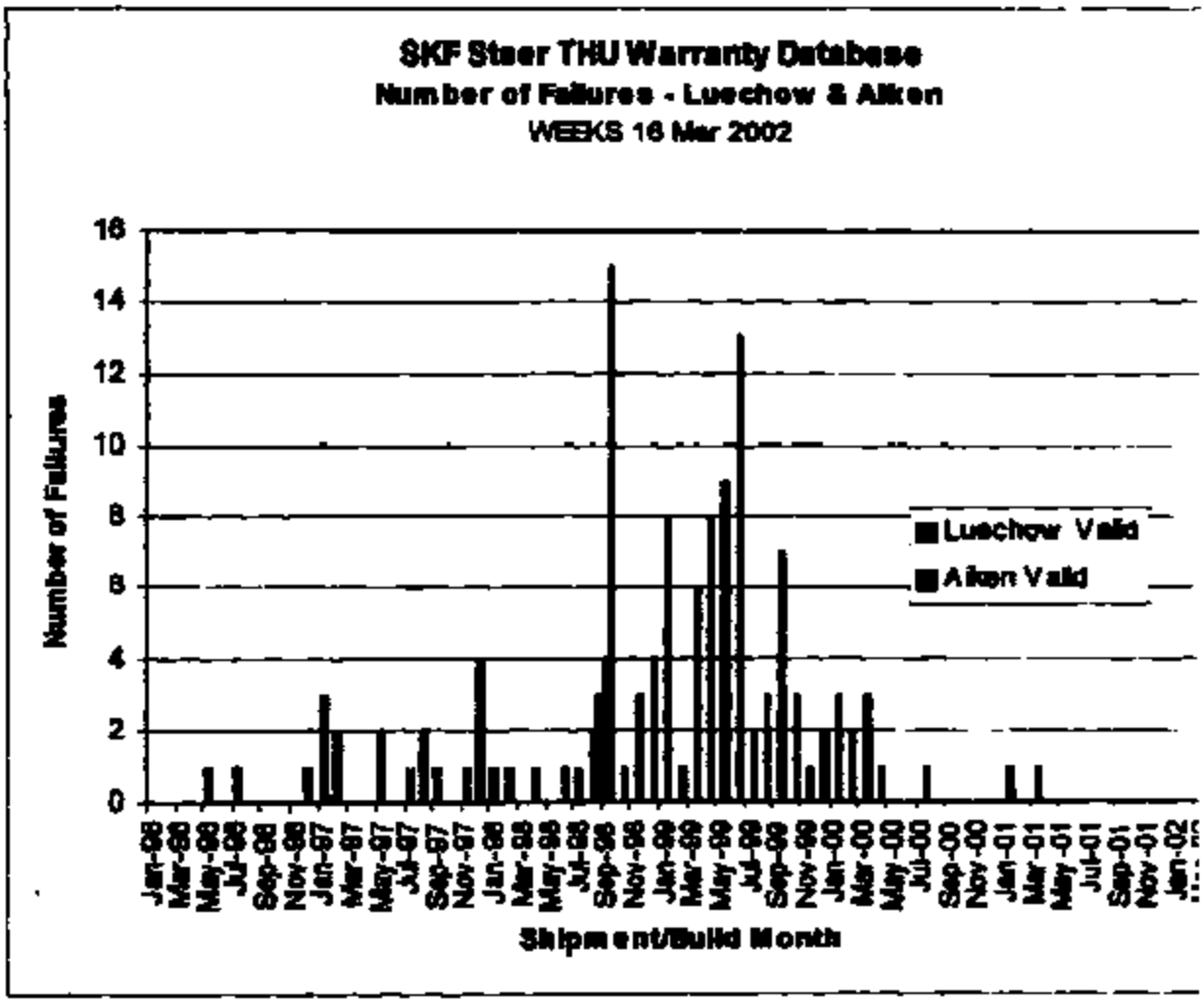
Printed for: MICHAEL LEWIS
04/03/2002, 07:57:54 PM, 2

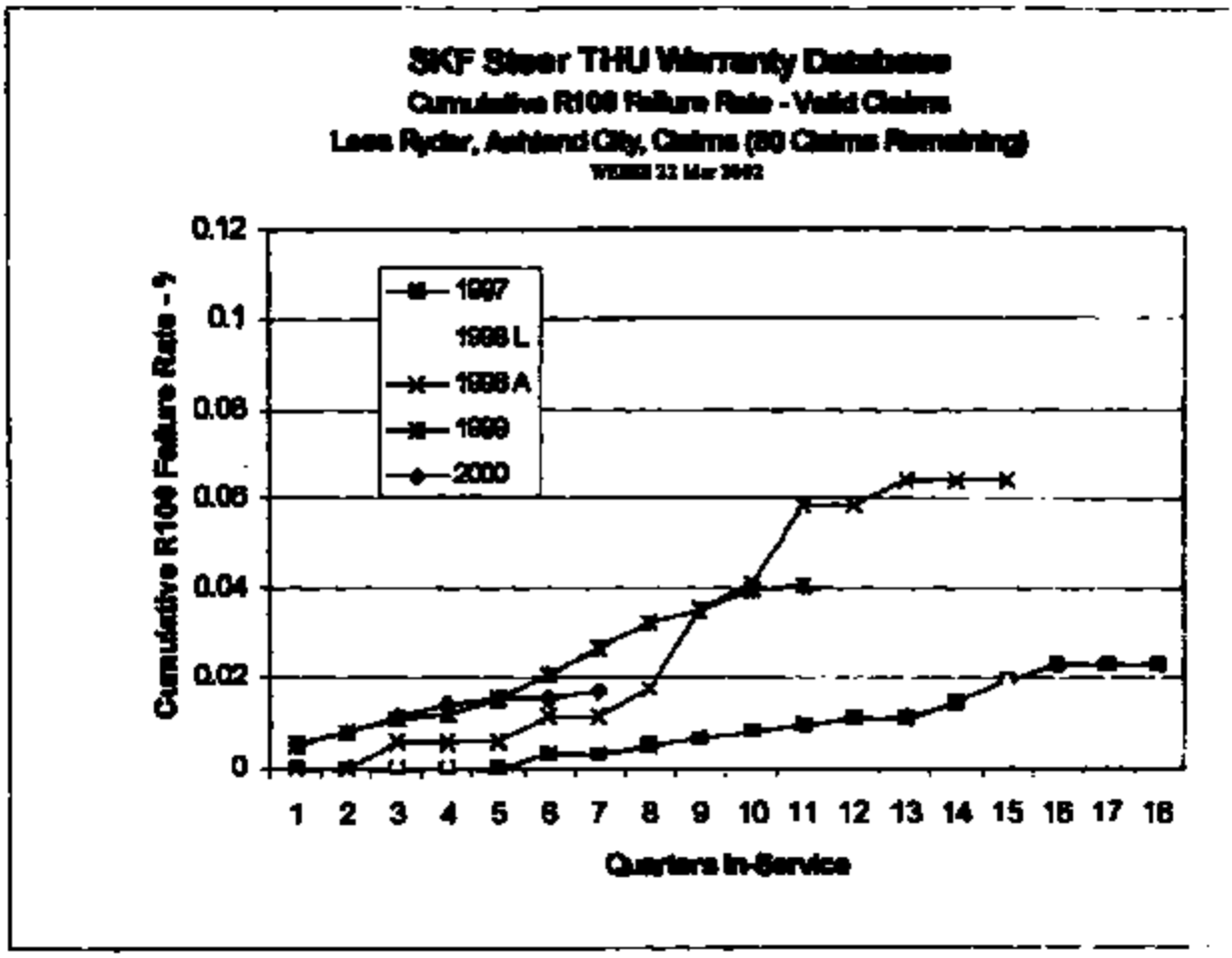
as of Dec 31, 2001.

