MAR 3 1 2000

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Susan M. Cischke, Vice President
Vehicle Certification, Compliance and Safety Affairs
DaimlerChrysler Corporation - CIMS 482-00-91
800 Chrysler Drive
Auburn Hills, MI 48326-2757

NSA-122jlq
EA99-013

Dear Ms Cischke:

This letter is to request additional information regarding NHTSA's investigation of crash-induced fuel filler neck assembly failure in 1996 through 2000 DaimlerChrysler NS-minivan vehicles.

For your information, NHTSA's examination of the fuel filler tube assembly in the 2000 Dodge Caravan that experienced the filler hose separation incident in the January 6, 2000 SINCAP test identified two additional failure modes for the filler neck assembly. The first involved contact between the anchor plate for the left-middle seat belt and the fuel filler pipe, resulting in a 37 mm x 4 mm puncture in the pipe. The second involved the plastic section of the fuel vent tube, which was cut across more than two-thirds of the tube circumference in an area where the tube was sandwiched between the fuel filler pipe and the left rail flange (directly behind the filler pipe puncture). Pictures of the fuel filler neck assembly crush and filler pipe puncture are enclosed.

Also, NHTSA has identified another left-side impact fire involving a subject vehicle in a search of the 1998 Fatality Analysis Reporting System (FARS) database. An August 23, 1998 crash in Texas involving a 1998 Dodge Grand Caravan resulted in three fatalities where the Most Harmful Event was coded as fire. The fatalities all involved occupants in left seating positions. Three occupants seated on the right side of the vehicle received non-incapacitating injuries.

Unless otherwise stated in the text, the following definitions apply to this information request:

- **Subject vehicles**: all 1996 through current model year DaimlerChrysler NS-minivans.
- **Subject fuel tank assembly**: all fuel storage tanks used in the subject vehicles.
- **Subject tank spud**: all fill spuds used in subject fuel tank assemblies.

801

- **<u>Subject hose joint</u>**: the clamped joint between the filler neck hose and the subject tank spud, including the hose, the clamp, and the tank fill spud, or any or all of the components thereof.

- **<u>DaimlerChrysler</u>**: DaimlerChrysler Corporation and Chrysler Corporation, all of its past and present officers and employees, whether assigned to its principal offices or any of its field or other locations, including all of its divisions, subsidiaries (whether or not incorporated) and affiliated enterprises and all of their headquarters, regional, zone and other offices and their employees, and all agents, contractors, consultants, attorneys and law firms and other persons engaged directly or indirectly (e.g., employee of a consultant) by or under the control of DaimlerChrysler (including all business units and persons previously referred to), who are or, in or after January 1994, were involved in any way with any of the following related to the alleged defect in the subject vehicles:

  a. design, engineering, analysis, modification or production (e.g. quality control);
  b. testing, assessment or evaluation;
  c. consideration, or recognition of potential or actual defects, reporting, record-keeping and information management, (e.g., complaints, field reports, warranty information, part sales), analysis, claims, or lawsuits; or
  d. communication to, from or intended for zone representatives, fleets, dealers, or other field locations, including but not limited to people who have the capacity to obtain information from dealers.

- **<u>Alleged defect</u>**: shall refer to crash-induced fuel filler neck assembly failure.

- **<u>Documents</u>**: "Document(s)" is used in the broadest sense of the word and shall mean all original written, printed, typed, recorded, or graphic matter whatsoever, however produced or reproduced, of every kind, nature, and description, and all nonidentical copies of both sides thereof, including, but not limited to, papers, letters, memoranda, correspondence, communications, electronic mail (e-mail) messages (existing in hard copy and/or in electronic storage), faxes, mailgrams, telegrams, cables, telex messages, notes, annotations, working papers, drafts, minutes, records, audio and video recordings, data, databases, other information bases, summaries, charts, tables, graphics, other visual displays, photographs, statements, interviews, opinions, reports, newspaper articles, studies, analyses, evaluations, interpretations, contracts, agreements, jottings, agendas, bulletins, notices, announcements, instructions, blueprints, drawings, as-builts, changes, manuals, publications, work schedules, journals, statistical data, desk, portable and computer calendars, appointment books, diaries, travel reports, lists, tabulations, computer printouts, data processing program libraries, data processing inputs and outputs, microfilms, microfiches, statements for services, resolutions, financial statements, governmental records, business records, personnel records, work orders, pleadings, discovery in any form, affidavits, motions, responses to discovery, all transcripts,

802

administrative filings and all mechanical, magnetic, photographic and electronic records or recordings of any kind, including any storage media associated with computers, including, but not limited to, information on hard drives, floppy disks, backup tapes, and zip drives, electronic communications, including but not limited to, the Internet and shall include any drafts or revisions pertaining to any of the foregoing, all other things similar to any of the foregoing, however denominated by DaimlerChrysler, any other data compilations from which information can be obtained, translated if necessary, into a usable form and any other documents. For purposes of this request, any document which contains any note, comment, addition, deletion, insertion, annotation, or otherwise comprises a nonidentical copy of another document shall be treated as a separate document subject to production. In all cases where original and any non-identical copies are not available, "document(s)" also means any identical copies of the original and all non-identical copies thereof. Any document, record, graph, chart, film or photograph originally produced in color must be provided in color. Furnish all documents whether verified by the manufacturer or not. If a document is not in the English language, provide both the original document and an English translation of the document.

