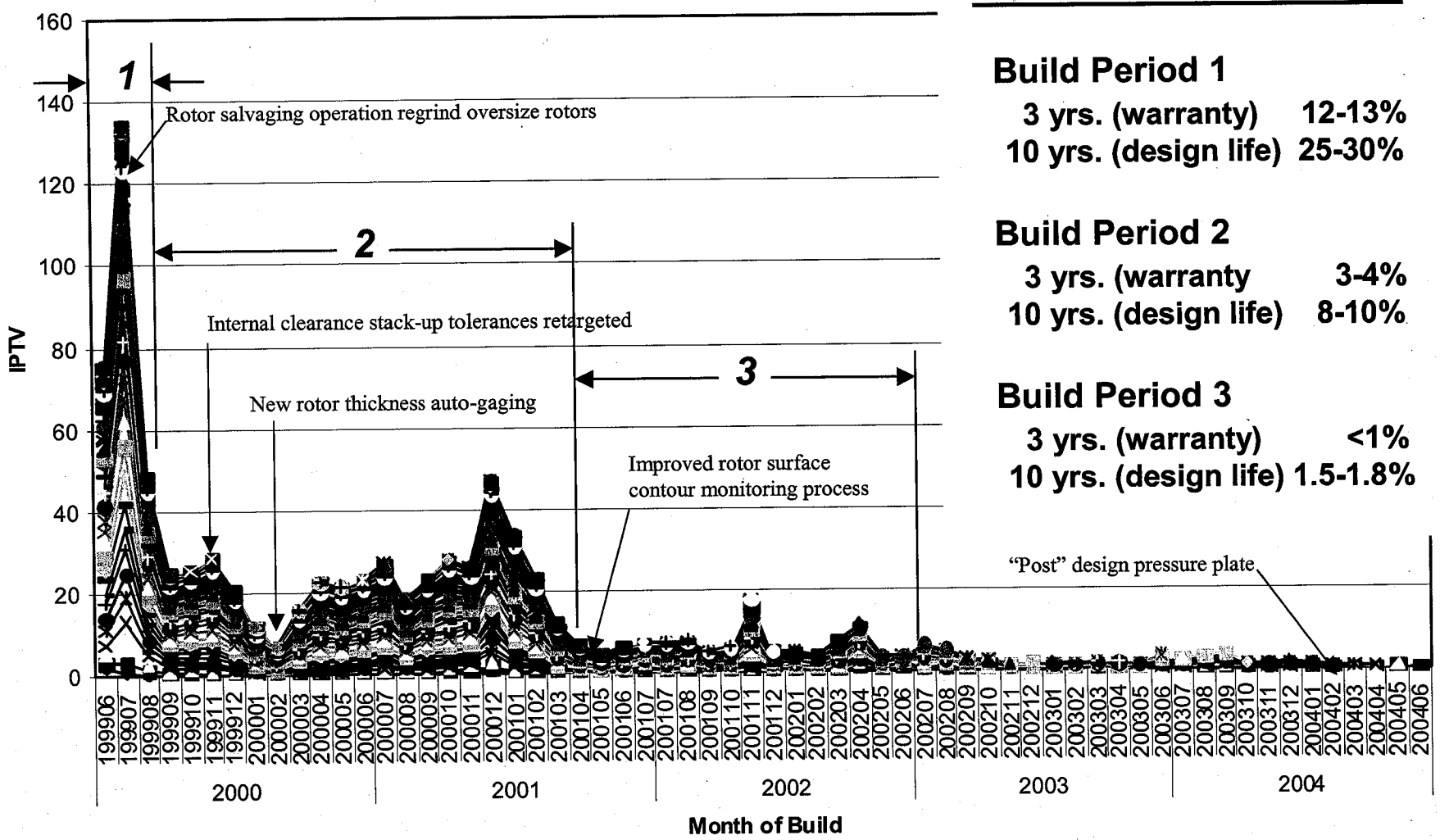
2000 to 2004 2500 and 3500 C/K and G/H Vans Warranty for E9050 (1A, 1D, 4D, 6C) GM651



Weibull Failure Prediction

Build Period 1

3 yrs. (warranty)	12-13%
10 yrs. (design life)	25-30%

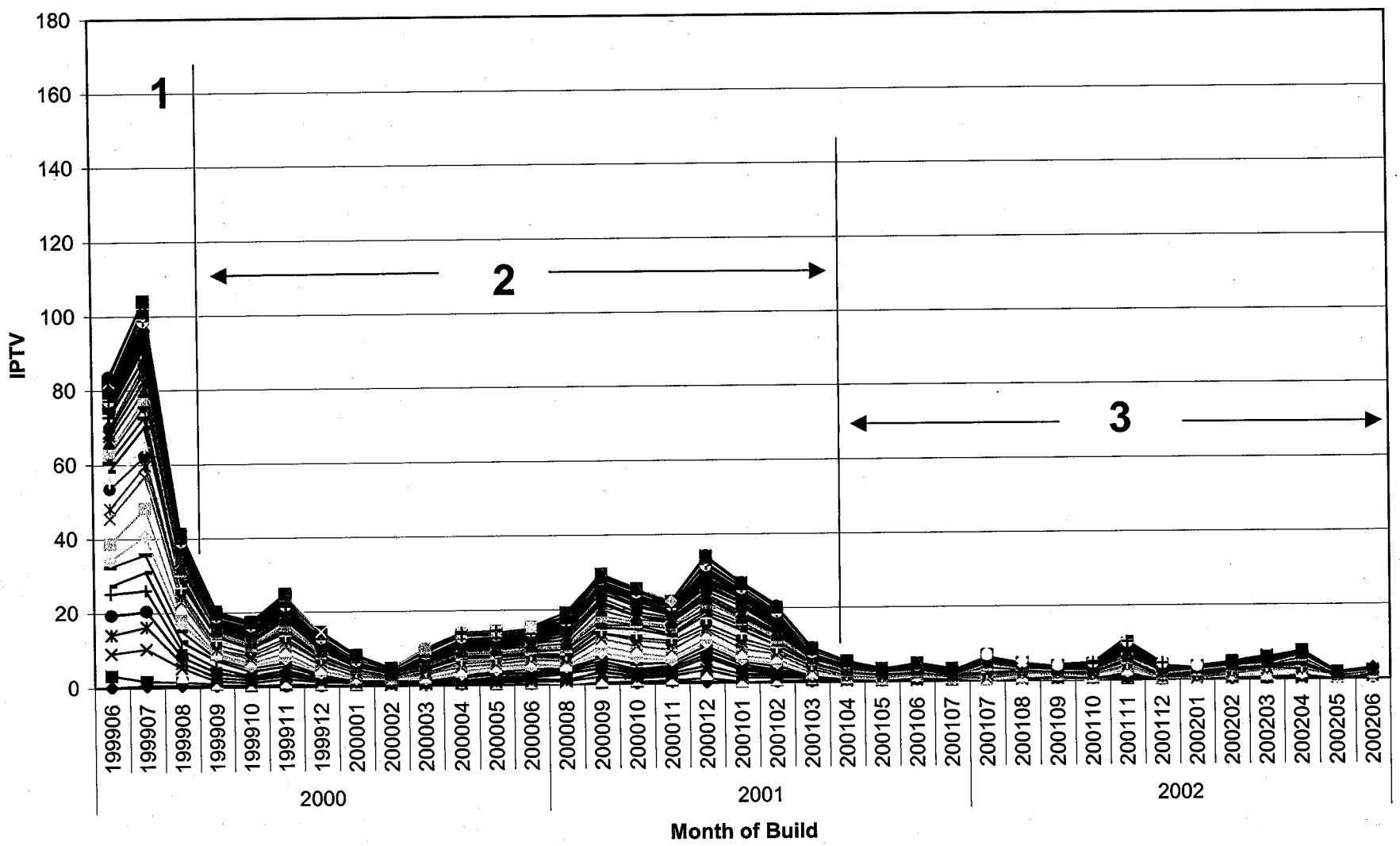
Build Period 2

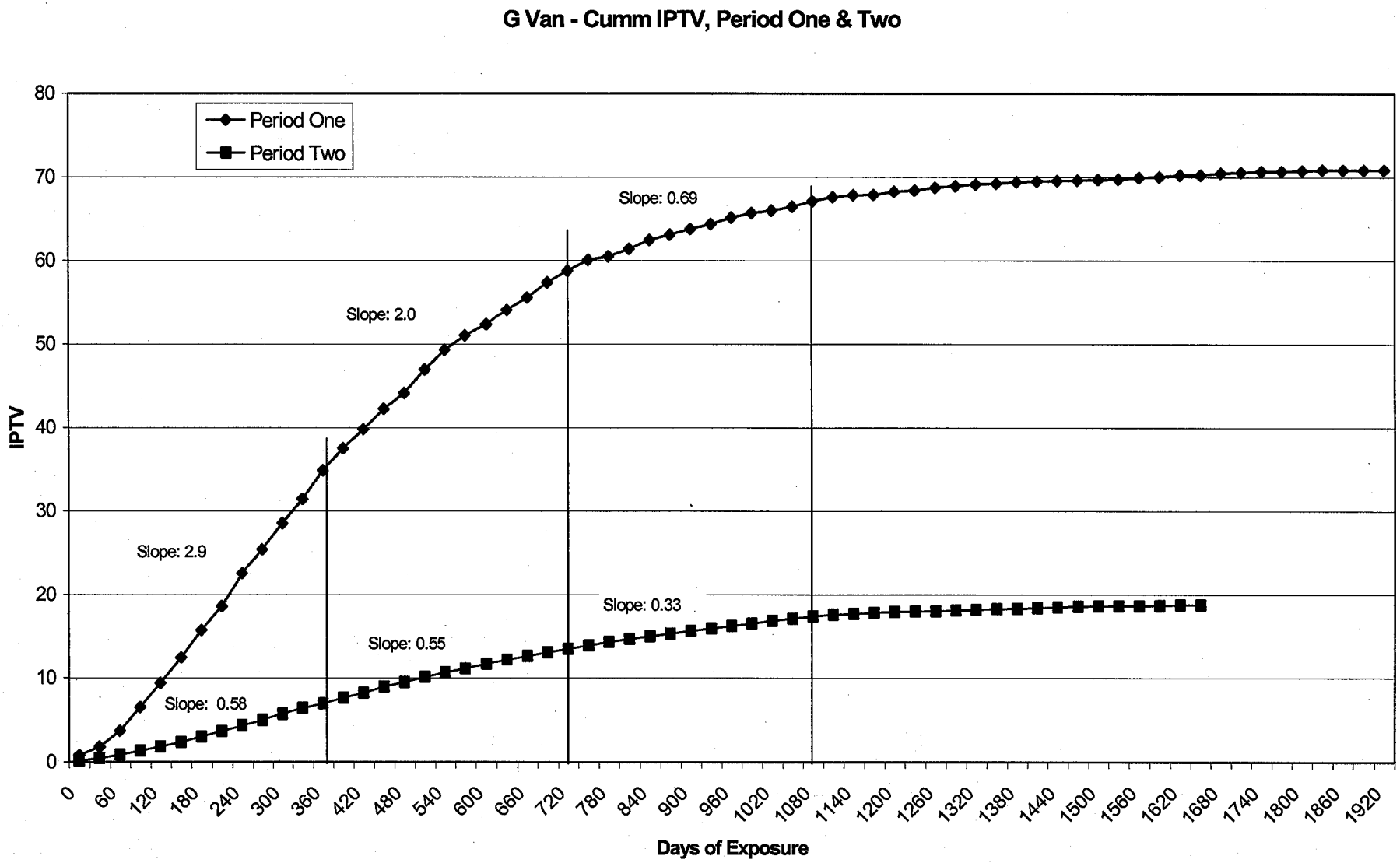
3 yrs. (warranty	3-4%
10 yrs. (design life)	8-10%