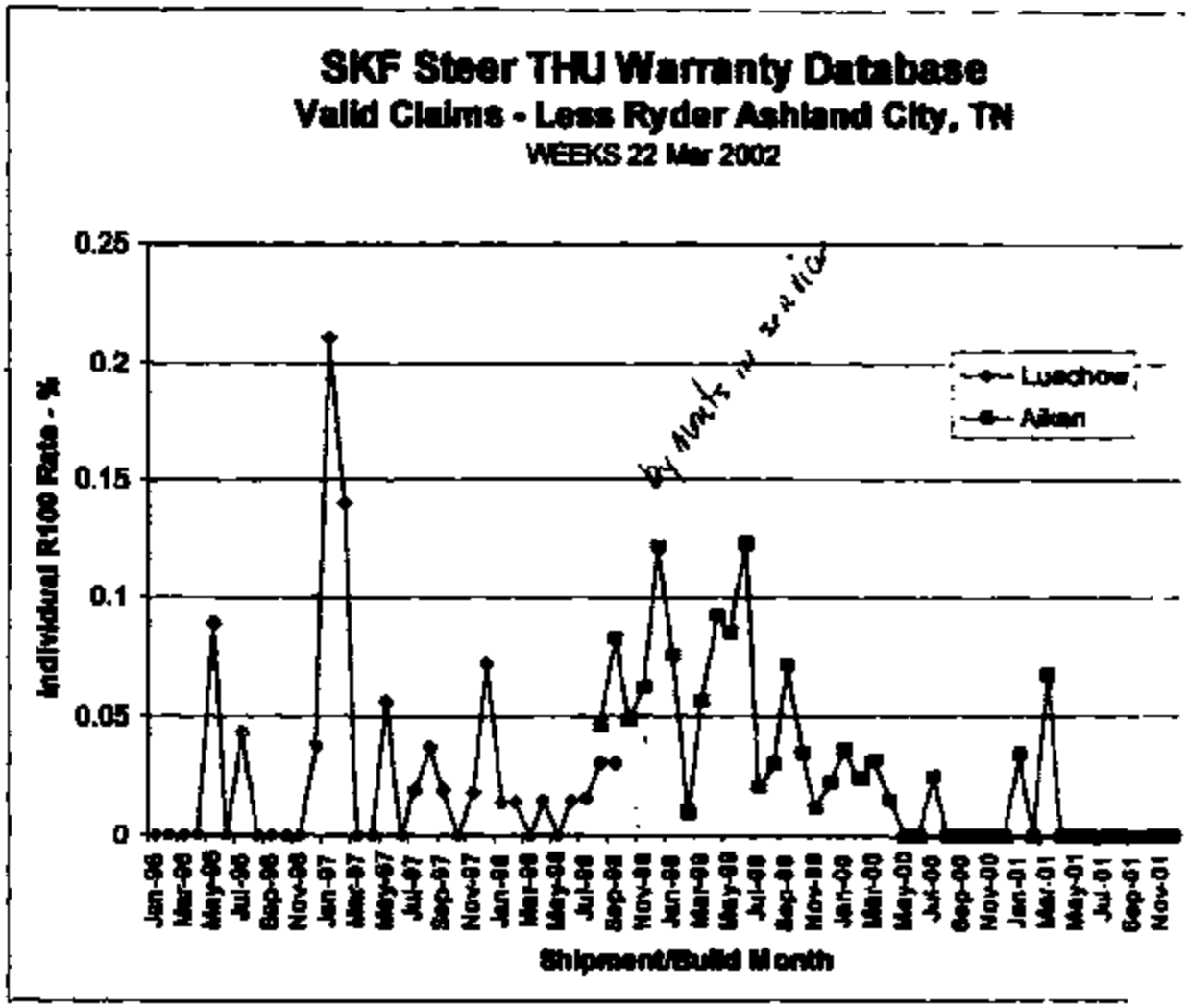
Please keep in mind that decisions made for this product could potentially influence other parts/applications (Trailer and ConMet ATMU).

During our meeting, we will review this background information, answer questions, and try to decide our direction regarding this issue.

Regards,
Mike




SKF Steer THU Warranty Database
Cumulative R108 Failure Rate - Valid Claims
Lease Ryder, Ashland City, Claims (80 Claims Remaining)
Cumulative R108 Failure Rate - %
0.12
0.1
0.08
0.06
0.04
0.02
0
1997
1998 L
1998 A
1999
2000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Quarters In-Service


SKF Steer THU Warranty Database
Valid Claims - Less Ryder Ashland City, TN
WEEKS 22 Mar 2002
Individual R100 Rate - %
0.25
0.2
0.15
0.1
0.05
0
Luechow
Aiken
Shipment/Build Month

Printed for: MICHAEL LEWIS
04/03/2002, 01:54:51 PM, 1

Michael D Lewis
04/03/2002 01:50 PM

To: Robert J Bondy/DET/SKF@SKF, Bruce Weeks/AMER/SKF@SKF, William J Ferrell/ELG/SKF@SKF, Christopher Jones/AMER/SKF@SKF, Richard W Frett/ELG/SKF@SKF

cc:

Subject: Dale Bell

To all:

I have made an appointment with Dale Bell of ARM at 1:30 on Friday April 5th. As a minimum, SKF needs to discuss the root cause of the R-safe seal failures. I would like to use an 8D type approach with Dale - Cause, corrective action, quantify parts affected, and containment. I'm not sure we will be ready to stop shipment on the BTF-0085, but I would like to make that recommendation. We will probably have to involve Ashville in that discussion. [illegible]?

I've put together a rough agenda for the meeting (below). We should discuss the points we need to make and the limits of the conversations. Under "Other Issues", I have listed the greasing issue, the PLB involvement, etc. - Some issues that we may not be ready to discuss - if not, we can delay them for some short period of time, but if we have any limits on what we want to share, then lets make sure that they are clearly defined.