In order for my staff to evaluate the alleged defect, certain information is required. Pursuant to 49 U.S.C. § 30166, please provide numbered responses to the following information requests. Please repeat the applicable request verbatim above each response. After DaimlerChrysler's response to each request, identify the source of the information and indicate the last date the source updated the information prior to the preparation of the response. Insofar as DaimlerChrysler has previously provided a document to ODI, DaimlerChrysler may either produce it again, or identify the document, the document submission to ODI in which it was included and the precise location in that submission where the document is located. When documents are produced, the documents shall be produced in an identified, organized manner that corresponds with the Information Request letter (including the subparts). When documents are produced and the documents would not, standing alone, be self-explanatory, the production of documents shall be supplemented and accompanied by explanation.

If DaimlerChrysler cannot respond to any specific request or subpart thereof, please state the reason why it is unable to do so. If DaimlerChrysler claims that any document or other information or material responsive to any of the following items need not be provided to NHTSA because it is privileged or the work product of an attorney, separately by information request number, for each such document or other information or material, state the nature of that information or material and identify any document in which it is found by date, subject or title, name and position of the person from, and the person to whom it was sent, and the name and position of any other recipient. DaimlerChrysler must also describe the basis for the claim, and explain why DaimlerChrysler believes it applies.

1. Furnish the following dimensions, in millimeters, for both the short- and long-wheelbase subject vehicles:

a. the longitudinal dimension from a vertical plane passing through the front axle centerline to the rear edge of the anchor plate for the left-middle seat belt (furnish these dimensions for each seating option available in the subject vehicles);
b. the longitudinal dimension from a vertical plane passing through the front axle centerline to the front and rear of the rail opening through which the fuel filler vent tube passes (vent tube pass-through);
c. the longitudinal dimension from a vertical plane passing through the front axle centerline to the interface between the sill inner wall and the left-rear wheelhouse extension;
d. the lateral dimension from a vertical plane passing through the vehicle centerline to the inner and outer edges of the fuel tank spud;
e. the minimum clearance between the fuel filler tube and: (1) the left rear wheelhouse; and (2) the sill inner wall;
f. the lateral dimension from a vertical plane passing through the vehicle centerline to the anchor bolt for the left-middle seat belt (furnish these dimensions for each seating option available in the subject vehicles); and
g. the vertical dimension from the bottom edge of the fuel tank nipple to the lower dimensions of the anchor plate for the left-middle seat belt (furnish these dimensions for each seating option available in the subject vehicles) and the vent tube pass-through.

2. Furnish copies of all engineering standards, specifications, and guidelines regarding fuel tank and filler neck assembly packaging in the subject vehicles. "Packaging" should be interpreted in the context used in Section 4.12 of the enclosed copy of Society of Automotive Engineers Information Report SAE J1664, "Passenger Car and Light Truck Fuel Containment."

3. State whether DaimlerChrysler has ever considered the safety implications of the packaging of the subject vehicle fuel filler neck assembly relative to the left-middle seat belt anchor plate and, if so, provide copies of all related documents.

This letter is being sent to DaimlerChrysler pursuant to 49 U.S.C. § 30166, which authorizes NHTSA to conduct any investigation that may be necessary to enforce Chapter 301 of Title 49. DaimlerChrysler's failure to respond promptly and fully to this letter could subject DaimlerChrysler to civil penalties pursuant to 49 U.S.C. § 30165 or lead to an action for injunctive relief pursuant to 49 U.S.C. § 30163. Other remedies and sanctions are available as well.

DaimlerChrysler's response to this letter, in duplicate, must be submitted to this office by May 5, 2000. Please include in DaimlerChrysler's response the identification codes referenced on page one of this letter. If DaimlerChrysler finds that it is unable to provide all of the information requested within the time allotted, DaimlerChrysler must request an extension from Mr. Thomas Z. Cooper at (202) 366-5218 no later than five business days before the response due date. If DaimlerChrysler is unable to provide all of the information requested by the original deadline, it

804

must submit a partial response by the original deadline with whatever information DaimlerChrysler then has available, even if DaimlerChrysler has received an extension.