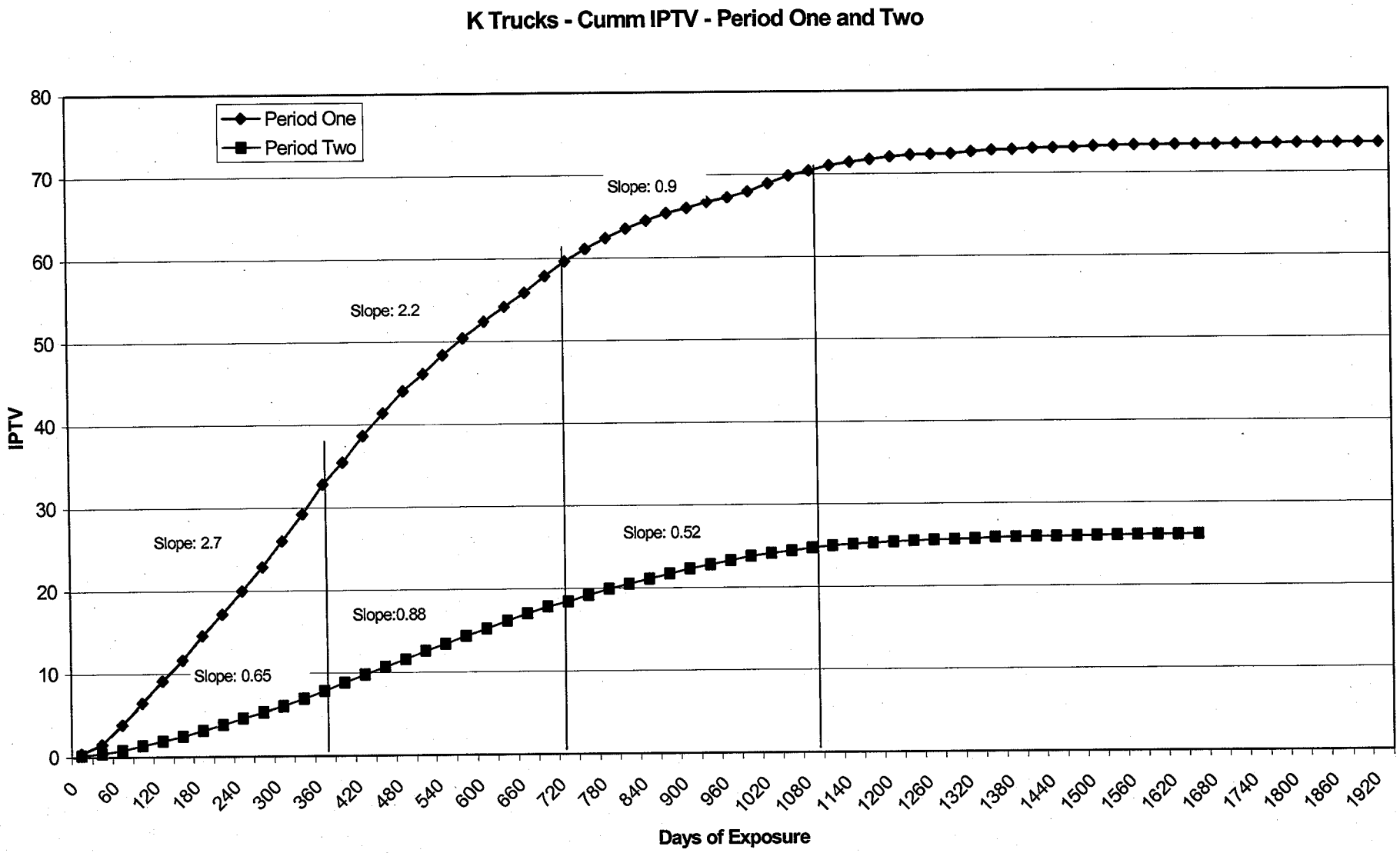
Build Period 3

3 yrs. (warranty)	<1%
10 yrs. (design life)	1.5-1.8%

C series - E9050 Hyrdaulic Pump replace




G Van - Cumm IPTV, Period One & Two
Period One
Period Two
Slope: 0.69
Slope: 2.0
Slope: 2.9
Slope: 0.33
Slope: 0.55
Slope: 0.58
IPTV
Days of Exposure
0
10
20
30
40
50
60
70
80
0
60
120
180
240
300
360
420
480
540
600
660
720
780
840
900
960
1020
1080
1140
1200
1260
1320
1380
1440
1500
1560
1620
1680
1740
1800
1860
1920


K Trucks - Cumm IPTV - Period One and Two
Period One
Period Two
Slope: 0.9
Slope: 2.2
Slope: 2.7
Slope: 0.52
Slope:0.88
Slope: 0.65
IPTV
Days of Exposure
0
10
20
30
40
50
60
70
80
0
60
120
180
240
300
360
420
480
540
600
660
720
780
840
900
960
1020
1080
1140
1200
1260
1320
1380
1440
1500
1560
1620
1680
1740
1800
1860
1920

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GM Contentions

- The pump shaft is most likely to fail during low-speed, parking lot maneuvers.
- If a high speed failure occurs, steering forces are lower. Loss of power steering assist is unlikely to cause serious injury from a high-speed crash.
- The hydro-boost accumulator has enough reserve to allow a transition from power-assisted to manual braking.
- Most drivers of the subject vehicles are male, only 2% were female on their call list.

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Warranty Rates and Parts Sales

ID

PE 04-004

General Motors

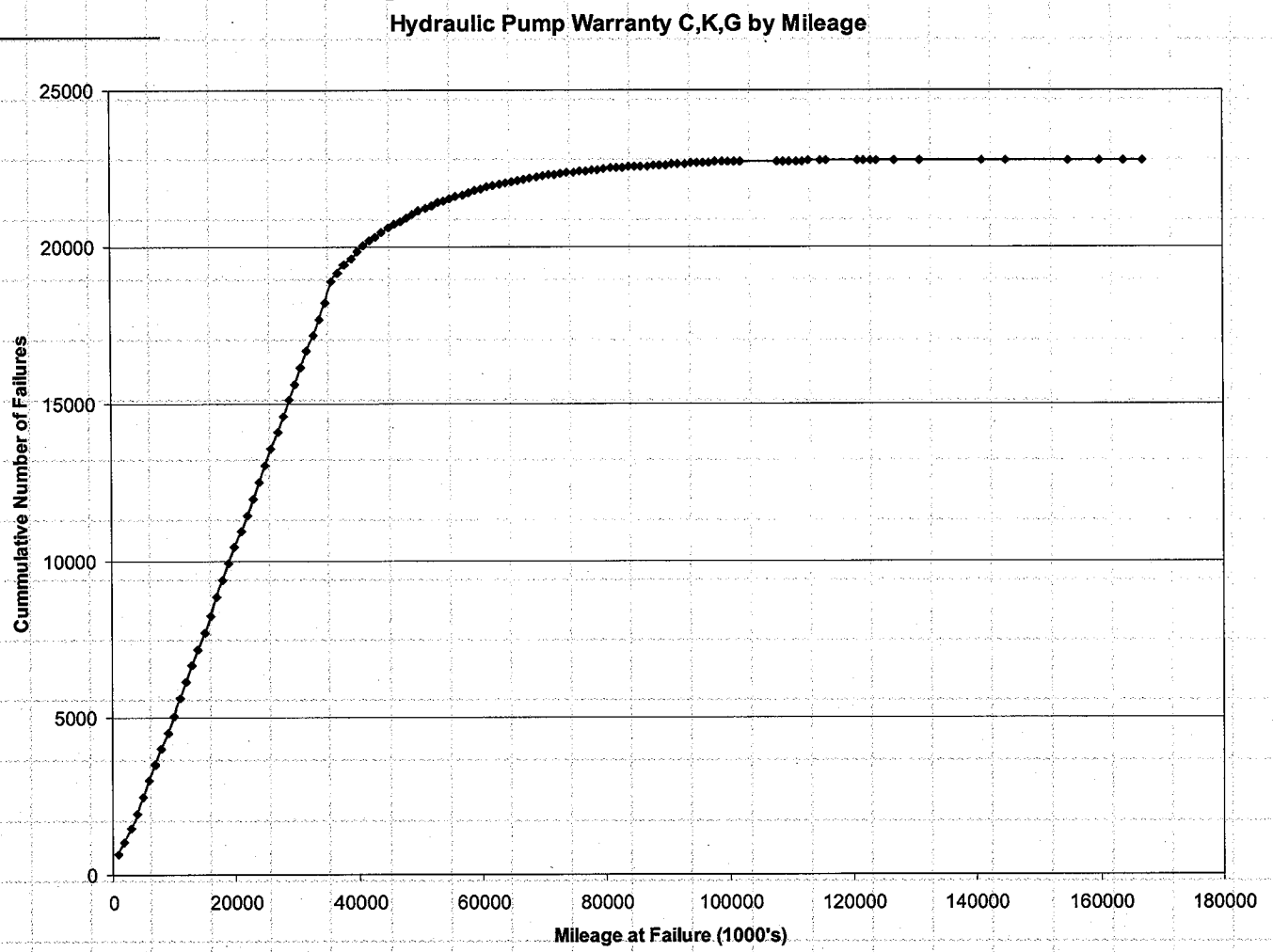
Population

1,137,753

	Counts	Percentage	R/100K
Owner/Fleet complaints	261	0.023%	23
Field Reports	22	0.002%	2
Crash/incident claims	19	0.002%	2
Injuries	4	0.000%	0
Subrogation claims	0	0.000%	0
Lawsuits	1	0.000%	0
Third-party arbitration proceedings	0	0.000%	0
Warranty	20404	1.793%	1,793
Parts Sales	104243	9.162%	9,162

Models		Crashes
Chevrolet Avalanche	6,087	0
Chevrolet Silverado/Fleetside	586,431	13
Chevrolet Suburban	32,998	1
Chevrolet Express	231,978	4
GMC Sierra	182,675	3
GMC Yukon XL	10,714	0
GMC Savana	83,872	0

Pump Warranty Claims



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Comments from GM Crash Reports

- 23 Reports
  - Driving down a steep incline the steering went out and couldn't stop. Lowered plow to help slow, but left the roadway and hit a telephone pole.
  - Customer couldn't steer or brake, ran off the road and hit a tree.
  - Was plowing snow, first realized couldn't steer, then couldn't stop. Slide into snow bank and damaged door.
  - While backing trailer steering and brake failed causing jackknife.
  - Steering and Brakes went out and caused customer to "bump" into a bench at home
  - Female could not stop her vehicle for stopped vehicle in front of her from 20mph. GM settled lawsuit Aug 03

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Comments from GM Crash Reports

- Steering went out and hit a tree, breaking the side mirror.
- While towing trailer lost brakes and hit a fence pole. Construction vehicle.
- Making a left turn going up a hill steering failed and slid into a ditch and hit brush and a small tree at approx 15 mph.
- Steering "locked" then brakes "locked" resulting in the vehicle to "go over a mountain"
- Steering went out and couldn't brake, drove over a bank and wrecked vehicle.
- Driving across field when steering and brakes went out, hit a bench containing iron pile
- Steering and Brakes went out, going 20-25 mph down hill… and hit 2 parked cars

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Comments from GM Crash Reports

- Vehicle was parked, when put in gear, no brake or steering and hit a pole.
- Customer was hooking up to a trailer when the pump failed. Vehicle didn't stop as expected and hit trailer causing damage.
- Collided with a mailbox.
- Driving to cabin on snow covered road, driver noticed that steering was very difficult, then slid off road and hit telephone pole
- Customer tried to slow, but no brakes and couldn't steer. Resulted in hitting a fence.
- Couldn't stop for an intersection. There was a vehicle in front of customer, so he turned to the right to avoid that car but could not correct to avoid hitting barrier.