We still need some detail to fill in the gaps in our knowledge. More detail is needed for: Corrective actions, seal lot production information (how many and when seals were produced, number of field returns from that lot, etc).

Some of these issues and questions will be answered by the PLB meeting, so we should have a phone conference to discuss them after the PLB discussion.

Call if you have questions.

Regards,
Mike

Agenda:

1. R-safe failure analysis
   - 8 units returned to date
     - production dates
     - Root cause
       - Seal mold issues X% based on current inventory
       - Register problems Y% based on current inventory

2. Corrective actions
   - Cleaning procedures
   - Etc.
   - Currently trying to produce new seals
     - Estimated delivery date ????

3. Containment
   - Parts from current inventory show defect
   - Returns from ??? lots of seal production show problem

4. Recommended action:
   Stop shipment of current parts
   PLB involvement

Other issues

Failure mode discussion - does ARM expect all these units to last the life of the truck ??
Failure detection - sharing of ideas ??
Freudenberg/Alkan production - Greasing issue ???
PLB involvement

George F Wireman
03/25/2002 03:03 PM

To: Michael D Lewis/DET/SKF@SKF
cc: Christopher Jones/AMER/SKF@SKF, Mario G Winkler/AKRON/SKF@SKF, Edward F Collier/AMER/SKF@SKF, Achim Mueller/SCHW/SKF@SKF, William J Ferrell/ELGIN/SKF@SKF, Robert H Edwards/AKRON/SKF@SKF
Subject: Re: Grease charge for the BTF-0002

Dear Mike,

A review was completed with Mario and the technicians on the THU channel related to the grease applied to the Freudenberg seal with the final results :

1) The purpose of applying the grease was to insure we have sufficient lubricant to install the seal. The main purpose was to act as a precautionary measure to insure we have a complete insertion of the seal. No specification to the amount of grease was applied at the time since it wasn't considered necessary by product design.

2) The amount of the grease was not considered critical as long as "sufficient" lubricant was applied in order to achieve complete circumferential coverage. If we inspect the seal pocket, the volume of grease we are applying is sufficient to fill the seal pocket as required. The calculation is as follows: the positive displacement pump delivers 0.246 cm^3 = .015 in^3 = 0.235 grams (where 1 in^3 = 15.7 grams).

Hopefully the above discussion will be helpful in your analysis of possible problem conditions for the seals. If you have any questions please let me know.

Thank you and Best Regards,

GFW

Michael D Lewis

Michael D Lewis
03/22/2002 03:21 PM

To: Christopher Jones/AMER/SKF@SKF, Mario G Winkler/AKRON/SKF@SKF
cc: Edward F Collier/AMER/SKF@SKF, Achim Mueller/SCHW/SKF, William J Ferrell/ELGIN/SKF@SKF, George F Wireman/AMER/SKF@SKF

Subject: Grease charge for the BTF-0002

Chris and Mario,

As you are aware, Allen and Luechow have a distinct difference in the amount of grease applied to the Freudenberg seal at assembly. Luechow has a charge of 1.5 grams and Allen has a charge of 0.3 grams (rough estimates both). These are significantly different - although we are not sure at this time what impact, if any, that this would have on seal performance. We will try to do some comparative testing soon.

Can you determine where the 0.3 gram fill specification comes from ? How was this derived ? I realize you may need to do some digging to find out (George Wiseman may be of some help here), but would you look into this ?

Any information you can provide would be greatly appreciated.

Achim, can you ask Luedrow to provide the same information regarding the 1.5 gram charge ?

Best regards,
Mike

Michael D Lewis
04/02/2002 09:09 AM

To: Bernd Stephan/SCH/SKF@SKF, Matthias Haupt/SCH/SKF@SKF, Arno Stubenrauch/SCH/SKF@SKF, Juergen Schultheis/SCH/SKF@SKF, Richard W Frets/ELG/SKF@SKF, William J Farrell/ELG/SKF@SKF
cc: David M Simms/ELG/SKF@SKF, Robert J Bandy/DET/SKF@SKF, Bruce Weeks/AMER/SKF@SKF (bcc: Michael D Lewis/DET/SKF)
Subject: Outline - Comprehensive Plan to fix steer problem

To all:

As you are all aware, we have 30 days (from March 25th) to respond to ARM regarding the steer unit warranty issues. We have tried to put together an outline of the items we (SKF) need to address to keep the ARM business. The three major areas listed below are what ARM has indicated need to be part of our comprehensive plan to correct the current situation. In addition, in the week since our meeting at ARM, there have been a number of wheel offs reported. The frequency of "progressive incidents" seems to be growing - we may not have 30 days to respond.

Root cause/corrective actions
    Address current production and field issues
Detection of failures (on trucks)
    Units in the field (something retrofittable)
    Future production (could be more sophisticated than the above)
Cost containment (or transfer to SKF) related to claims and customer dissatisfaction issues

If we break this into the major areas of root cause, detection, and cost, we can begin to see what needs to be done.

Root cause:

From the SKF side, we have two major root causes (account for over 75% of returns):

    Seal ingress leaks
    Unhardened raceways

Of these, seals remain unexplained and only somewhat corrected. We currently have 3 issues with seals.

1. Freudenberg seal/Luechow production - the seal does not last 100% through the warranty period, while the target is the life of the truck.
2. Freudenberg seal/Allen production - the seal seems to fail earlier and at a greater rate than the Luechow production.
3. R-Seto seal/Allen production - The seals molded at Bethlehem for the last 2 years have molding defects which cause shortened life.

Root cause actions listed:

Freudenberg/Allen Production
Investigate the effect of reduced grease charge on seal installation (Allen used 0.3 grams of grease, Luechow used 1.5 g)
    Wear test - Parts now in Elgin. Completion date??? Dave Simms please advise
    Mud slurry (to be done if wear test shows no difference in performance) - completion date ???
Dave Simms please advise
Investigate large rib surface finishes of Allen and Luechow parts (Completed - surface finishes similar

Allen is slightly better).

R-seals - Bethlehem production
2 R seals units returned from the field show molding defects. 2 of 30 seals from current Allen inventory show severe molding issues
4 R seals units were returned from ARM last week for early failure
Need root cause analysis - D. Simms please advise
Define quantity affected and time frame
Inspection of 100 pieces current inventory of loose seals (currently in Elgin)
Seals from other lots from THU inventory (necessity TBD)
Check inspection records from Bethlehem (R. Frett and CR Elgin Quality)
Mud slurry testing to confirm performance - (necessity TBD)
R-Seals Elgin
Elgin has tried to mold R-seals seals from orginal mold and has exertenced register problems
Elgin is currently trying to rework the molds to make good parts

Detection:

Need plan for detection device development - Arno Stubenrauch to advise

Cost Containment:

Other Issues:

ARM has requested a copy of DFMEA - Does this show some increased risk of fire ? What do we say is the level of detection for a wheel bearing failure, etc. ?