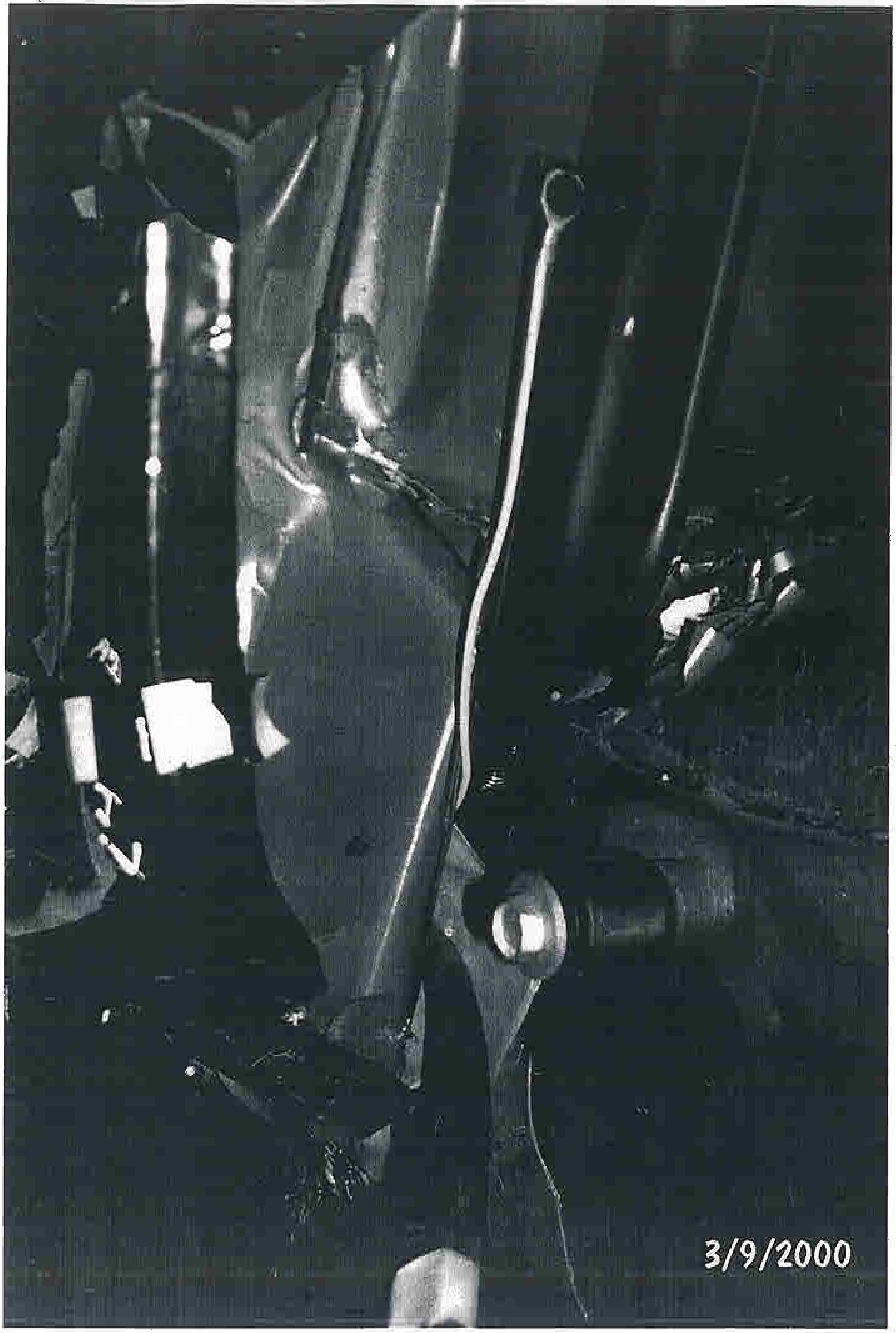
If DaimlerChrysler considers any portion of its response to be confidential information, 49 CFR Part 512, "Confidential Business Information," requires that DaimlerChrysler submit two copies of those document(s) containing allegedly confidential information (except only one copy of blueprints) and one copy of the documents from which information claimed to be confidential has been deleted, to the Office of Chief Counsel, National Highway Traffic Safety Administration, Room 5219 (NCC-30), 400 Seventh Street, SW, Washington, D.C. 20590. In addition, DaimlerChrysler must provide supporting information for the request for confidential treatment in accordance with 49 CFR Section 512.4(b) and (e) and include the name, address, and telephone number of a representative to receive a response from the Chief Counsel.

If you have any technical questions concerning this matter, please call Mr. Jeff Quandt of my staff at (202) 366-5207. If you have any questions concerning confidentiality claims, please contact Ms. Heidi Coleman, Assistant Chief Counsel for General Law, at (202) 366-1834.

Sincerely,

/s/ DB for
Kathleen C. DeMeter, Director
Office of Defects Investigation
Safety Assurance