Comments from GM Crash Reports

- Backing out of driveway and couldn't steer. Backed into ditch and damaged running board
- Couldn't stop for a stop sign. Reported to police
- Power brakes and steering went out when descending a mountain. Reported to police

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Vehicle Research and Test Center

Hydraulic Pump Failure on GM Hydro-boost Vehicles MY 2000-2004

Pump Failure on GM Hydro-boost

- Hydro-boost Background
- VRTC Testing & Video
- Summary and Conclusions
- Additional Information
  - NHTSA VOQ Interviews
  - GM Crash Data
  - Delphi Pump Information
  - Bosch Hydro-boost

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Alleged Defect

- Hydraulic (power-steering) pumps are failing at high rates on GM Hydro-boost trucks resulting in loss of power-assist to both steering and brakes.
  - Population ~1,140,000 (MY 2000-2002)
  - 20,000 warranty claims (1,800 per 100K)
  - 100,000 part sales (9,000 per 100K)
  - 23 alleged crashes
  - Four injuries

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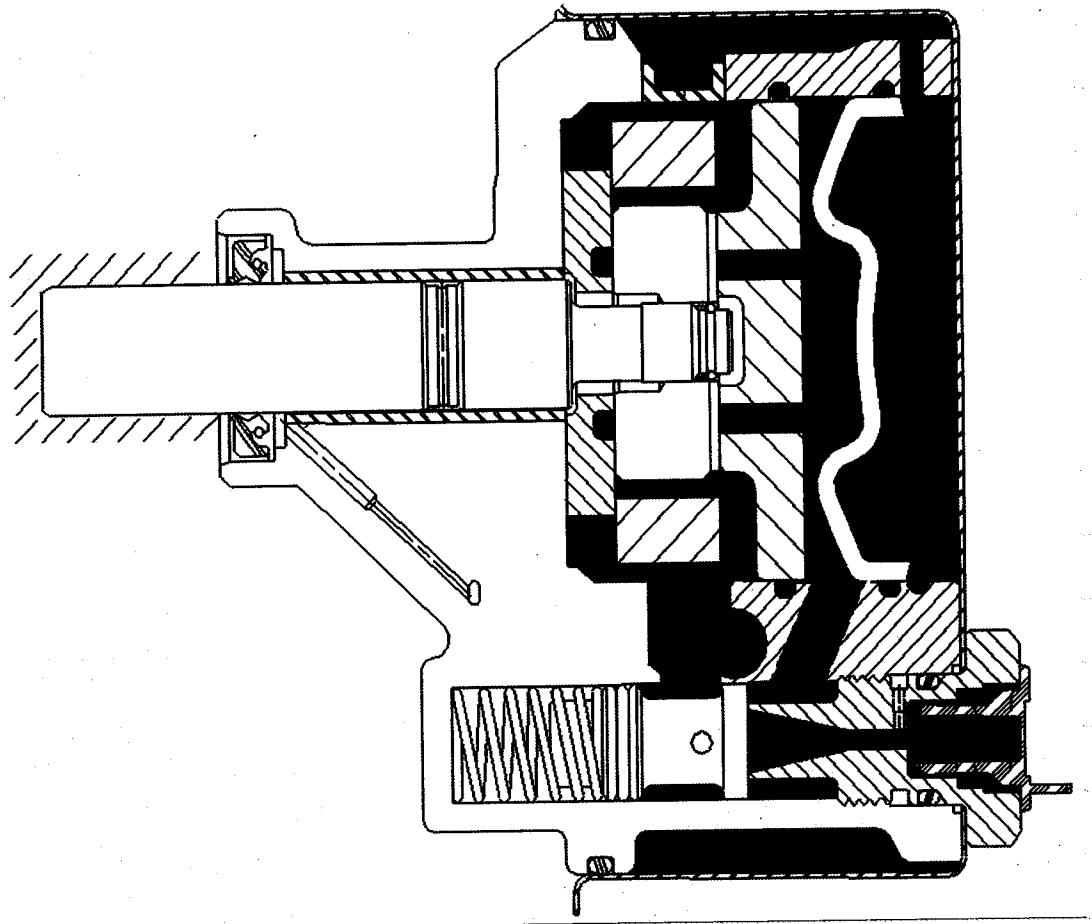
Test Objectives

- Quantify steering and braking performance degradation with pump failure.
- Evaluate how drivers respond to simultaneous loss of power-assist for steering and braking.

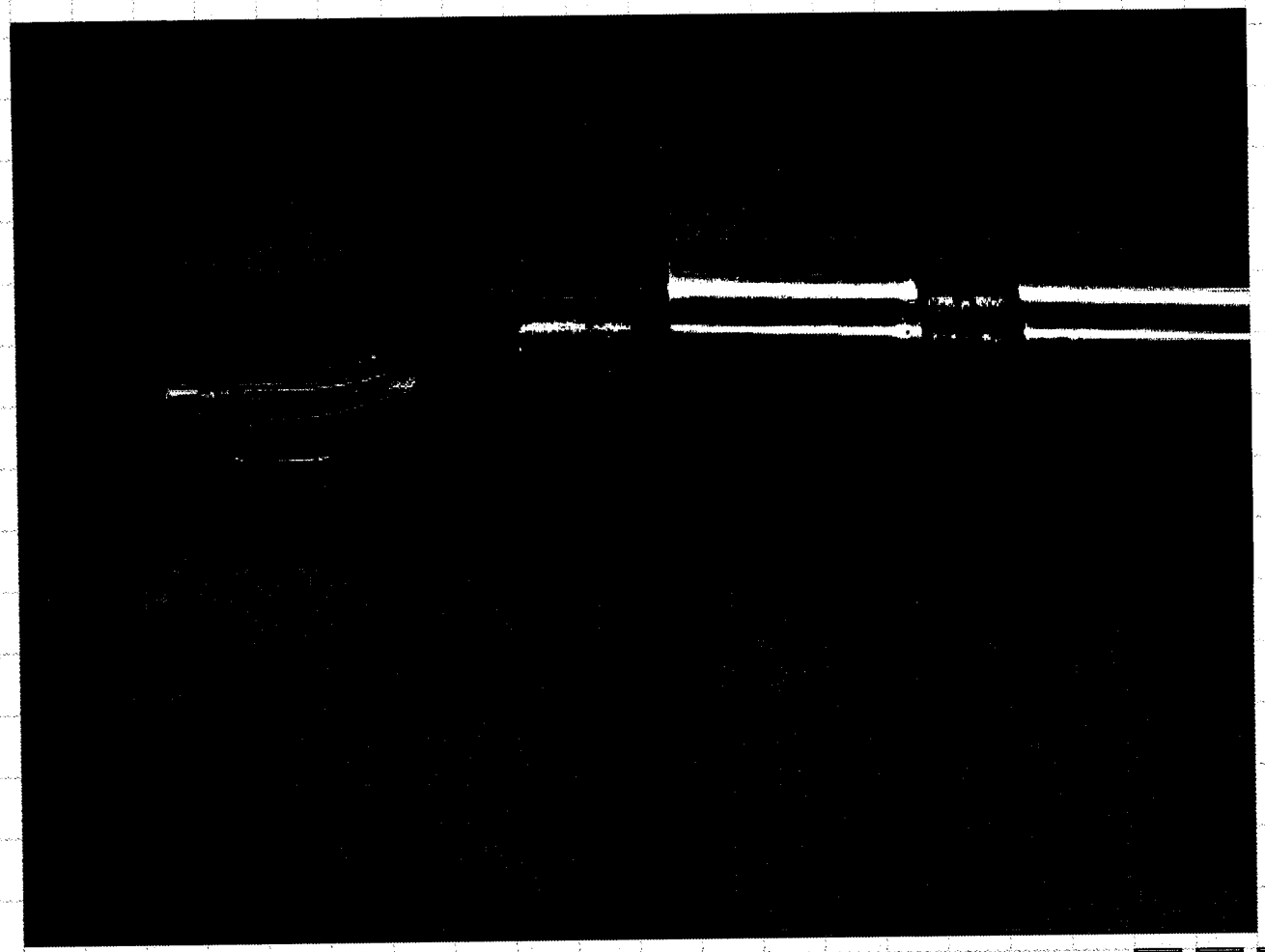
Hydro-boost System

TFR-ISO WORK

Delphi Pump Cross Section



Broken Drive Shaft



VRTC Testing

- Brake Tests
  - FMVSS 105
  - Brake Line Pressure Tests
- UN ECE Steering Test
- Human Factors Tests
  - Description of TRC Driver Tests
  - Video of Typical Tests
  - Summary of Results
  - Conclusions