ARM has requested a detailed breakdown of the differences between the Europeas vs. North American Applications
Shoot flange, full flange
Spindle (1 pc vs 2 pc)
Disc brake vs Drum
Maintenance practices

03.26.2002 M. Lewis, R. Bewley, B. Weeks, B. Ferrell
Action Items

LAYOUT AIKEN & LUSTROW PARTS
RADIAL & AXIAL SURFACE FINISHES
FOR CONE LARGE RIB

BEVEL - 3/27

RPN # ON FORCE - M. LEWIS

EUROPEAN VS N.A. APPLICATION
- SHORT PLUNGE
- SPINDLE (1R)
- DISC BRAKE/DRUM
- MAINTENANCE REACT.

DETECTION

SKF 001172

03.26.2002 M. Lewis, R. Bondy, B. Weeks, B. Farrell

Action Items

- Production Records from Bethlehem - R. Frett
- Define & Quantify R-Safe Seal Issues -
  - Investigate 4 new R-Safe Failures
    - Send to D. Simms
      - Material Defects ?
      - Pour out / Alignment Defect ?
      - Other ?
  - Quantify Current loose Seal Inventory for Material + Runout Issues
    - 100 pcs to D. Simms
    - Test ?
- Fruedenberg
  - Low Grease Fill Performance
    - Test ??
    - Seals to Dave

SKF 001173

SEALS

Freudenberg

Aiken → Effect of Grease Charge?
Water Test → Comp Date
Mud Slurry → Comp Date

Luechow → Design not capable of 750 ~ 1000,000 miles

R-Safe

Mold Defects (Axial Lip "Runout" + Material Defects)
- Define
  - Qty Affected/Time Frame
    - Inspect Parts
      - Current Pickup Inventory Loose Seals
      - Other Lots (TVU)
    - Test
      Material Defects? > Mud Slurry?
      Runout Issue

30 DAYS

Comprehensive Plan to Fix Problem

Root Cause / Corrective Actions — Production/Field

Detection (Field/Production)

Cost Containment/Transfer to SKF ≈ 3.0 million (1% x 400,000 units x $750/[illegible])

Root Cause (Masters)

- Unhardened Raceway (20/130)
- Inboard Seal (80/130)
  - Freudenberg
    - Aiken
    - Luechan
  - R-Safe
    - Molding Defects
    - "Cocking" Defects

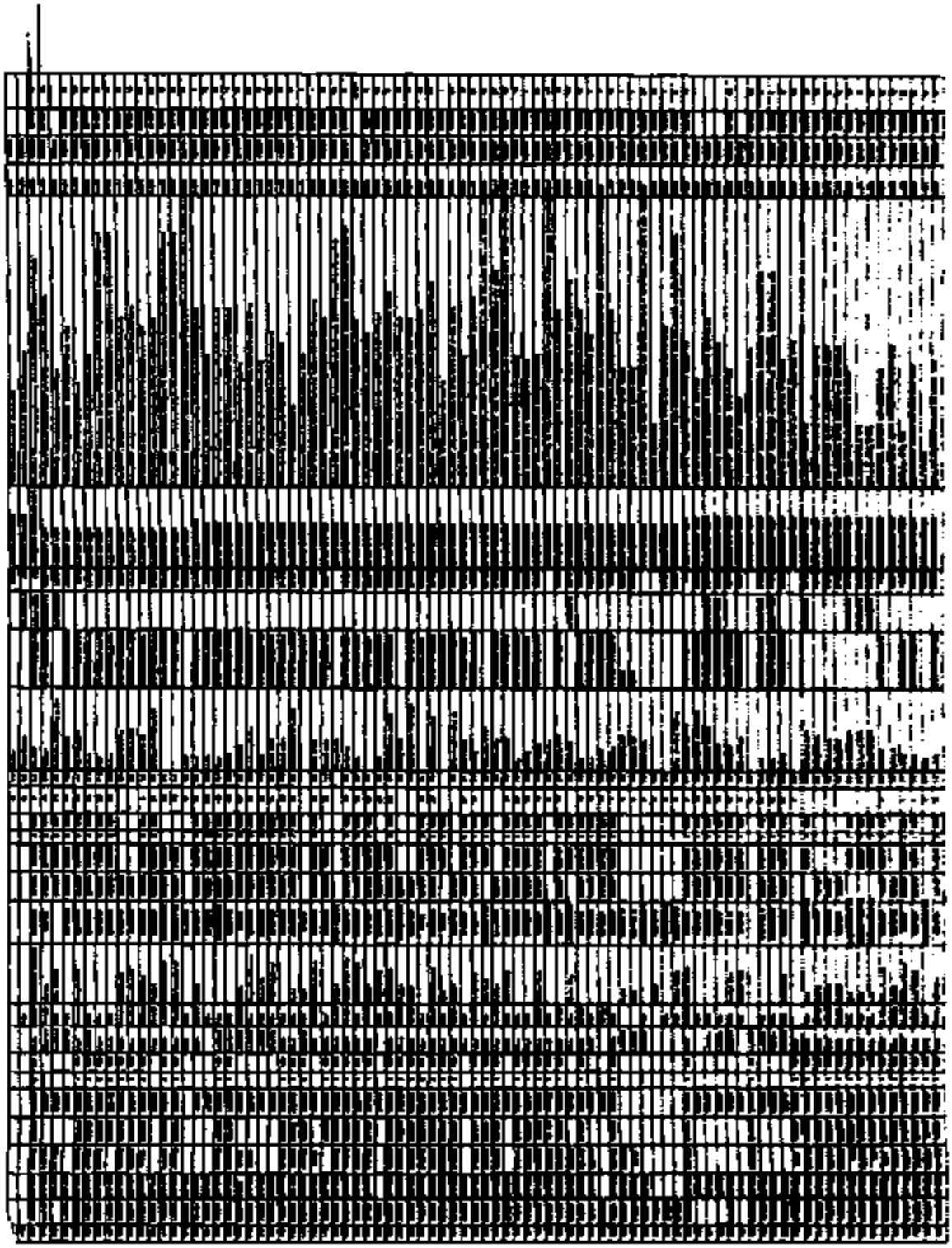
Detection

- Field
  - Hub Cap
  - ABS
- Future Production
  - Hub Cap
  - ABS [illegible]/Temp Sensor

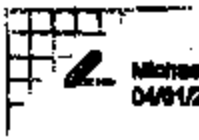
SKF 001175

SKF 001178

SNF 00117



SKF 001178



Michael D Lewis
04/01/2002 03:00 PM

To: Douglas S Beyers/AMER/SKF,
cc: Bruce Weidel/AMER/SKF, Achim Meyer/SCHWSKF, Bernd Stephan/SCHWSKF, Arno Stubenrauch/SCHWSKF, David M Simms/ELG/SKF, William J Ferrel/ELG/SKF,
Subject: Steer unit surface finishes