Enclosures



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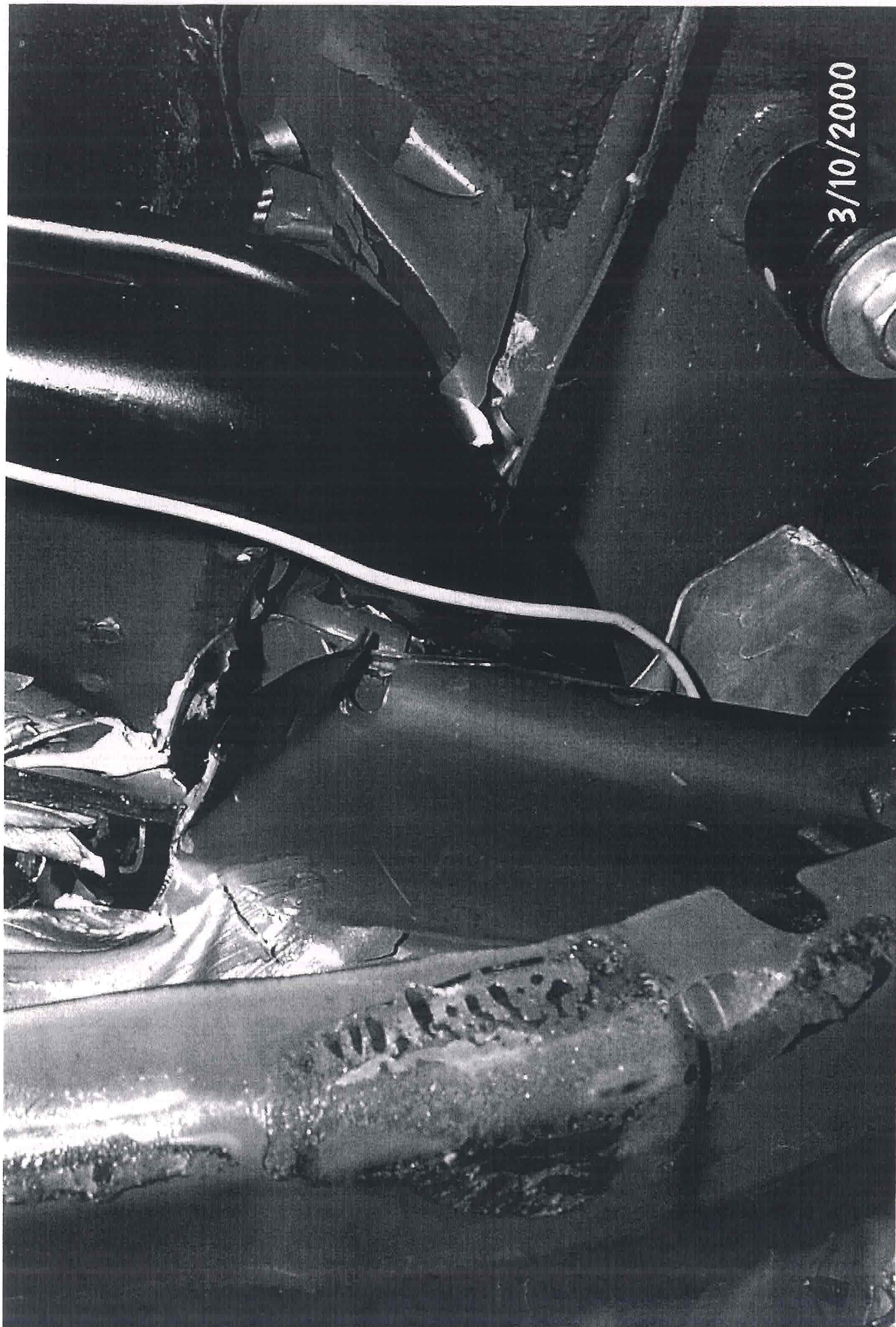

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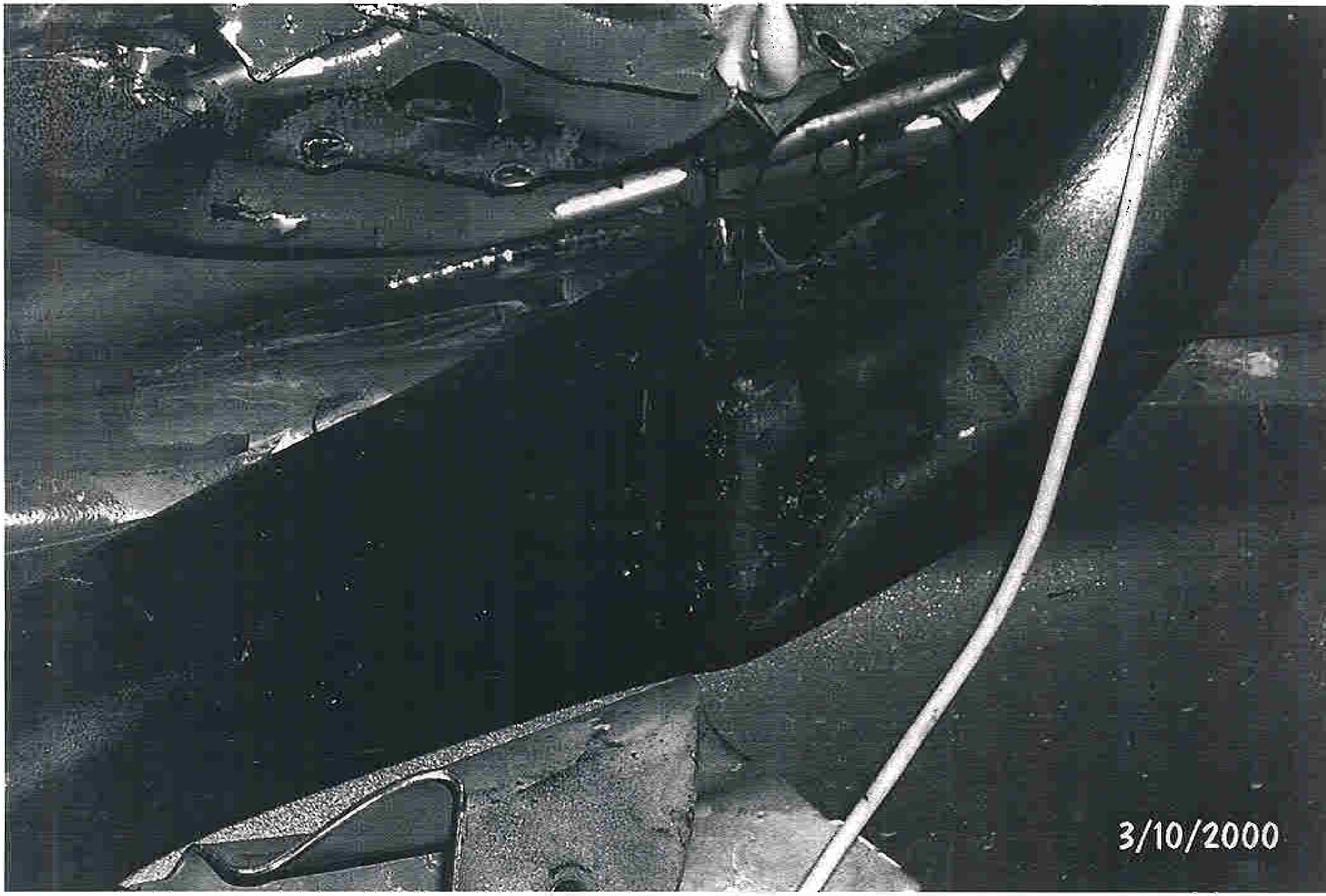

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809

PASSENGER CAR AND LIGHT TRUCK FUEL CONTAINMENT—SAE J1664 JAN94

SAE Information Report

Report of the SAE Fuel Containment Standards Committee approved January 1994.