Subject Test Vehicle

Chevrolet Silverado K3500

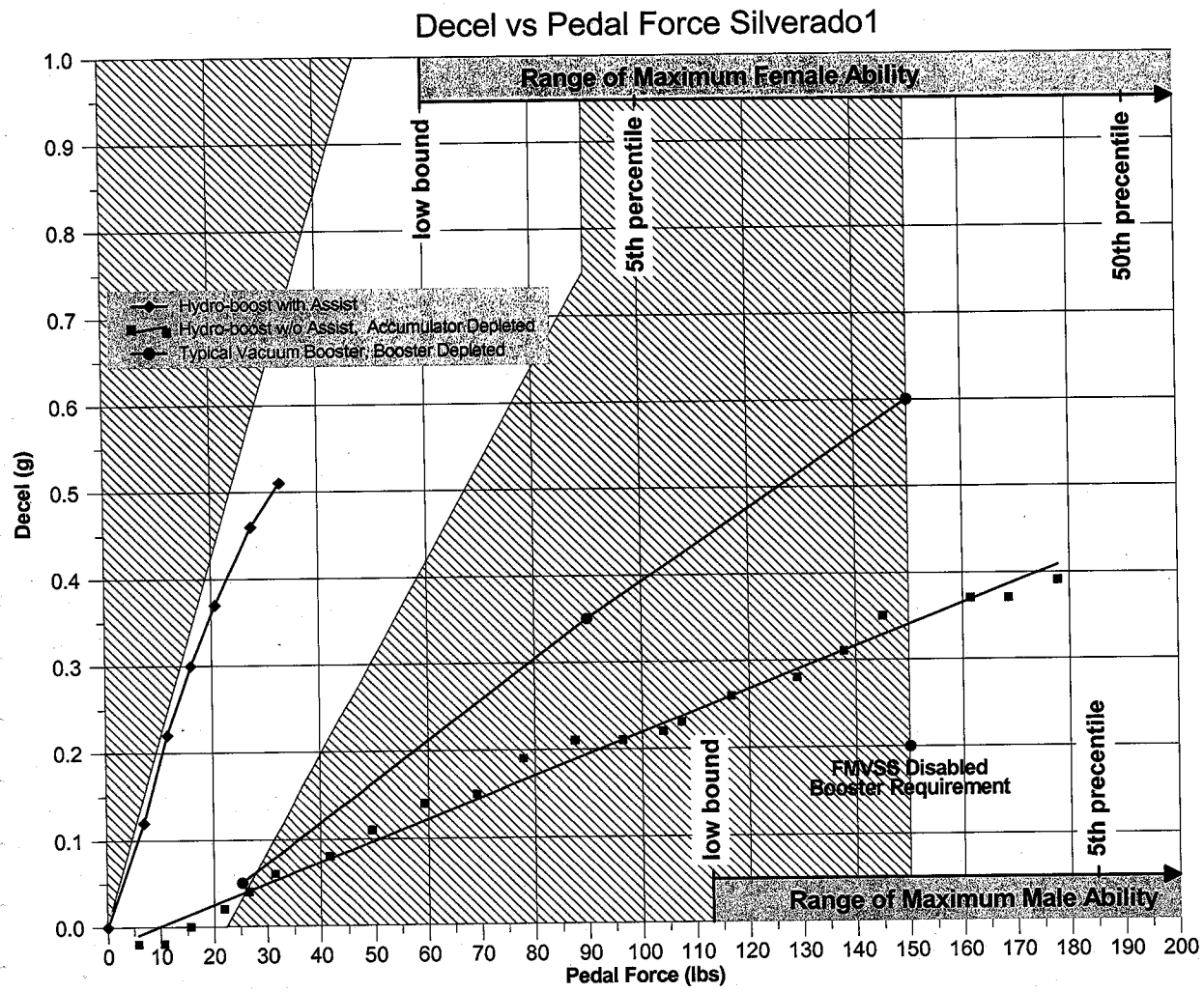
4wd, Extended Cab with Dual Rear Wheels

Diesel 6.0L, 154.5 inch WB, 14,400 GVWR

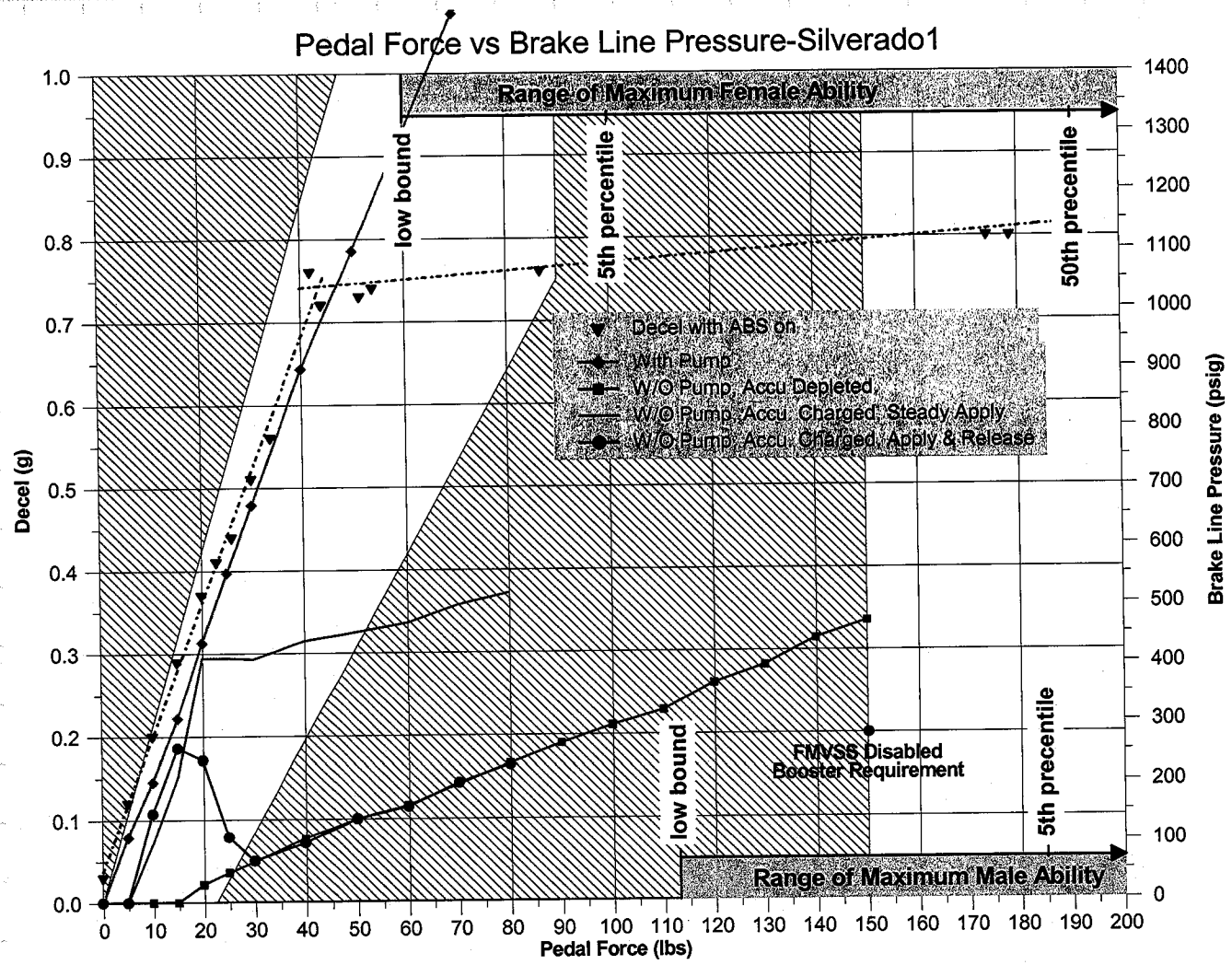
Instrumentation

- Data acquisition
  - Steering wheel torque
  - Steering wheel angle
  - Vehicle speed
  - Brake pedal force and travel.
  - Deceleration.
  - Power steering pump pressure
  - Front & rear brake line pressure (BLP)
- Pump flow diverter valve with manual switch

105 Brake Tests



Brake Line Pressure Tests



Steering Test

Steering Tests in Accordance with UN Standard
GM C/K Trucks with Hydro-boost

Vehicle tested: 2001 Chevrolet Silverado K3500, loaded to GVWR (11,400 lb).

The tests were conducted May 25, 2004 using the M1 category vehicle criteria, which has the highest performance requirements (sharpest turn, lowest efforts). M1 is for a passenger vehicle with at least four wheels and up to nine passengers.

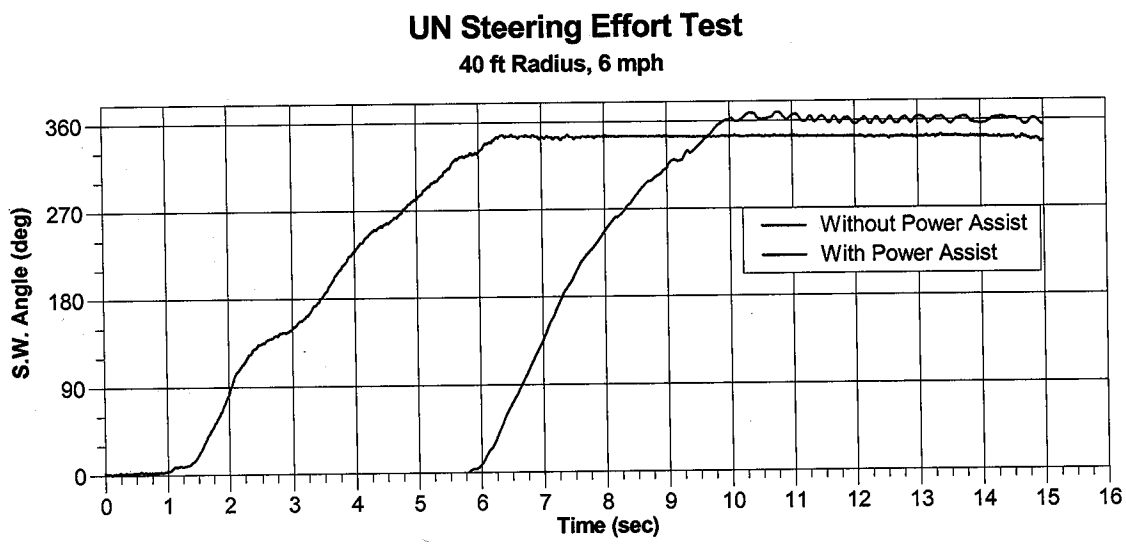
The tests were conducted per the following sections with the pump on and the pump off.

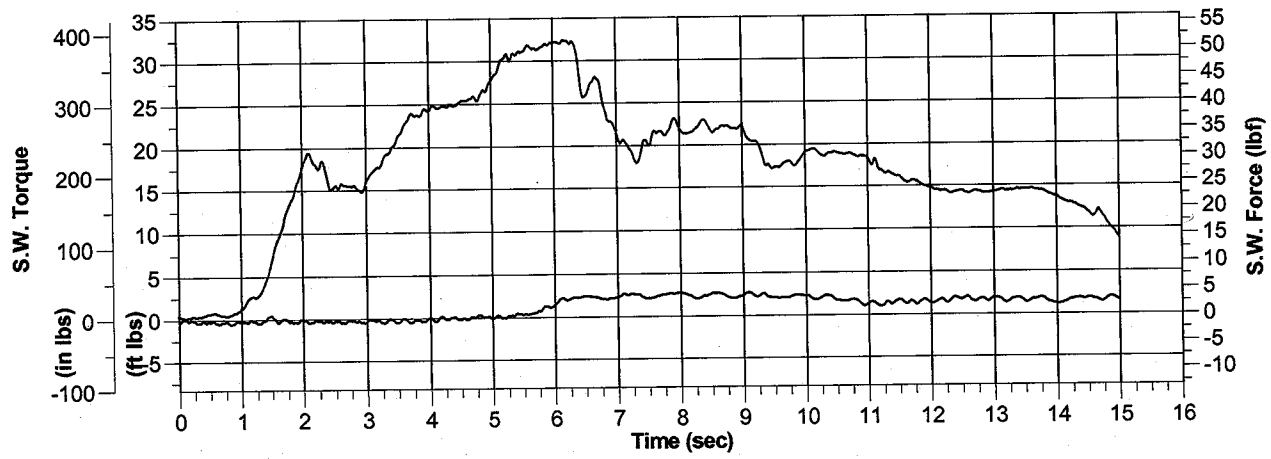
Section 6.2.5. Measurement of steering efforts with intact steering equipment:
Section 6.2.6. Measurement of steering efforts with a failure in the steering equipment.