Doug,

As you are aware, we have some failures of the Allen THUs with Freudenberg seals. We have been trying to rule out some of the possible reasons for differences between failure rates between Allen and Luechow. One thing we wanted to look at was the surface finishes. So, we have measured the surface finish (both axially and radially) of the large diameter rib of the bearing cones (where the inboard seals ride) from both Allen and Luechow production. The results are:

	Axial Ra (microns)	Radial Ra (microns)
Luechow:	0.44	0.22
Allen:	0.37	0.16

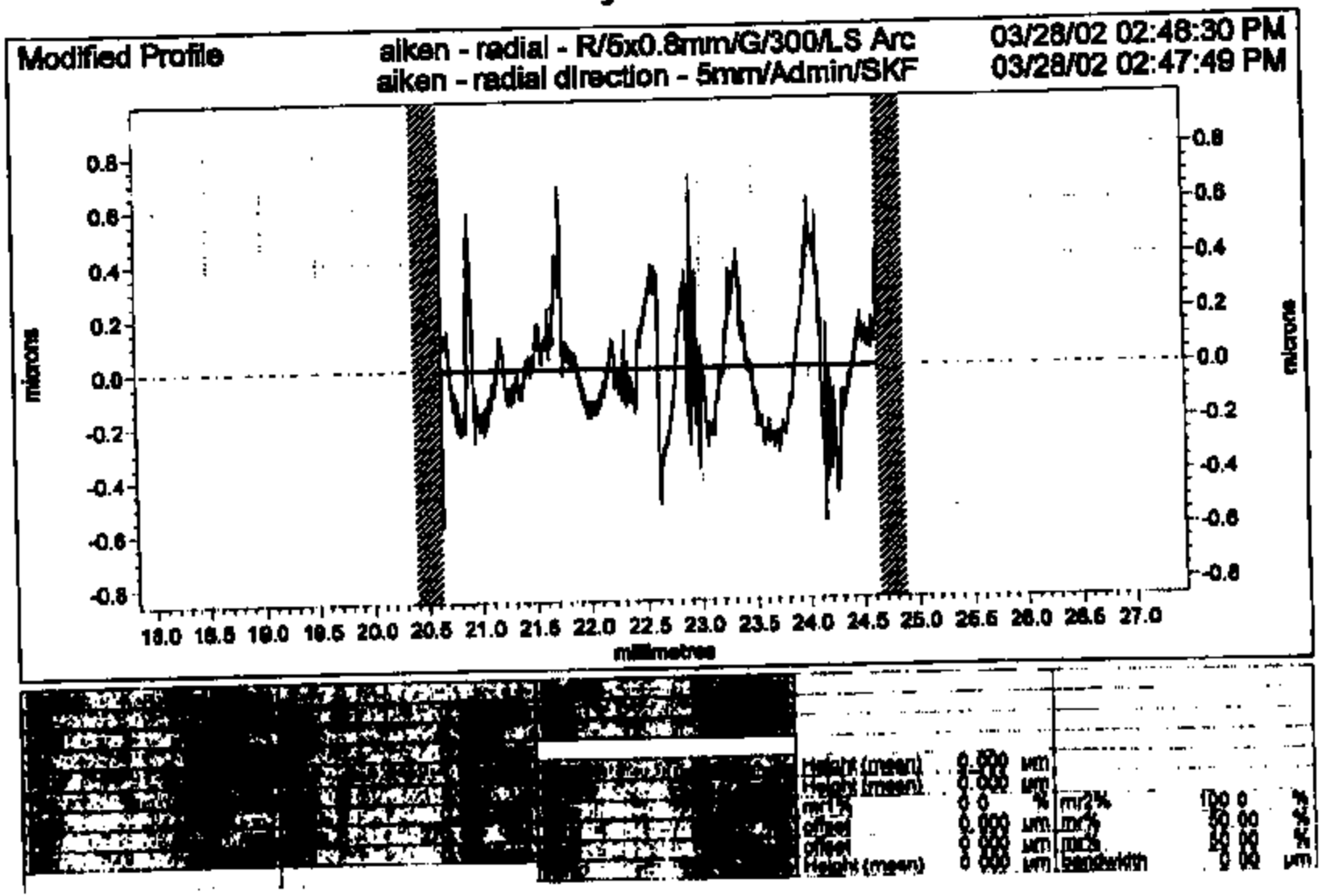
I can send you the print outs of the measurements if you want them.

I don't see much difference in the surface finishes, but you are the seal expert. Are these finishes OK for this type of seal ?

Please advise.