Foreword—The integrity of the fuel containment system has been a longstanding concern of automotive engineers throughout the industry and has been specifically addressed by government regulatory authorities in the U.S., Europe, and Japan. This document is intended to point out design aspects that are important and thus offer an opportunity for overall improvement in system design.

a. Vehicle manufacturers should conduct proving ground and customer fleet tests to confirm their fuel system design will meet the regulated time or mileage requirements. The proving ground durability tests should include stone pecking (gravel impingement) and ground clearance tests as appropriate. Any fuel-system shielding should be evaluated to the same durability standards (including corrosion resistance) that apply to the fuel containment components.
b. Failure Mode and Effects Analysis (FMEA)—As a useful tool for design, manufacturing, and assembly evaluation, FMEA or a similar methodology is suggested for application during the development of the fuel containment system.
    (1) In addition to meeting government standards, consideration should be given to all reasonably likely "real world" causes of fuel containment failure including reasonably foreseeable crashes, long-term corrosion effects, and other abnormalities such as failure of other vehicle components, assembly or service errors, and failures or abnormalities on other vehicles which might be involved in a crash situation.
    (2) It would not be reasonable or practical to design fuel containment systems that would completely eliminate all risks of failure in any condition identified in a FMEA study; however, a disciplined FMEA approach can eliminate many "real world" failure modes and reduce the frequency of many others.

1. Scope—The scope of this SAE Information Report is the liquid fuel containment system for gasoline or flexible fuels (up to 85% methanol in gasoline), along with their associated vapors, as designed for use on passenger cars and light trucks. For purposes of this document, fuel containment addresses the fuel tank and components that are directly attached to the fuel tank. These components may include the filler neck, tank, fill vent tube, fuel cap, pump-sender, and rollover control valve closure seals, insofar as they act as closure or containment mechanisms. Emphasis will be on fuel containment and the required system closures. Furthermore, emphasis will be placed on design recommendations as they relate to performance. Mounting and shielding of the "system" components are included only to the extent they affect the containment aspects.

1.1 Purpose—The purpose of this document is to suggest design practices for automotive fuel tanks and any related components that directly close the fuel tank. This document incorporates the consensus of the SAE Fuel Containment Standards Committee as to those practices that are reasonable, practicable, and appropriate.

2. References

2.1 Applicable Documents—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1681—Gasoline Methanol Mixtures for Materials Testing

2.1.2 ASTM PUBLICATION—Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM B 117—Method of Salt Spray (Fog) Testing

2.1.3 FEDERAL PUBLICATION—Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

FMVSS 301

2.1.4 ECE PUBLICATION—Available from Commission of the European Communities, 200, Rue de La Loi, B-1049 Brussels, Belgium.

ECE 34

2.1.5 NHTSA PUBLICATION—Available from Superintent of Documents, U.S. Government Printing Office, Washington, DC 20402.

"Fires and Burns in the Towed Light Vehicle Crashes," 1992, Susan Partyka

2.2 Related Publications—The following publications are provided for information purposes only and are not a required part of this document.

EPA Evaporative Regulation 40 CFR Part 86

CARB Regulation Evaporative Emission - Title 13 California Code of Regulations Sect 1976

3. Principles—This section details the general principles suggested by the Fuel Containment Standards Subcommittee. If the Guidelines in Section 6 are incomplete, or if there appears to be inconsistency or ambiguity in the application of the Guidelines, the Principles should be applied to resolve the uncertainty.

3.1 Normal Use Principle—The fuel containment system should provide for a lifetime of customer service without maintenance or fuel leakage and with continuing compliance to applicable emission or safety regulations.

3.1.1 Furthermore, current Environmental Protection Agency (EPA) requirements for fuel system useful life are 10 years or 160 900 km (100 000 miles), whichever comes first for all passenger cars and light trucks below 1701 kg (3750 lb) gross vehicle weight and 11 years or 193 080 km (120 000 miles) for all other light-duty trucks. No fuel leaks or increase in evaporative emissions above those allowed by regulation are permitted throughout the useful life.

3.2 Abnormal Use Principle—The fuel containment system should be designed in anticipation of certain abnormalities which could occur in customer usage so as to prevent, to the extent practicable, the release of fuel even in such abnormal conditions. Each design should be subjected to a FMEA to identify abnormal failure modes and to suggest approaches to eliminate, to the extent practicable, system failures or misuse that could release fuel.

3.3 Collision Damage Principle—An automotive vehicle and its fuel containment system are subject to collision damage in an infinite variety of situations including various angles, speeds, and fixed or moving objects impacted, multiple impacts, and rollovers with or without preceding or subsequent impacts. A FMEA should be performed and consideration given to vehicle package and fuel containment system design in order to eliminate or minimize collision-related fuel spillage to the extent practicable.