The tests were conducted with the vehicle moving at 10 kph (6.2 mph). The steering wheel was turned to the required turn radius in 4 seconds.

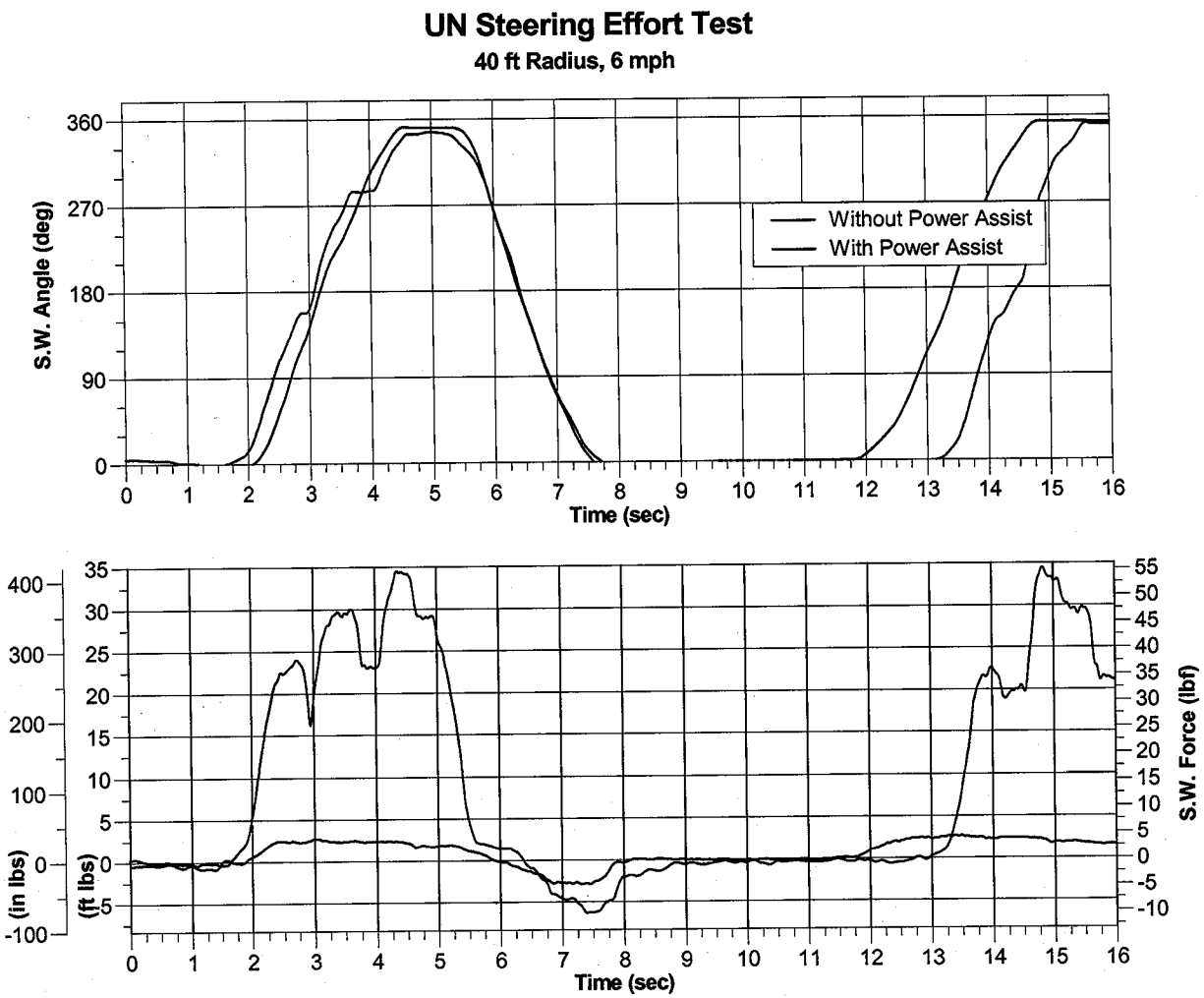
	Test Criteria				Results	
	Turn Radius	Steering Wheel Angle	Maximum Steering Efforts	Equivalent Torque	Average Peak Torque	Average Peak Force
Pump on	12 m (40 ft)	350°	15 daN (34 lb)	250 in-lb	45 in-lb	6.0 lbs
Pump off	20 m (66 ft)	220°	30 daN (67 lb)	500 in-lb	300 in-lb	40.0 lbs
Pump off	12 m (40 ft)	350°	n/a	n/a	400 in-lb	53.3 lbs

Steering Test





Steering Test



Human Factors Tests

- Tests were structured as a driver/vehicle braking reaction and performance tests.
- The first failure was a surprise event.
- Pilot Tests were conducted to practice and develop the test procedures.
- TRC Drivers were used.

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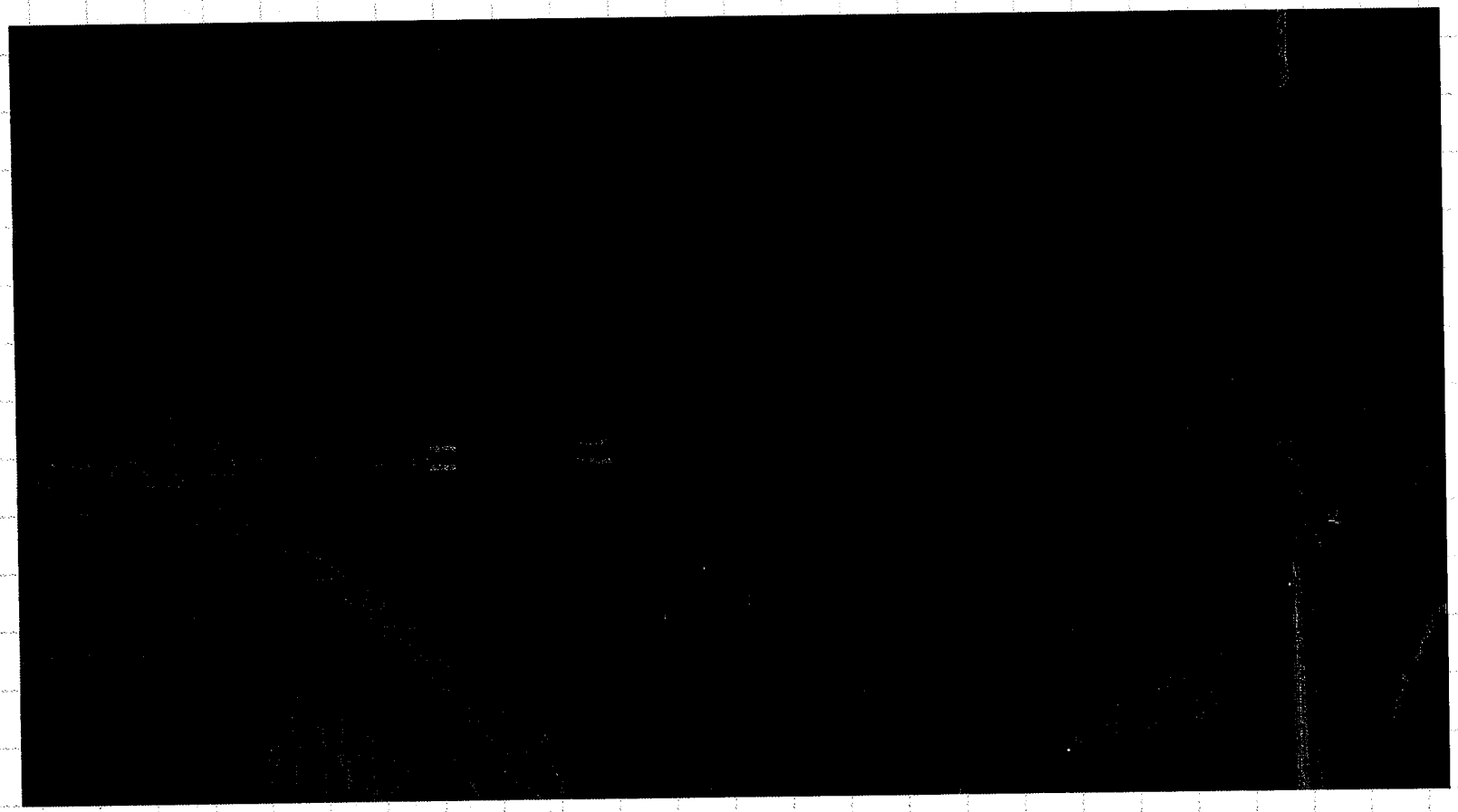
Test Sequence

- Driver briefing, information form with secrecy reminder.
- On-board observer briefing from script.
- Record static brake applications for normal and maximum pedal effort.
- Five to six stops or until the driver is comfortable with the routine.
- Failed pump tests.
- Questionnaire & debriefing.