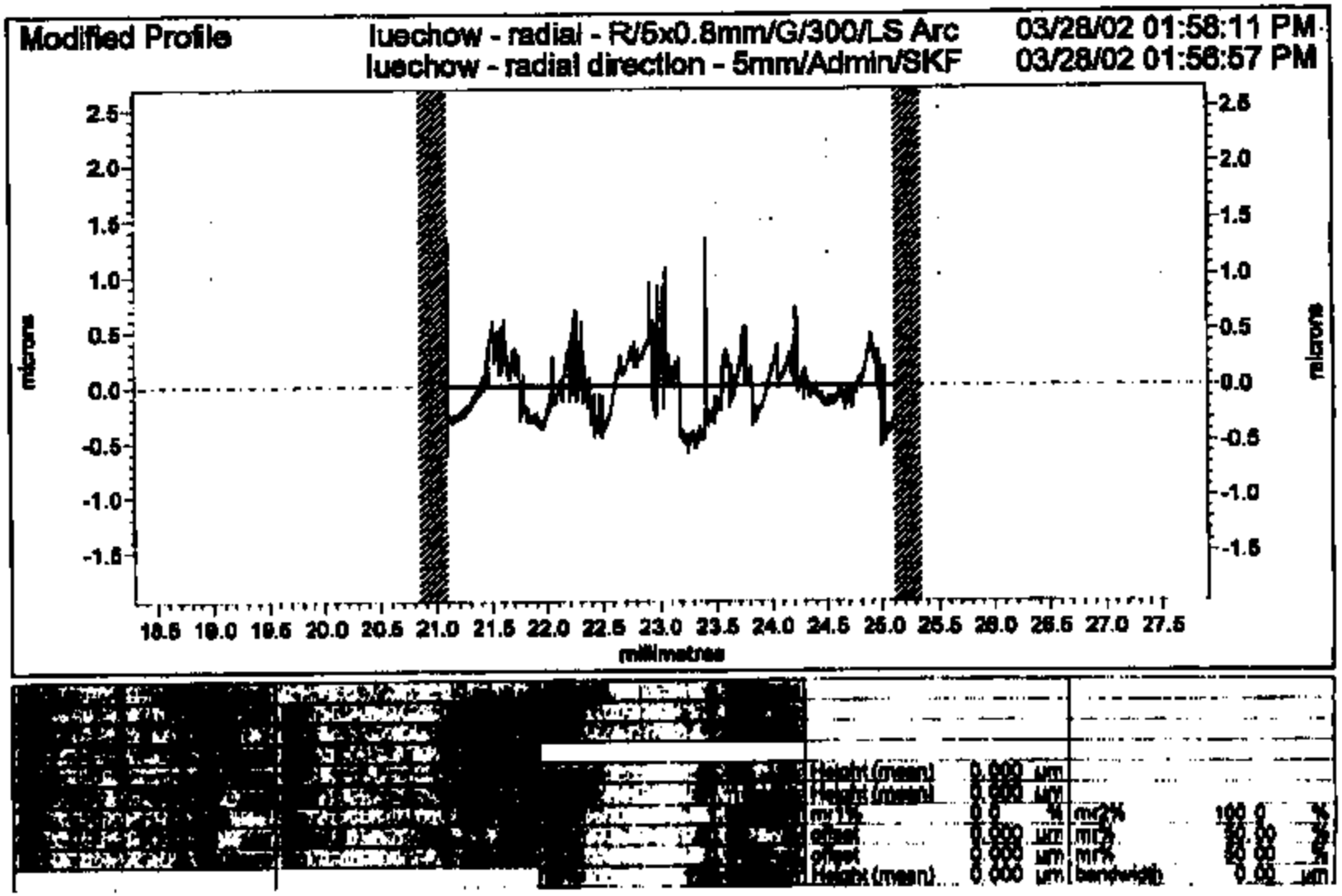
Best regards,
Mike

Taylor Hobson



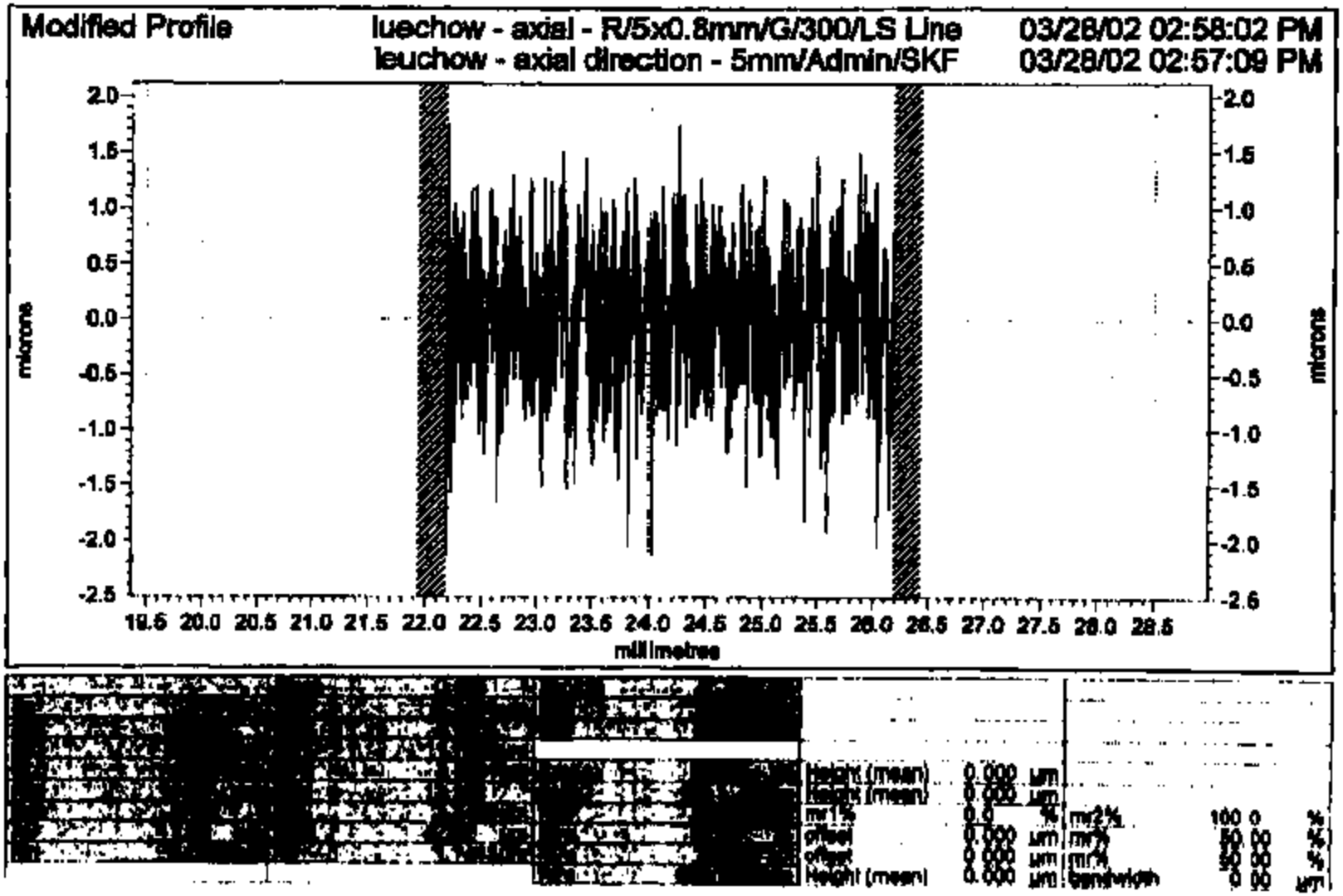
SKF 001180

Taylor Hobson



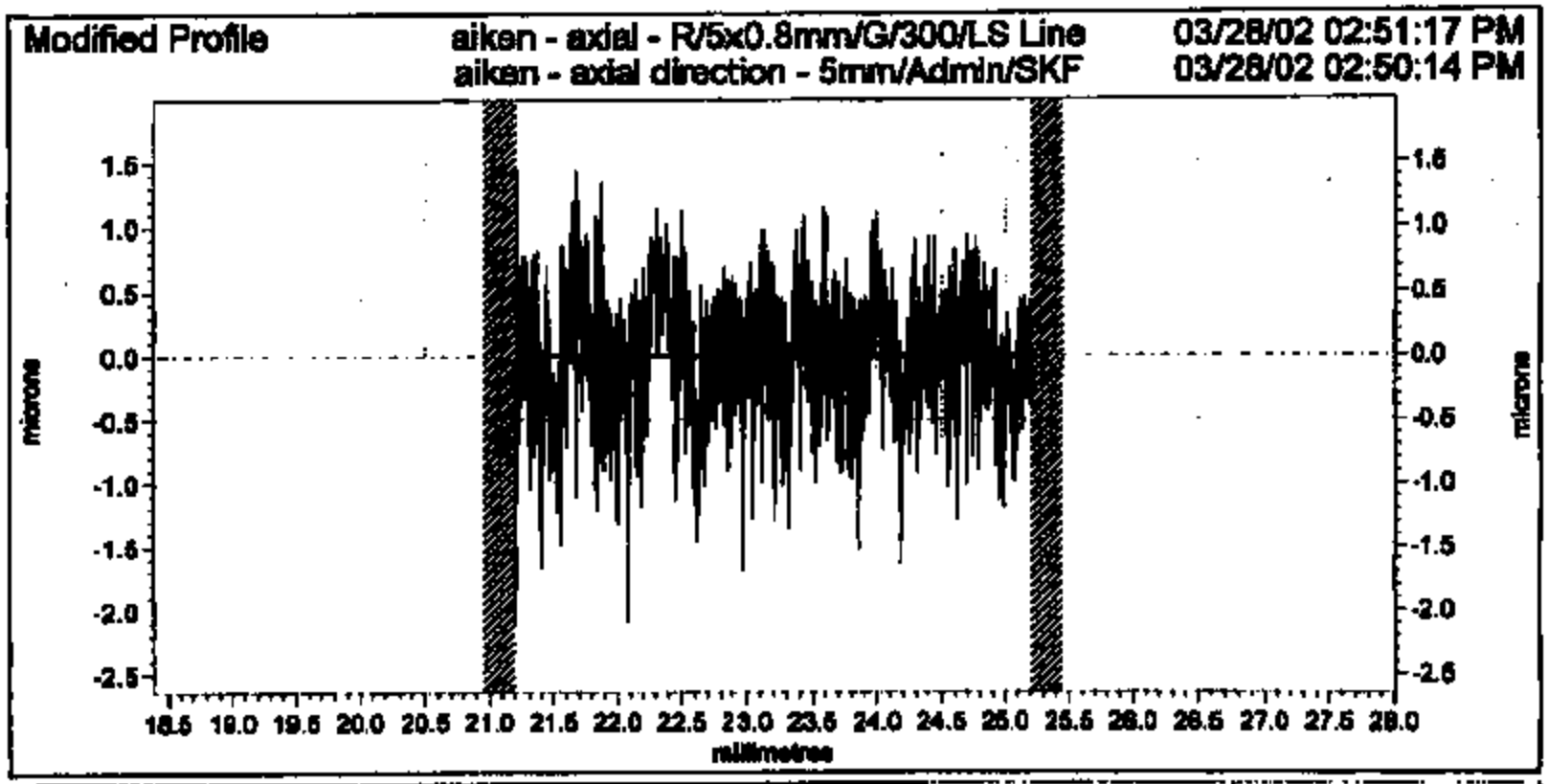
SKF 001181

Taylor Hobson



SKF 061182

Taylor Hobson



Height (mean)	0.000	µm			
Height (mean)	0.000	µm			
mr1%	0.0	%	mr2%	100.0	%
offset	0.000	µm	mr%	50.00	%
offset	0.000	µm	mr%	50.00	%
Height (mean)	0.000	µm	bandwidth	0.00	µm

SKF 001183

Factory: SKF N.A. TECH CENTER
Type:
Operation:

Machine: MWA100 - 4102-01
Operator: Hickling
Shift:

SKF

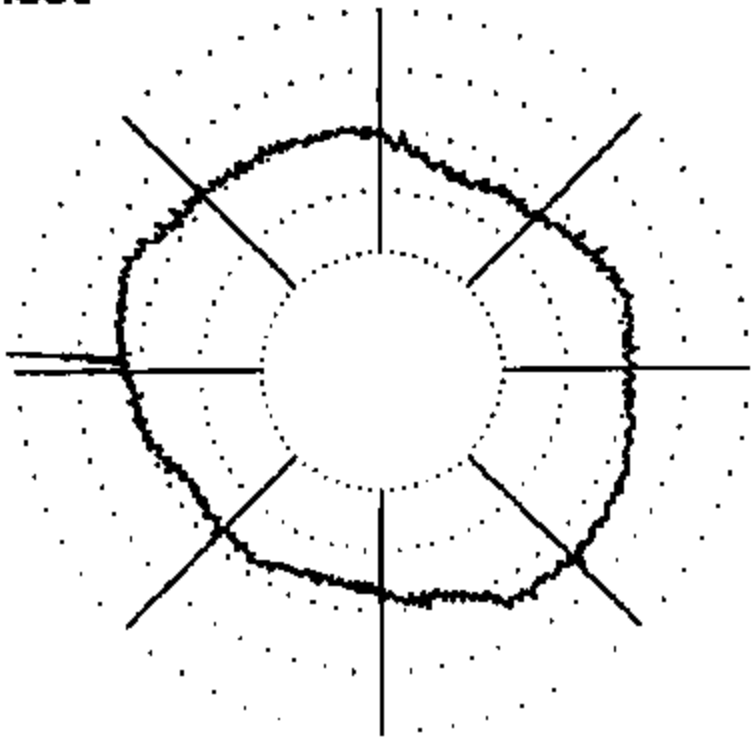
UNFILTERED POLAR DIAGRAM

Note: Luechow

Change MS with +/-
Screen - Configuration
Measuring range

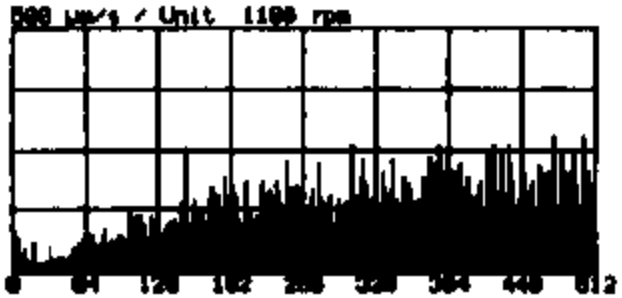
MS01

5 µm / Unit (2000)



FFT	max1	=	1.976 µm
	max2	=	0.646 µm
	max3	=	0.210 µm
LSC	Δr	=	13.596 µm
MD1	L	=	476.035 µm/s
	M	=	1431.97 µm/s
	H	=	1705.81 µm/s

500 µm/s / Unit 1100 rpm



NMP = 1024 4 036 rpm 03/28/02 10:50:02

SKF 001184

Factory: SKF N.A. TECH CENTER
Type:
Operation:

Machine: MWA160 - 4102-01
Operator: Hickling
Shift:

SKF

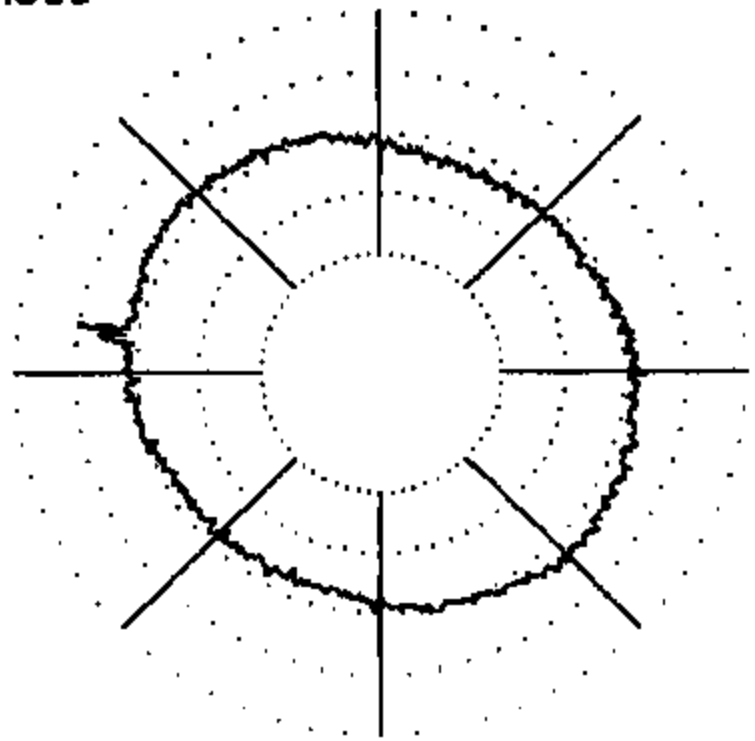
UNFILTERED POLAR DIAGRAM

Note: Aiken

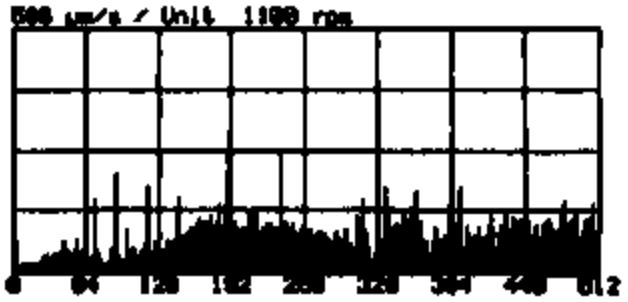
Change MS with +/-
Screen - Configuration
Measuring range

MS01

6 µm / Unit (2000)



FFT	max1	=	1.533 µm
	max2	=	0.125 µm
	max3	=	0.110 µm
LSC	Δr	=	7.201 µm
MDi	L	=	304.772 µm/s
	M	=	1419.71 µm/s
	H	=	942.191 µm/s



NMP = 1024 5.122 rpm 03/26/02 16:58:12

SKF 001165

SKF

SKF Automotive Division
[illegible]

27 MAR 01

BRIAN-

I NEED SURFACE FINISH MEASUREMENTS ON THESE 2 INNER RINGS, ON THE JOINT SHOULDERS, BOTH AXIALLY & CIRCUMFERENTIALLY

WHAT PAPERWORK DO YOU NEED FOR THIS SMALL JOB?

CAN YOU GET THIS DONE BY 28 MAR END OF DAY?

Thanks
Bruce Weeks

Sum of SumOfInvoice	Designation										
Year	Month	BTF-0031	BTF-0032	BTF-0032	BTF-0032	BTF-0048	BTF-0048	BTF-0049	BTF-0049	BTF-0052	BTF-0052	BTF-0065	BTF-0065	Grand Tota
1997	01				4									4
	02	1,170												1,170
	03	2,024			1,075									3,099
	04	630			1,440									2,070
	05	3,600		0	1,301									4,901
	06	1,710			1,506									3,216
	07	3,105			1,125									4,230
	08	2,338			2,460									4,798
	09	2,745			2,299									5,044
	10	4,028			1,436									5,464
	11	2,835			2,115									4,950
	12	3,825			1,350									5,175
1997 Total		26,010		0	16,111									44,121
1998	01	225			1,575			3,150	495					5,445
	02	-25			-2			4,320	1,710					6,003
	03	-108			-68			4,590	3,420					7,838
	04	-27			-16			4,500	2,160					6,617
	05	-6			-11	405	450	3,916	2,200					6,954
	06							3,555	3,330					6,885
	07							3,708	3,011					6,719
	08							2,203	1,028	1,395	765			5,391
	09							135	180	6,789	3,060			10,164
	10							1,575	1,260	3,131	2,070			8,036
	11							43	27	4,725	3,195			7,990
	12				0	0	0	764	1,125	2,551	1,054			5,494
1998 Total		61			1,478	405	450	32,459	19,946	18,591	10,134			83,524
1999	01			0				90	45	5,040	3,555			8,730
	02							126	87	7,611	4,571			12,395
	03							90		4,500	4,230			8,820
	04								1,890	4,896	3,330			10,215
	05									5,946	5,340			11,286
	06									7,020	5,130			12,150
	07							-69		4,095	2,295			6,321
	08						0	0	0	6,525	5,310			11,835
	09									7,380	2,970			10,350
	10									8,280	3,105			11,385
	11									7,605	3,195			10,800
	12									2,702	990			3,692
1999 Total				0			0	237	2,022	71,599	44,021			117,979

2000	01							6,185	2,070				8,235
	02							5,634	2,505				8,139
	03	-1					0	6,030	3,190				9,219
	04							4,410	2,340				6,750
	05							4,805	2,475	810			8,190
	06							180	2,070	4,365			6,615
	07							43	1,167	2,700			3,910
	08							-875	1,260	3,420	315		4,320
	09								45	2,160	1,890		4,095
	10								90	3,060	945		4,095
	11								90	2,520	2,070		4,680
	12									2,243	1,079		3,322
2000 Total		-1					0	26,662	17,302	21,278	6,289		71,570
2001	01									1,440	1,485		2,925
	02									1,170	990		2,160
	03									2,115	990		3,105
	04									1,930	1,529		3,459
	05									1,840	1,260		3,100
	06									1,845	1,305		3,150
	07									1,665	765		2,430
	08									1,890	1,530		3,420
	09									1,530	1,755		3,285
	10									1,845	1,980		3,825
	11									1,530	945		2,475
	12									855	900		1,755
2001 Total										19,655	15,434		35,089
2002	01									2,295	1,305		3,600
	02									1,663	900		2,563
	03									2,430	1,305		3,735
	04									2,682	1,953		4,635
	05									3,735	1,919		5,654
	06									1,611	2,067		3,678
	07									3,510	2,520		6,030
	08									2,281	2,387		4,668
	09									4,408	1,772		6,180
	10									3,827	2,350		6,177
	11									1,659	476		2,135
	12									1,306	464		1,770
2002 Total										31,607	19,418		51,025
Grand Total		1	28,071	0	17,569	405	450	32,696	21,908	116,982	71,457	72,540	41,151	403,308