4. Guidelines

4.1 Durability Guideline—Laboratory bench tests and proving-ground vehicle-durability tests under conditions representative of worst-case customer use should be performed to confirm fuel-system lifetime capability.

4.2 Corrosion Guideline—The fuel-containment system must be robust with respect to exterior corrosion so as to provide high confidence in passing expected use over the vehicle's lifetime.

Attention should be given to not only material selection but also protective coatings and galvanic interactions between dissimilar metals.

4.2.1 Some manufacturers utilize accelerated vehicle proving-ground corrosion tests that subject vehicles to a fairly corrosive environment over several months as a simulation of lifetime corrosion exposure. A minimum of 2000 h salt-spray test (per ASTM B 117) is suggested for evaluating exterior-corrosion protection. In addition, various fuel soaks and laboratory exposure tests are suggested for determining interior-corrosion performance of fuel-containment components, as discussed in more detail as follows:

4.2.2 Provisions should also be made through proper material selection and, if necessary, the use of protective coatings for the fuel containment interior surfaces to provide appropriate corrosion and fuel resistance, including resistance to additives, water, or other contaminants.

4.2.3 There should be no component-related contribution to fuel contamination from lead, silicone, phosphorus, aluminum, plasticizers, barrier treatments, or from material-corrosion by-products.

4.2.4 Verification of successful performance of internal- and external-corrosion protection should take place after completing proving ground durability or corrosion tests and laboratory soak tests using recommended fuels from SAE J1681. A minimum of 4000 h of internal component exposure to these SAE fuels is suggested. Note that for some applications, corrosion requirements may need revision to meet more stringent situations (e.g., worldwide use).

4.2.5 Verification should include component visual inspection inside and out plus system testing for evaporative emissions using a full vehicle size Sealed Housing for Evaporative Determination (SHED) or a mini-SHED large enough to contain the fuel system. Tests should be conducted according to California or Federal evaporative regulations.

NOTE—The fuel constituents (particularly alcohol levels used during durability or soak tests) can affect SHED test results.

810

4.3 **Aging Guideline**—Accelerated corrosion tests, proving-ground durability tests, and rapid accumulation of mileage through commercial-fleet testing are methods used to simulate real-world effects of time and mileage. These can be augmented by various laboratory bench tests (e.g., long-term fuel soaks, ozone tests, and pressure-cycle fatigue tests). Also, knowledge gained during reviews of customer units that have been in use for long periods is helpful to fuel system engineers. It is difficult, however, to predict precisely how a new material or process will perform after 10 or more years based on the previous tests. Consequently, a certain degree of "overdesign" may be advisable.

4.4 **Fatigue Guideline**—Fuel-containment components should be subjected to laboratory fatigue tests with inputs derived from customer applications using instrumented vehicles. The primary fatigue loadings are from system pressure and vacuum cycles coupled with those from road-induced mechanical input. Consideration should be given to extreme loading situations, vibration inputs, and cold- and hot-ambient operating conditions.

4.5 **Permeation Guideline**—Evaporative losses must be within state (e.g., California) and Federal requirements (total vehicle not just the fuel system). Check to insure latest state and Federal requirements are reviewed. Addresses and telephone numbers of interest:

a. Environmental Protection Agency
   Regulation Development and Support Division
   2565 Plymouth Rd.
   Ann Arbor, MI 48105-2425
   Telephone: (313) 741-7828

b. State of California
   Air Resources Board
   Haagen-Smit Laboratory
   9528 TelStar Avenue
   El Monte, CA 91731-2990
   Telephone: (818) 575-6800

4.5.1 An initial (24-h test) target for the fuel-containment system should be established low enough to allow the total vehicle to meet the requirement at the end of the necessary time, 10 years (Car) and 11 years (Light Truck), or the mileage shown previously. Vehicle background hydrocarbons (e.g., from tires, paint, plastics, and interior trim) affect the total vehicle hydrocarbon evaporative emission results.

4.5.2 It is important to insure the fuel containment system is properly "stabilized" relative to hydrocarbon permeation prior to testing (e.g., lab soak at 40 °C for 8 weeks or 90 days minimum vehicle soak and driving). It may be advisable to soak the fuel containment system for 8 weeks, or more, to attain equilibrium and then stabilize at room temperature for 12 to 24 h prior to SHED tests to avoid abnormal peaks in HC data. As a general rule, the more resistant a material is to permeation, the longer it will take to stabilize at its equilibrium rate.

4.6 **Fuel Compatibility Guideline**—Fuel compatibility with respect to fuel system components should receive appropriate attention. Of concern should be tank/pump/other component interior corrosion effects as well as effects of fuels on various elastomers (especially with regard to property reduction, swell after exposure, shrink after dry out, and leaching out of plasticizers). The 4000-h test suggested in 4.2.4 is applicable here.

4.6.1 Fuel-system components themselves may be adversely affected by fuels (e.g., some of the residual constituents may be dissolved by fuel and carried forward through the pump, filter, and injectors). It is important to subject various fuel components to the range of expected fuels and additives to understand any deleterious effects on materials.

4.6.2 Reference SAE fuels are advisable for use in testing because they represent recognized, reasonable worst-case conditions and to allow uniform comparison with other industry available information. The SAE has a subcommittee addressing appropriate fuel formulations, including additives (reference SAE J1681).