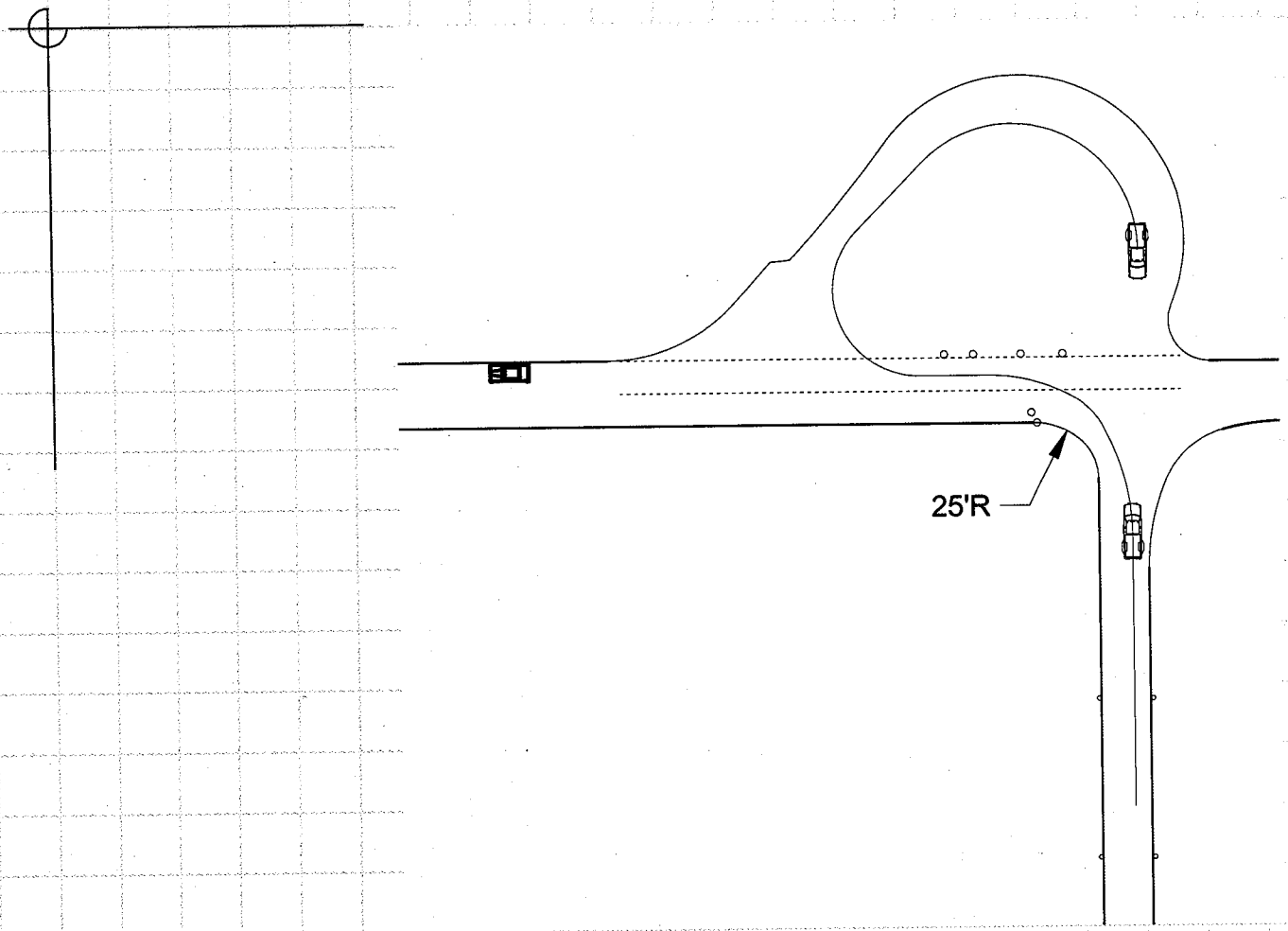
Failed Pump Tests

- 1st Failure-designed to surprise the driver.
  - Then the true purpose of the test was explained and hydro-boost was described.
  - For the remaining tests, the driver knows the pump will fail but does not know when.
- Turns with pump shut-off during the turn.
  - Left turns at intersection, Two failures per driver.
- Turns with pump shut-off before the turn.
  - Turns with partially depleted brake accumulator.
- Record driver's maximum steering efforts.

