~ This Section Is Currently Being Revised ~
04: Design Guidelines - Fuel Supply - General

Tech Club: CHASSIS SYSTEMS
Sub-Tech Club: Fuel Systems
Book Title: FUEL SYSTEMS
Version Number: 1
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Section Status: Marked as Approved by Donna D Macauley on 01/26/99 at 12:51:49 PM

Document Summary:
This section contains general fuel supply design guidelines.

Leading Practice:
Fuel Tank

Basic Configuration

1. The capacity of the tank should give a minimum driving range of 300 miles (482km). Exact range specifications for each vehicle program will be determined by program management.
2. The tank should be located in a manner that avoids known impact areas and provides isolation from the passenger compartment. Fuel Systems Engineering is to be consulted during advanced fuel tank packaging studies.
3. The shape of the tank should minimize the weight of the tank and support system.
4. Longitudinal and lateral restraints should be provided by the underbody shape to eliminate the need for additional body support components.
5. If the tank contains a pressure relief / roll-over valve, this valve should be positioned in the top of the fuel tank. For more details see the fuel tank venting section.
6. The fuel pump / level unit assembly should be capable of being serviced without removal of the tank.
7. The tank should be serviceable without removal of adjacent components.
8. The design of the fuel tank and fuel supply system should not be compromised for bumper or platform hitches. It is the responsibility of Body in White Engineering to insure that the performance of the fuel system, as defined in these guidelines, not be impaired.
9. The number of components mounted to the fuel tank should be minimized to reduce the number of seals required. This will help keep tank assembly permeation losses to a minimum. The exact target for tank assembly permeation will be determined by the appropriate emissions development

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Packaging Clearances

1. General - 12mm to a friendly surface and 75 mm to an unfriendly surface, with special consideration given to crash protection.
2. Ground Clearance - The minimum fuel tank clearance to ground is measured by design L/O under full jounce metal to metal (includes tire deflations as calculated for the dynamic tire loading conditions of a particular vehicle). Each platform should consult their Advanced Chassis Design and/or Vehicle Development departments to assure their vehicle's goals are met. However, Fuel Systems Engineering shall determine if the fuel tank ground clearance meets all safety requirements.
3. Departure Lines - A 0.25" (6.4mm) clearance must be maintained between the tank and departure line determined by a tangent constructed between the tire centerline at full jounce and the bottom edge of the bumper, tie down skid plates or structurally sound license plate bracket. Additionally, the tank should not fall below a horizontal line drawn 0.25" (6.4mm) above the tangent to the rear seat foot well or other adjacent, leading structural member.
4. Spring Clearance - The minimum clearance to the tank or tank flange is 2.0" (50.8mm) static and 0.75 (19.1mm) under dynamic sway deflection. – See figure 2.
5. Exhaust Clearance - Steel tanks: a minimum of 1.5" (38.1mm) between exhaust component and tank, and 1.0" (25.5mm) to tank flange. See figure 2. Plastic tanks: A minimum of 3" (75mm) between exhaust component and tank. Tank must be shielded to the exhaust system to protect against continual temperatures exceeding 175 degree F.
6. Axle, Bumper, Shock, Strut and Unfriendly Surfaces - This clearance to be determined by Advanced Chassis Design crush analysis and verified by vehicle impact testing. No contact should occur between these components and the tank during the impact event. All components must present a smooth and friendly surface to the tank (axle, vent, brake tee, shock plate, bumper, etc ...).
7. Shock and Spring Shackle Access - The tank must permit servicing of the shock absorber and spring shackle without removing the tank or distorting the flanges.
8. Shipping and Tie Down Provisions - A minimum of 0.5" (12.7mm) clearance must be maintained between the body tie down provisions and the tank. This includes removable shackles and chain envelopes.

Detail Design and Performance

Tank Capacity - The rated capacity of the fuel tank is determined as follows:

1. With a fuel tank mounted in a program level vehicle or a representative buck, determine fluid level performance level by performing a SAE fuel fill. This volume represents the usable + unusable fuel. To determine fluid level from a CAD model, set fill level 1/2" above the internal fill nipple termination point.
2. To determine unusable fuel level, perform a run-out-of-fuel test on a program vehicle and measure fuel remaining in the tank. If vehicle testing is not possible, unusable fuel can be estimated at 0.25 gallons.
3. At the fill level determined from Step 1 or 2 (above), the tank assembly, including filler tube, must pass tip angles of 19.3 degrees fore/aft and 14 degrees side to side, without the fuel level being higher than the venting point of the rollover valve(s).
4. The fluid level must also remain below the venting point of the rollover valve(s) during thermal expansion - thermal expansion = 0.027 @ T=40 degrees F.
5. If conditions are not met in step 3 or 4, increase the length of the internal vent nipple and repeat steps 1-4.
6. Rated capacity is the final volume from step 1 minus the unusable from step 2.