4.6.3 In the case of flexible fuels, the engineer should consider a range of fuels from M0 to M85 (100% unleaded fuel to 85% methanol + 15% unleaded gasoline) as well as various levels of ethanol in the fuel. Further, the oxygenate Methyl Tertiary Butyl Ether (MTBE) is coming into more widespread use, and its effects alone and in combination with ethanol or methanol are worth considering.

4.7 **Service Guidelines**—It is advisable to instruct users that fuel-containment components must not be repaired, but should be replaced with Original Equipment Manufacturer (OEM) or OEM recommended parts if evidence of a leak exists or replacement is necessary. Warning labels or other indicators with this information placed on the components and in appropriate sections of service manuals are suggested. Design engineers should be aware that fuel tanks are sometimes cleaned by non-OEM repair shops that may use aggressive cleaners.

4.8 **Manufacturing Guidelines**—Tank manufacturers must provide strict attention to process parameters to assure leak-free parts. Care must be taken not to damage protective surface finishes during the manufacturing process. For plastic tanks, process effects on interior treatments for permeation resistance (e.g., sulfonation or fluorination) must be considered. Uniform coverage on interior surfaces (especially on complex tank shapes) must be provided.

4.8.1 Several sources of contamination exist. Manufacturing and assembly engineers should be cognizant of these: (a) residuals from the tank manufacturing or assembly process that are not properly removed (e.g., die lube, weld spatter, machining chips for High Density Polyethylene (HDPE) tank openings), (b) contaminants introduced by assembly plant fuel fill, and (c) contaminants introduced as a result of the tank leak test process (usually residual water).

4.8.2 Appropriate filtration of in plant fuel and quality checks of incoming fuel should suffice for item 4.8.1(b). Surveys of fuels available in the field should help determine what foreign matter must be handled by the fuel system. Understanding these factors is important to be able to protect the fuel system and provide long-service life.

4.8.3 Specification and verification methods for contamination should be agreed on by the tank supplier and purchasing or engineering.

4.9 **Leak Testing and Pressure Resistance**—No residual water must be left in the tank (e.g., from weld-cooling process on steel tank) prior to leak testing. Such water can plug pin-hole leaks and give a false "pass." Two possible leak test methods are: (a) pressure decay test or (b) air-under-water test with no leaks at manufacturer-determined internal tank pressurization. Leak tests with water must be evaluated for post-test residual water that might remain inside the tank. Current test procedures and leak rates are 13.79 to 27.58 kPA (2 to 4 psi) under water and no pressure loss for 2 min or no evidence of air bubbles. With the tighter standards for evaporative emissions, current methods of leak detection are inadequate. These will identify gross leaks. The only known method to find very small leaks is via helium gas leak detection.

4.10 **Abnormal Use Guideline**—Among the abnormalities that should be considered are misassembly, either in production or in subsequent service, vent system failure, engine or fuel system malfunction, exhaust system leakage or failure, overfilled fuel tanks, possible combinations of these, and other abnormalities identified by the FMEA.

4.11 **Heat-Protection Guideline**—Proximity of the fuel-containment components to exhaust system and other sources of heat must be given careful attention early in the design stage. Design clearance standards, if available to the engineer, should be confirmed on the specific design via vehicle testing. Component surface temperature and fuel-temperature monitoring is suggested.

4.11.1 Care must be taken to examine extreme vehicle use situations (those which will create maximum temperatures) and maximum expected ambient conditions (including altitude effects). Extreme limit conditions could be the effects of 1 h of operation with reasonably severe engine malfunctions (e.g., single failed spark plug or exhaust system leakage) with maximum in-tank fuel temperature of 60 °C. Effect of failed components or lack of proper maintenance should be factored into the FMEA.

4.11.2 In a malfunction condition that develops excessive heat, consider effects on the contained fuel temperatures, vapor generation rates, and resulting fuel system pressures.

4.12 **Packaging Guideline**—As government standards become more stringent in either impact speed or location, the design engineer will become increasingly challenged to protect the fuel containment system. A combination of analytical/computer modeling, lab testing, and actual vehicle tests is advisable. Unfortunately, models have not progressed to the stage where actual design confirmation crash tests can be eliminated.

4.12.1 Crash testing required by FMVSS 301 is one method to assess the crashworthiness of a vehicle's fuel system. The intent of the regulation is to minimize the risk of injury or death due to crash induced fuel fires. Crash tests other than those prescribed by FMVSS 301 may be necessary to evaluate fuel system performance.

4.12.2 Packaging aspects of the fuel-containment system are very design dependent. What "works" (passes crash testing) for one tank or component design may not be acceptable for another design or location.

4.12.3 Design considerations as to tank location (forward in chassis, mid-vehicle, or rearward in vehicle), tank shape (rectangular, long and narrow, or "pancake" design) should receive considerable **up front** evaluation in the platform design. Requirements for crash protection may differ with tank or component location in the vehicle and may also depend on vehicle intended use. The package location and surrounding environment of the fuel tank should also be included in the FMEA to eliminate, to the extent practicable, fuel spillage in a collision due to tank puncture or rupture from intrusion by other vehicle components.

4.12.4 Package must also consider the location and failure susceptibility of the fuel filler pipe and cap, the fuel pump and sender, and of vent valves and other devices that require openings and closures to the main storage tank.

4.13 Tank Pressure Resistance Guideline—Most containment systems include a safety pressure relief device to prevent fuel system damage if the normal vent system fails to function properly. Testing of the fuel system to maximum pressure expected under failed tank vapor control (i.e., pinched line) in the "as-installed" condition is advisable.