ABS Course



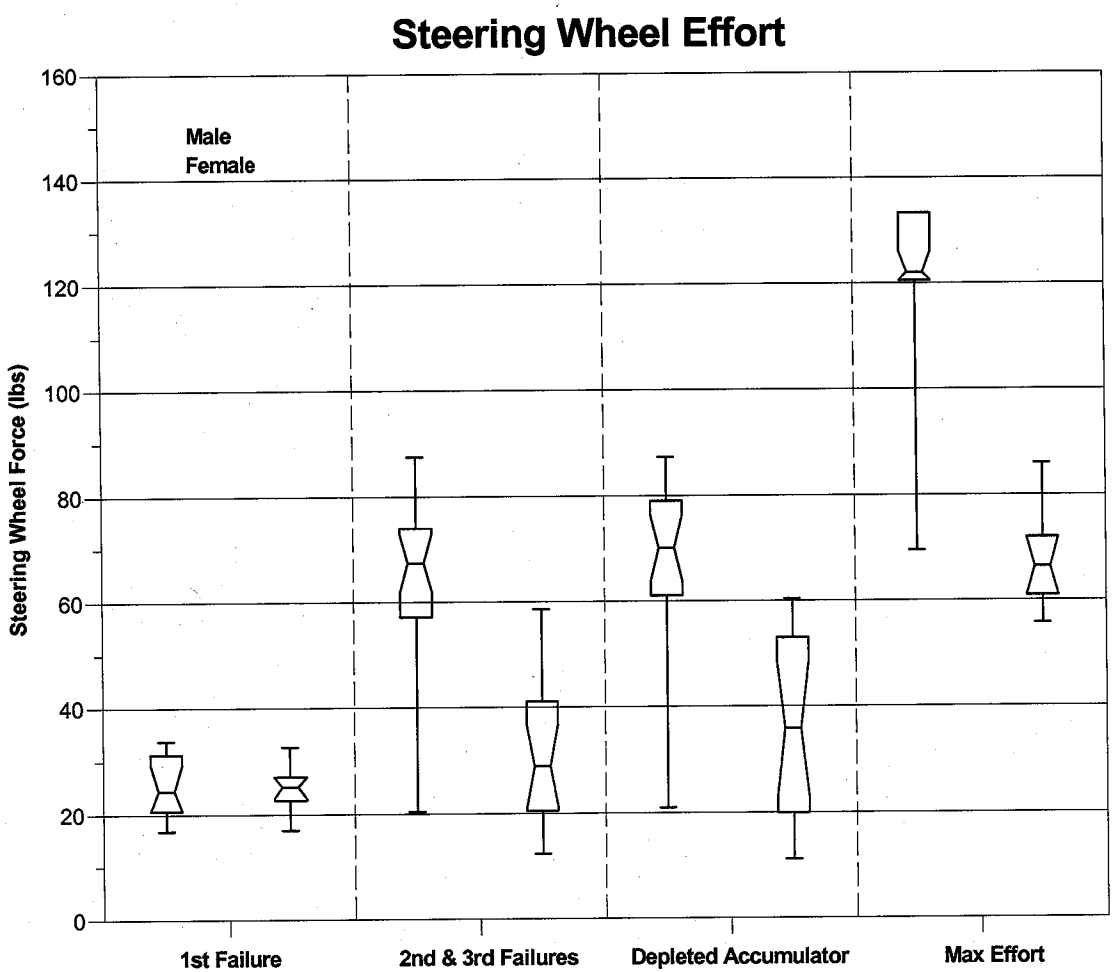
ABS Turnaround



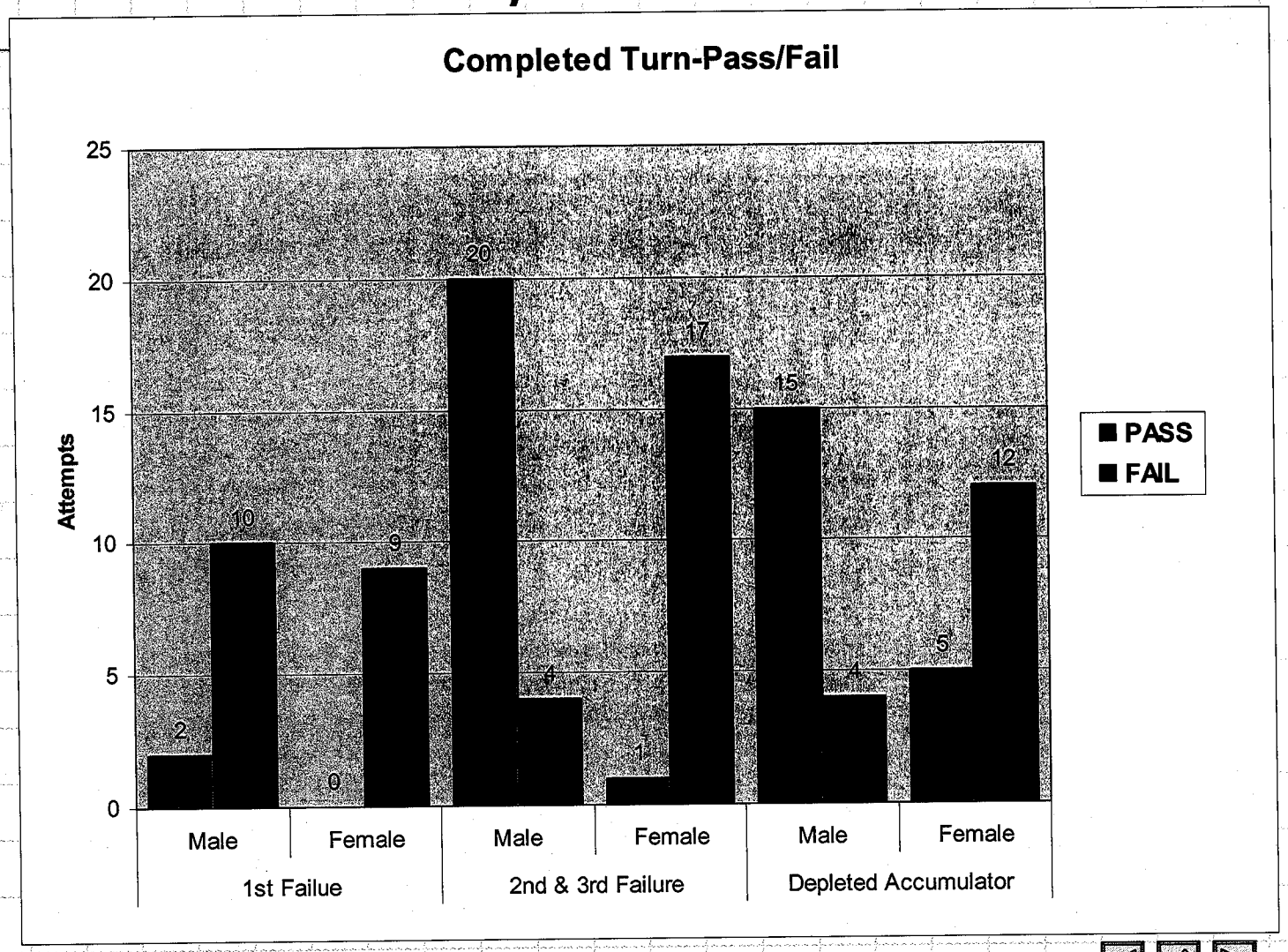
Human Factors Testing

Video

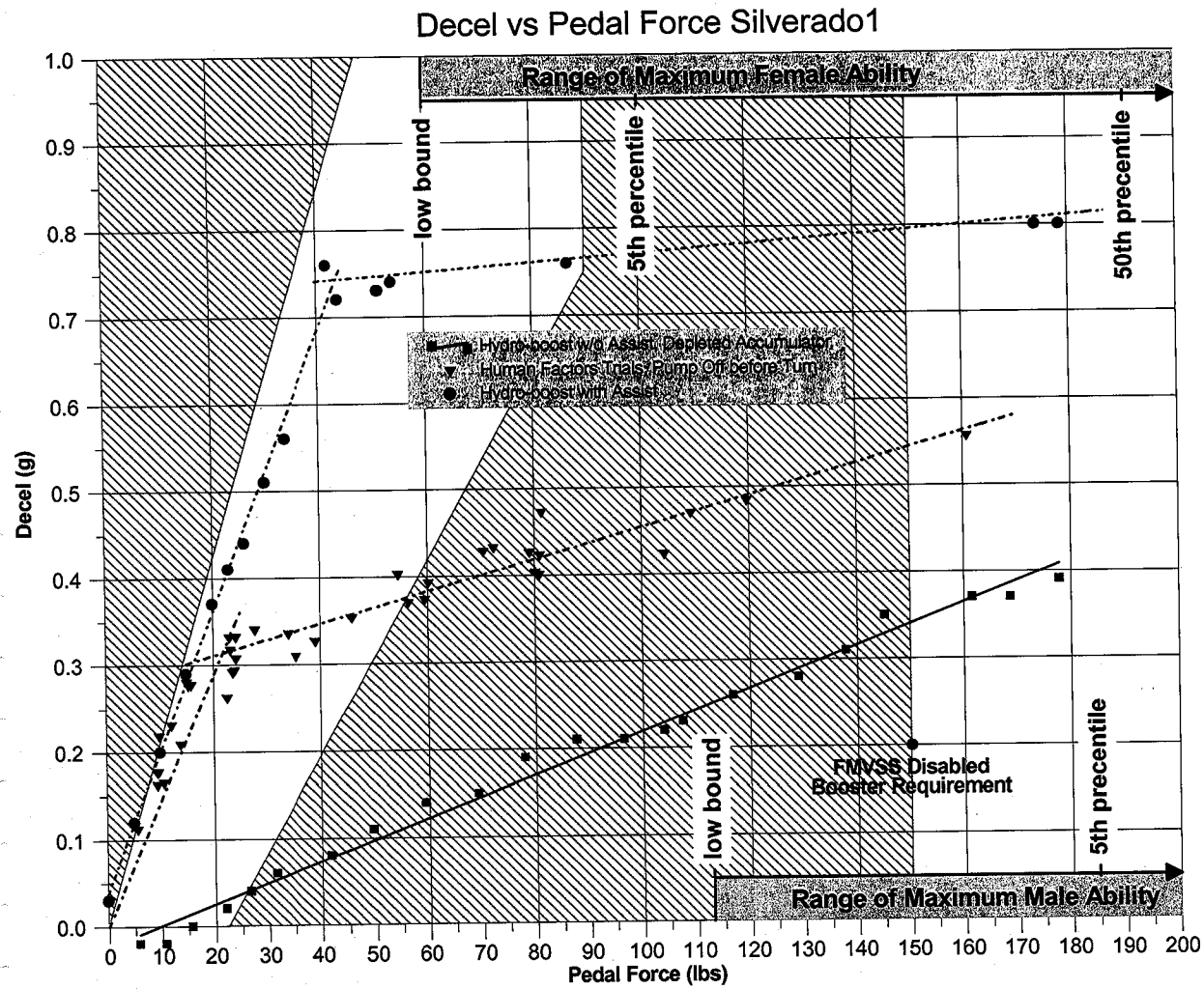
Steering Efforts



Pass/Fail Results



Partially Depleted Accumulator Test



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Summary

During the surprise event:

- Drivers gave up at an average of 25 lbs steering wheel force.
- Men and women performed about the same.
- Even though drivers may be capable of driving without power-assist, drivers may quit or react too slowly.

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Summary

After the surprise event:

- The turn required an average of over 60 lbs SW force.
- Most male drivers were able to make the turn.
- Women were capable but not willing to exert the required steering efforts to make the turn.

Summary

During turn with added brake applies:

- Some drivers did not attempt to turn.
  - Drivers would either steer or brake during the tests.
- Performance of male drivers decreased, performance of female drivers increased.
- The added task distracted some drivers.
- Most drivers commented on the reduced brake capability.

NHTSA

Summary

- GM contends there is a low risk of *serious* injury because the pumps are most likely to fail at low speed, parking lot maneuvers.
- Delphi found that pumps failed under low temperature, high RPM conditions.
- Almost half of the VOQ failures were over 15 mph.
- At low speeds, drivers anticipate a shorter stopping distance, and when they perceive a problem, they do not have time to react even if they are capable of applying the additional pedal force.
- GM's position does not account for striking a pedestrian or being struck by a fast-moving vehicle.

NHTSA

Summary

- GM contends that if a pump fails at higher speed, low steering forces will allow the driver to transition to manual steering and maintain control. The brake accumulator will provide enough reserve to stop.
- Some drivers react by pumping the brake pedal, depleting the accumulator before stopping.
- Some drivers think they have experienced a total brake failure when normal brake capacity is not available, and fail to apply sufficient pedal force.
- Some drivers simply freeze and fail to respond when confronted with an unfamiliar hazard.

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Summary

- Some drivers are not aware that Hydro-boost powers both steering and brakes. (Based on VOQ interviews and TRC driver debriefing)
- Manual efforts for steering and braking are higher than in the past as manufacturers design trucks to reduce efforts to be more like passenger cars.
- Many complainants stated that steering and brakes were lost at the same time. (They either depleted the accumulator, it was not fully charged or it leaked).

Conclusions

- Loss of power-assist on brakes or steering does not normally present an unacceptable risk to the public because the failure rate is usually very low.
  - Vacuum boosters fail at a rate of less than 0.1 per 100K vehicles per year.
- Loss of power-assist on steering or brakes can create a hazardous situation if the failure occurs at exactly the wrong moment under the wrong conditions.
- A high failure rate places the public at risk.
- A combined loss of assist increases the hazard- (drivers must process additional inputs and make more decisions).

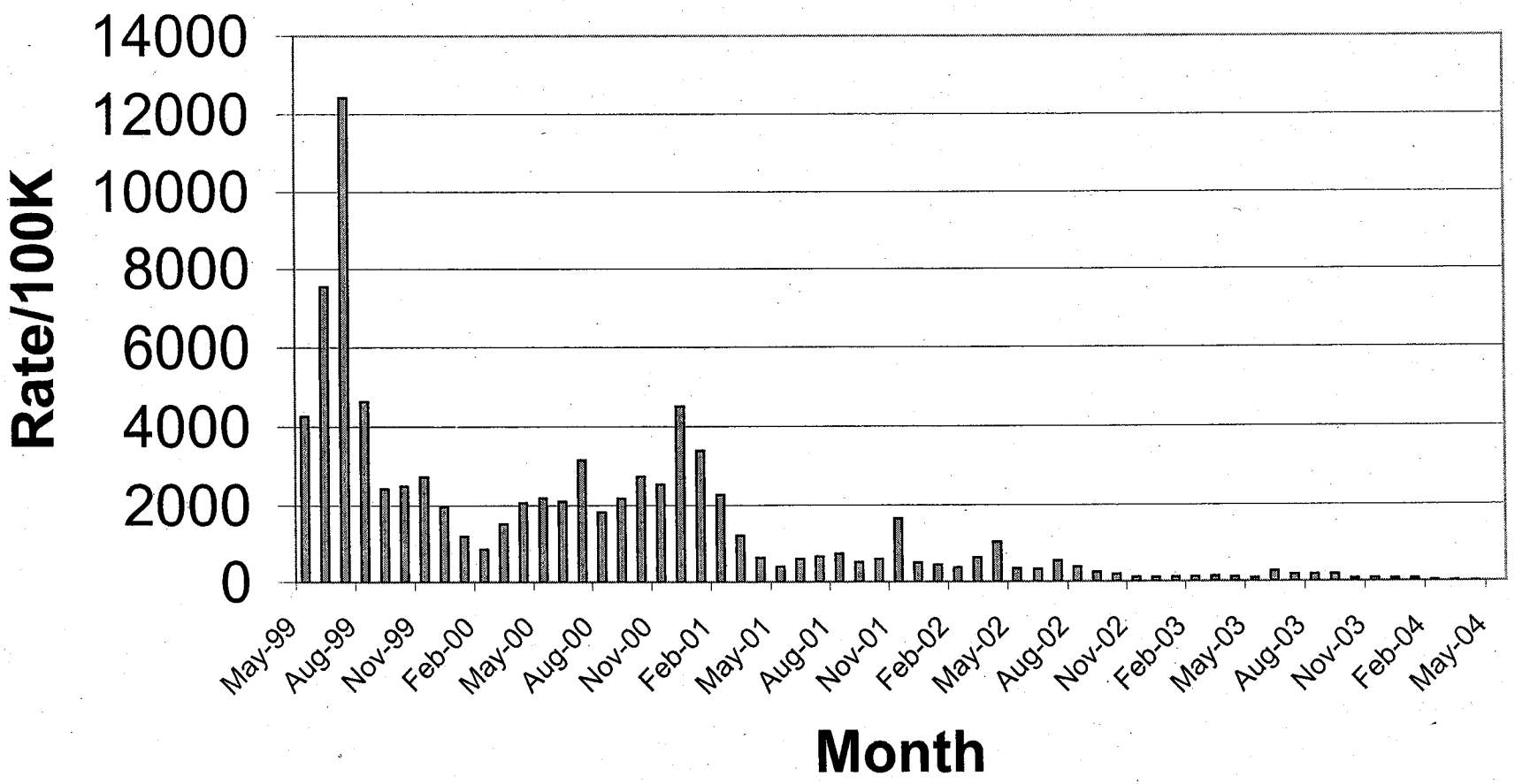
Other Information

- NHTSA VOQ's
- GM Crash Data
- Delphi Pump Information
- Bosch Hydro-boost

Warranty

Population	Range	Vehicles	Population	Rate/100K
1	Jun 99 - Oct 14, 99	5,455	98,221	5,553.8
2	Oct 14, 99 - Mar 30, 01	11,370	501,976	2,265.0
3	April 1, 01 - June 04	4,130	1,280,292	322.6
		20,955	1,880,489	

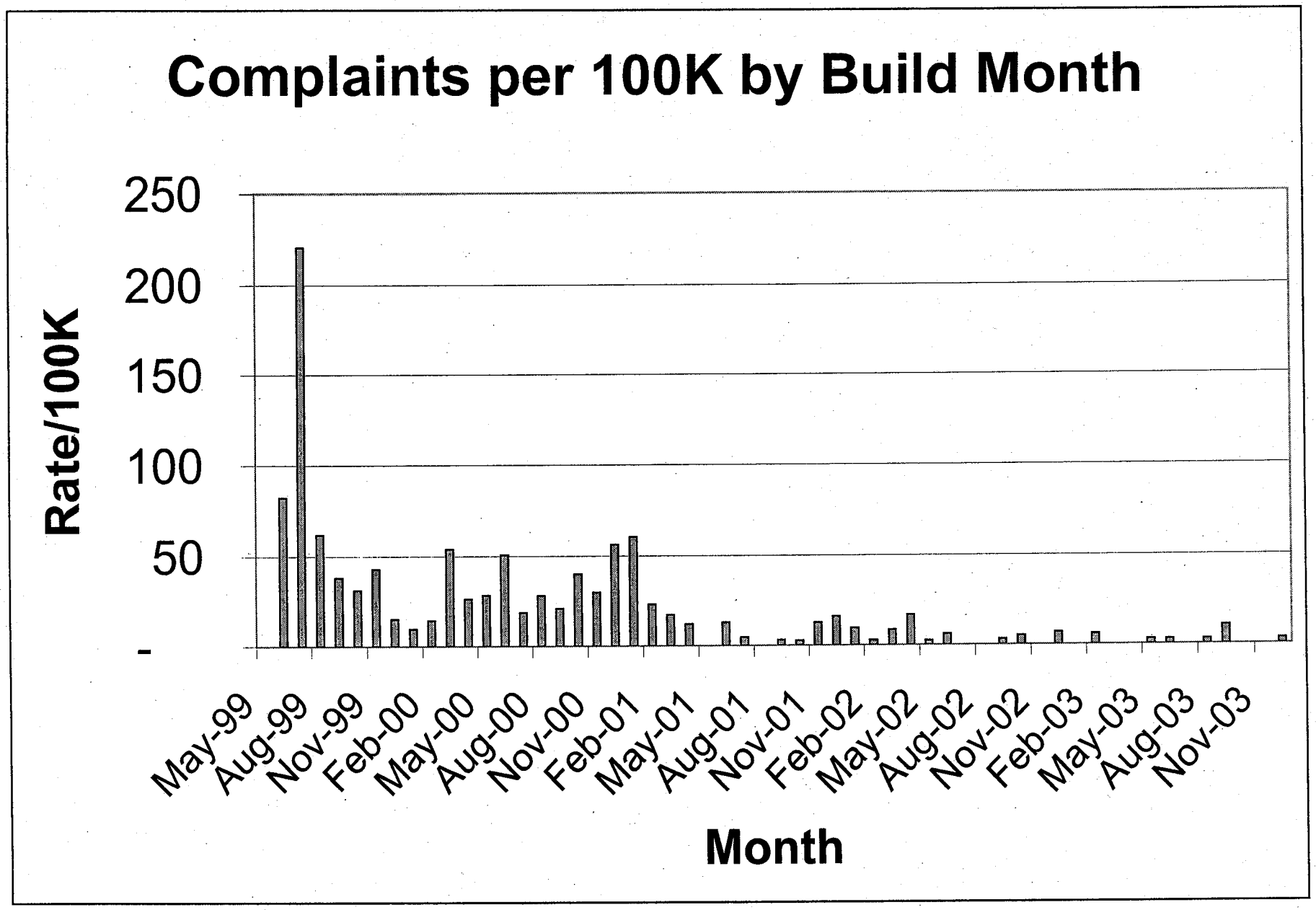
Normalized Warranty Data per Build Month