Body Tolerances

1. +/- 1.5mm for locating any one floor pan strainer to the floor pan centerline.
2. +/- 1.5mm lateral tolerance between on floor pan strainer to the other.
3. +/- 1.5mm longitudinal tolerance between strainers.

Tank Location

Lateral and longitudinal location to be provided by body formations (ex. seat pockets), or chassis cross-members.

Floor Pan Clearance

Design line to line clearance between the tank and the floor pan beads. If an insulator / sound pad is used, allow for 1.3mm pad thickness.

Flange (Steel Tanks)

1. Flange bend radius to be a minimum of 3 times the material thickness.
2. Flanges should not be folded, but where required, the transitions from fold to normal will be 38mm. In general, all folds are to be downward in direction (See figure 3). Folds at the support strap locations may be upward if this provides the most friendly bearing surface. Maximum bend to be 90 degrees with 15 degree tolerance.

Seam Welds (Steel Tanks)

1. Location - with fold - to be located outside of fold.
2. Location - without fold - located 6.5mm from wall of tank.
3. All manufacturing pre-seam spot welds must be located outside of the seam weld path.

Ribs (Steel Tanks)

Ribs will be at least 6.5mm deep.

Material Thickness

Minimums and maximums to be specified on the drawing with the minimum resulting from the combined testing of:

1. PV (pressure vacuum) per PF-8950 for plastic tanks and PF-8951 for steel tanks.
2. Shake per PF-8950.
3. Impact per FMVSS 301 impact testing.
4. ECE Regulation 34 for plastic tanks.

Leak Testing

Tank assemblies are to be tested for leaks per PF-8952.

Identification Marking

1. Steel Tank - Date codes will be stamped in appropriate size characters on bottom surfaces of the tank. Sharp corners are to be avoided.
2. Plastic Tanks - Date codes, SAE material codes, and the tank assembly part number, are to be molded on the bottom surface of the tank. Tanks used for European export are

additionally required to have the tank as-molded part number on the bottom surface.

Tank Attachments

1. The straps are to be equi-spaced about the longitudinal centerline of the tank to equalize strap loads under operating and impact conditions.
2. Two identical straps are to be used whenever possible.
3. The strap T-slot end is folded for double thickness, and spot welded.
4. The strap bolted end is to be folded for double thickness, and spot welded.
5. Developed strap length will be determined by on-vehicle program car assembly testing. Preliminary developed length will be determined by design.
6. Material thickness of the straps must be compatible with the tank material thickness.
7. Straps should shield openings at the front of strainers to minimize corrosion.
8. Between the tank and the underbody attachments, the strap should be perpendicular to the weld flange of the tank.

Fuel Filler Tube

Basic Configuration

1. Fill location may be on the left of right side of the car depending on platform/product needs. For impact reasons, the filler must not be located in the rear of the vehicle.
2. Concept layout should begin assuming a 2" O.D. tube.
3. The filler tube should be as short and straight as possible. If bends are required, keep them all in one place for better fill quality.
4. The internal fill vent tube end location, as it enters the fuel tank, determines the allowable fuel level in the tank.
5. Fill vent tubes running internally to the filler tube reduce the risk of permeation.
6. The configuration of the upper filler tube must comply with State of California Air Resources Board Specifications for Fill Pipes and Openings of Motor Vehicle Fuel Tanks.
7. The filler tube should be serviceable without removal of the fuel tank or other components if possible.

Packaging Clearances

1. The minimum clearance to fixed body components should be 0.5" (12.7mm).
2. If the tube passes through the tire wheelhouse, minimum tire clearance should be 3.0" (76.2mm) at full jounce.
3. If a break-away housing is used on the tube, and it is located in the wheelhouse, the housing drain must be located away from the radial wheel splash and hot exhaust components. Care should be taken in locating the drain hole to assure that gasoline drainage does not attack sealing areas of the lower wheelhouse.
4. Minimum clearance to spring dynamic roll should be 0.75" (19.1mm), and 2.0" (50.8mm) static full jounce.
5. The filler tube tank grommet and/or rubber hoses must be 5.0" (127.0mm) from the exhaust to avoid heat deformation of these parts.
6. All fasteners are to be pointed away from the filler tube.
7. All components surrounding the filler tube should present a smooth, friendly surface.