4.13.1 Some typical pressure resistance tests follow:

a. Zero - Safety relief pressure [usually 17.24 kPa (2.5 psi)] (with tank in "as-installed" constraint). Acceptance criteria are no leak under water and no distortion that affects function (e.g., gage indication, ground clearance, or fatigue resistance).
b. 17.24 to 31.03 (2.5 to 4.5 psi) (European requirement with tank in "as-installed" constraint). Acceptance criteria are no leaks under water and no permanent deflection beyond agreed upon percentage.
c. To monitor the manufacturing process, some manufacturers test fuel tanks pressurized above 31.03 kPa (4.5 psi) with the tank in an unrestrained condition under water. Acceptance criteria (leak or burst requirement) is as determined by agreement between the tank supplier/vehicle manufacturer.

4.13.2 Vacuum applied to the system can cause adverse effects, even if only of a dimensional nature. Vacuum cycling effects may become more significant as On Board Diagnostic (OBD) regulations phase in. Some strategies will utilize regular application of a vacuum to the system to verify evaporative system integrity. Such designs should account for the dimensional effects of the pressure fluctuations on the tank in the installed condition. Also, the pressure-cycling tests developed to prove tank fatigue capability must consider added fatigue damage from OBD.

4.14 Containment Integrity Guidelines—Under crash event per FMVSS 301 or other reasonable crash circumstance, there should be no component rupture, puncture, or closure element separation from the fuel tank. It is suggested the engineer test design sensitivity to a variety of reasonable crash circumstances.

4.14.1 GENERAL DESIGN CONSIDERATIONS TO PREVENT FUEL LOSS IN REASONABLY SEVERE CRASHES—Most importantly, fuel containment components should be packaged in a "friendly" environment. Material selection should consider puncture resistance, material thickness requirements, and burst pressure strength. Laminate or composite materials may have useful application, especially in providing a "shielding" function.

4.14.2 Key causes of fuel loss during or immediately after a crash:

a. Hydrodynamic Rupture—In selecting the fuel tank placement in the vehicle, the engineer must consider vehicle structural collapse insofar as such collapse may affect the hydrodynamic rupture characteristics of the tank. It might be necessary in a given location to strengthen the structure surrounding the tank to prevent or limit the amount of tank deformation in a specific crash mode. Other factors to consider are:
   (1) Shape of tank.
   (2) Vapor space when tank is filled to design maximum (allowing for fuel expansion with temperature—the larger the amount of vapor space versus liquid fuel, the greater the ability of the tank to withstand crush).
   (3) Material properties (e.g., tensile strength, ductility, including visco-elasticity, if present, and impact strength). (A ductile material will absorb more energy.)
b. Filler neck or other component separation from tank. Key elements to consider are:
   (1) Joint structural properties to resist leaking from twist, bending, or axial loads, or combinations of these.
   (2) Relative separation or crush loads experienced during a crash. The filler pipe and its attachments to the tank and the outer body at the filler inlet should be designed to prevent, to the extent possible, separating the pipe from the tank. For example, the pipe to body separation force should be significantly less than the pipe to tank separation force.
   (3) Fuel caps are often subjected to prying forces and direct impact during crashes. Reasonable design efforts are suggested with the objective of maintaining system integrity when fuel caps are subjected to these loading mechanisms.
c. Puncture—Basically, the fuel tank should be protected from intrusion by other components. Emphasis should be placed on the following considerations with respect to overall crash integrity:
   (1) Shielding and shield shape when it contacts the fuel tank in a crash.
   (2) Tank material and thickness.
   (3) Location of "unfriendly" surfaces/components (and the path they travel during a crash).
   (4) Vehicle structural collapse characteristics in relation to the fuel tank location (considering the variety of impact directions) as well as to other fuel containment components (e.g., fill neck).
   (5) Penetration by a striking object external to the vehicle.

4.15 Open Flame Resistance Guidelines—When considering resistance of the fuel containment system to open flame, design engineers are advised to address: (a) fire size and duration as established by the size of the assumed fuel spill (possibly from another vehicle per 4.15.3), (b) size and location of possible punctures in the fuel containment system caused from a collision, and (c) potential effects on the system from grass fires underneath the vehicle (a specific concern in some countries such as Australia).

4.15.1 Europe has an open flame test standard (part of ECE 34) which is required for plastic fuel tank equipped vehicles. Such vehicles manufactured in the U.S. for sale in Europe must also meet ECE 34, Annex 5, which requires no liquid fuel release after 2 min of fire exposure.

4.15.2 To conform to proposed requirements, fuel filler pipes for use with methanol (e.g., flexible fuel vehicles) must have anti-siphon capability. It may also be advisable to incorporate a flame arrestor on tanks designed for flexible fuel vehicles and to consider an anti-siphon capability on all new tank designs as an added safety feature.

4.15.3 Based on a 1992 NHTSA report, "Fires and Burns in Towed Light Vehicle Crashes" by Susan Partyka, 24% of fires came from outside the vehicle or unknown causes. Also from the same report (using data collected on 1979 to 1986 models and 1988 to 1990 models), 59% of fires involving crashes were frontal impacts, 12% rear impacts, 12% side impacts, and 14% from rollovers. Therefore, it may be advisable to apply the ECE 34, Annex 5, criteria for all new tank designs, regardless of material.