Month	Build	Warranty	Rate/100K
May-99	164	7	4268
Jun-99	8,460	637	7530
Jul-99	15,869	1972	12427
Aug-99	33,888	1576	4651
Sep-99	31,205	754	2416
Oct-99	31,787	791	2488
Nov-99	27,809	757	2722
Dec-99	26,387	518	1963
Jan-00	31,063	372	1198
Feb-00	34,576	295	853
Mar-00	40,782	619	1518
Apr-00	30,233	621	2054
May-00	35,078	762	2172
Jun-00	33,580	703	2094
Jul-00	10,654	335	3144
Aug-00	21,216	386	1819
Sep-00	23,702	513	2164
Oct-00	32,285	882	2732
Nov-00	26,608	674	2533
Dec-00	30,165	1363	4518
Jan-01	33,003	1118	3388
Feb-01	30,128	681	2260
Mar-01	40,343	489	1212
Apr-01	33,152	206	621
May-01	40,541	160	395
Jun-01	38,441	227	591
Jul-01	21,648	141	651
Aug-01	36,953	267	723
Sep-01	32,052	161	502
Oct-01	36,283	213	587
Nov-01	31,295	517	1652
Dec-01	24,946	122	489
Jan-02	31,026	136	438
Feb-02	37,022	136	367
Mar-02	35,256	219	621
Apr-02	41,296	429	1039
May-02	40,007	136	340
Jun-02	33,321	108	324
Jul-02	14,487	77	532
Aug-02	27,539	102	370
Sep-02	32,727	78	238
Oct-02	39,589	71	179
Nov-02	30,113	32	106
Dec-02	29,305	31	106
Jan-03	35,451	39	110
Feb-03	34,409	40	116
Mar-03	32,168	43	134
Apr-03	32,792	35	107
May-03	35,934	30	83
Jun-03	34,618	91	263
Jul-03	19,110	33	173
Aug-03	35,653	62	174
Sep-03	38,013	66	174
Oct-03	40,464	31	77
Nov-03	32,913	27	82
Dec-03	32,705	22	67
Jan-04	35,214	23	65
Feb-04	37,577	9	24
Mar-04	45,555	7	15
Apr-04	37,227	2	5
May-04	36,236	1	3

Complaints

Population	Range	Vehicles	Population	Rate/100K
1	Jun 99 - Oct 14, 99	84	98,221	85.5
2	Oct 14, 99 - Mar 30, 01	167	501,976	33.3
3	April 1, 01 - June 04	53	1,280,292	4.1


Complaints per 100K by Build Month
Rate/100K
250
200
150
100
50
-
May-99
Aug-99
Nov-99
Feb-00
May-00
Aug-00
Nov-00
Feb-01
May-01
Aug-01
Nov-01
Feb-02
May-02
Aug-02
Nov-02
Feb-03
May-03
Aug-03
Nov-03
Month

Month	Build	Complaints	Rate/100K
May-99	164		-
Jun-99	8,460	7	83
Jul-99	15,869	35	221
Aug-99	33,888	21	62
Sep-99	31,205	12	38
Oct-99	31,787	10	31
Nov-99	27,809	12	43
Dec-99	26,387	4	15
Jan-00	31,063	3	10
Feb-00	34,576	5	14
Mar-00	40,782	22	54
Apr-00	30,233	8	26
May-00	35,078	10	29
Jun-00	33,580	17	51
Jul-00	10,654	2	19
Aug-00	21,216	6	28
Sep-00	23,702	5	21
Oct-00	32,285	13	40
Nov-00	26,608	8	30
Dec-00	30,165	17	56
Jan-01	33,003	20	61
Feb-01	30,128	7	23
Mar-01	40,343	7	17
Apr-01	33,152	4	12
May-01	40,541	0	-
Jun-01	38,441	5	13
Jul-01	21,648	1	5
Aug-01	36,953	0	-
Sep-01	32,052	1	3
Oct-01	36,283	1	3
Nov-01	31,295	4	13
Dec-01	24,946	4	16
Jan-02	31,026	3	10
Feb-02	37,022	1	3
Mar-02	35,256	3	9
Apr-02	41,296	7	17
May-02	40,007	1	2
Jun-02	33,321	2	6
Jul-02	14,487	0	-
Aug-02	27,539	0	-
Sep-02	32,727	1	3
Oct-02	39,589	2	5
Nov-02	30,113	0	-
Dec-02	29,305	2	7
Jan-03	35,451	0	-
Feb-03	34,409	2	6
Mar-03	32,168	0	-
Apr-03	32,792	0	-
May-03	35,934	1	3
Jun-03	34,618	1	3
Jul-03	19,110	0	-
Aug-03	35,653	1	3
Sep-03	38,013	4	11
Oct-03	40,464	0	-
Nov-03	32,913	0	-
Dec-03	32,705	1	3
	1,720,214	303	

VIN	MY	Build Date	Source	
1GCGK29UXYZ103699	2000	6/21/1999	PE	16
1GCGK29U5YZ105456	2000	6/22/1999	PE	152
1GCHK33F3YF400447	2000	6/24/1999	PE	58
1GTGK29U7YZ108407	2000	6/25/1999	PE	53
1GBKC34FXYF401861	2000	6/29/1999	PE	165
1GTGK29U7YE107958	2000	6/29/1999	PE	172
1GBJG31R7Y1105210	2000	6/30/1999	PE	61
1GBKC34J3YF403018	2000	7/1/1999	PE	113
1GCGC29U1YE110139	2000	7/1/1999	PE	52
1GCGK24U6YE110194	2000	7/1/1999	PE	127
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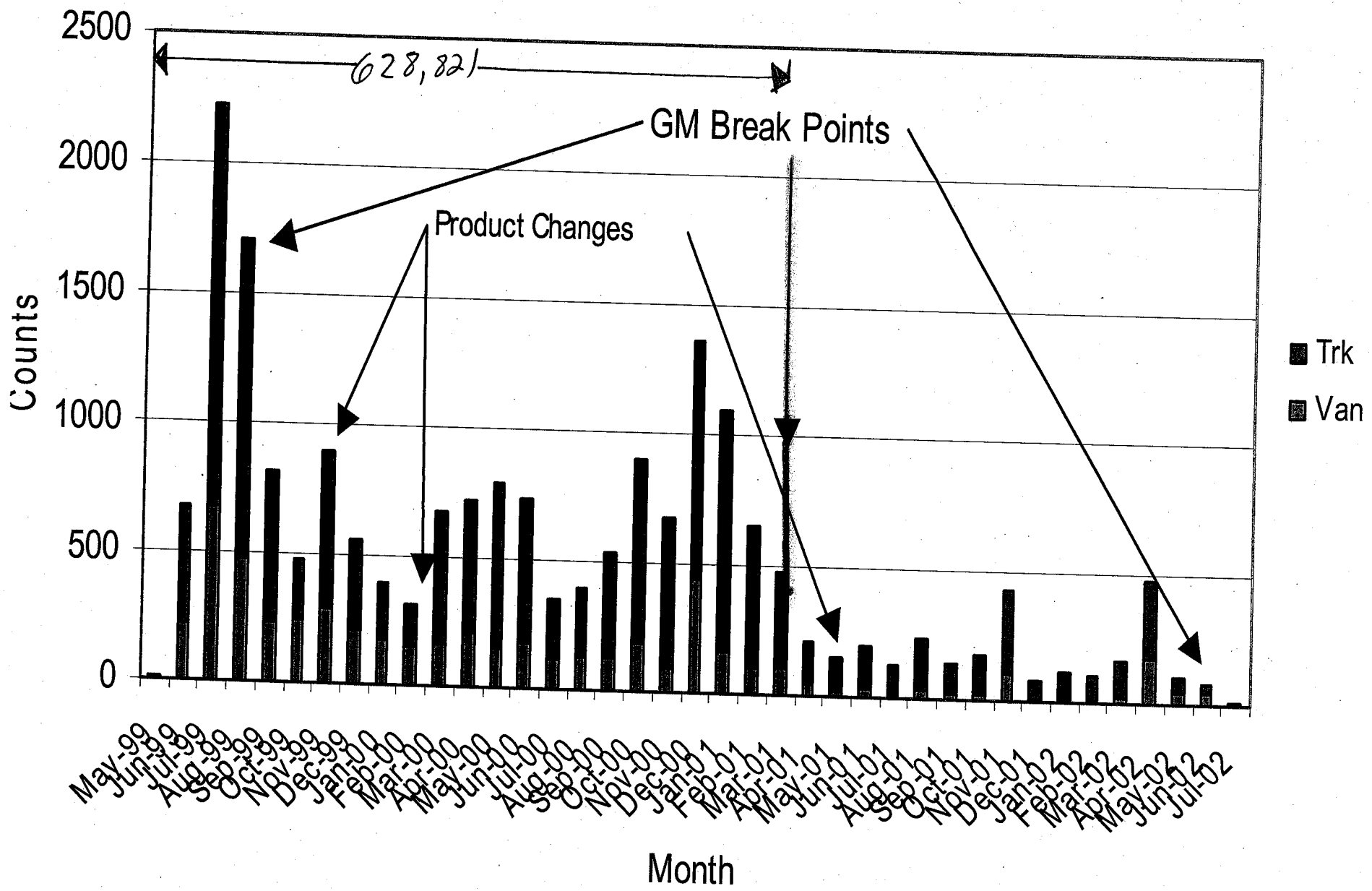
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