Detail Design and Performance

Note: In general the fuel filler tube must comply with PF-6458 (the Fuel Filler Tube Performance Specification).

1. The minimum centerline bend radius should be 5.0" (127.0mm) to permit less costly press bends on the tube (mandril bends are more expensive).
2. The minimum length of straight tube between bend tangents is two tube diameters.
3. The vent tube must allow an SAE fill at 12 gpm for a non vapor recovery nozzle and 10 gpm for a Stage 2 vapor recovery nozzle without spitback, spray or premature shut-off. Baffling or vent tube shall permit a 15 gpm plant fill without spitback, spray or premature shut-off when filling a virgin tank. Plant fill equipment must be accommodated by the tube design.
4. The roll over valve, if present, must prevent liquid carry over to the canister during attempted overfills.
5. The unleaded restrictor must comply with Federal requirements to prevent the insertion of a leaded gas nozzle. It must also allow no more than 700cc of leaded gas to pass into the tank when dispensed from a leaded gas nozzle, if attempted.
6. The filler tube and restrictor must survive a life cycle of 2500 nozzle insertions without failure.
7. The tube itself must pass a 5 second, 10 psi leak test after either a 500lb (2200N) pullout force is applied to the housing or a 250lb (1100N) push force is applied along its longitudinal axis. The filler tube assembly must pass a 3 psi leak test.
8. The nozzle must be retained by the filler tube during the fill process.
9. For impact considerations: a) the filler tube must penetrate the tank grommet by at least 2.75" (69.9mm), b) the grommet sealing zone is to be sized to within 0.015" of the nominal filler tube diameter and be smooth without discontinuity in an area of +/- 2.0" (50.8mm) of the designed seal location c) the surface of the filler tube within 2.0" of the grommet is to be free of underbody sealer.
10. The filler tube coating must meet the requirements of MS-8954, Underbody Rust Prevention, section 2.2.3.c.
11. Permeation of the filler tube assembly should be held to 0.1gm/24hrs or less to assure total vehicle compliance with both CARB and Federal stricter evaporative standards.
12. The maximum allowable angularity of the filler tube to grommet is 10 degrees.
13. When the filler tube is articulated in the tank grommet, it must not come in contact with any part of the fuel level sending unit. To accommodate assembly techniques, it may be necessary to use foam tube stops. Beads as assembly aids are to be avoided.
14. The filler tube must comply with EPA fuel dispensing spitback procedure (Section 86,146-96) which requires no more than 1.0 gram of spitback.
15. The filler tube, in combination with the fuel tank must not allow fuel to carry over to the canister to a maximum angle of 16 degrees fore and aft and 14 degrees side to side.
16. No fuel expulsion shall be experienced on cap removal.

Fuel System Venting

1. The vent system should always maintain a path of vapor communication
2. A full tank must vent under the following conditions: a) 16 degree fore/aft vehicle attitude, b) 14 degree side to side vehicle attitude, c) delta T of 40 degree F combined with a and b.
3. Rollover valve to comply with PF-8801
4. Liquid carry over test T.B.D.

Fuel Delivery Module

Corrosion

1. Must have sufficient corrosion protection to withstand 11 years/ 120,000 miles of service.
2. All metallic surfaces must meet the requirements of Chrysler Laboratory Procedure 461H-44 or ASTM B117 after 96 hours.
3. All metallic components must function properly after 170 cycles of the vehicle corrosion test program

Service

1. Service must be accomplished with a minimum of system tear-up (Body and Chassis) without the use of special tools, if possible.
2. A means of draining fuel should be provided to enable pump module removal, especially on tanks having the module opening below the fuel level.
3. The module inlet filter, level unit and pressure regulator (mechanical returnless fuel system with regulator in the fuel tank) are the items for service only.

Electrical Connections

1. Hard shell locking connector systems should be used.
2. Electrical connections should be sealed to withstand all harsh environments.
3. Maximum loads of the system must not fail the connector assembly or parts used within the assembly.

Hydraulic Connections

1. Quick-Connect style connections must conform to Performance Specification PF-8190.
2. Tube end forms must conform to Process Specification PS-8152.

Bottom Referencing

Bottom referencing must be maintained so that all fuel is accurately gaged and available for vehicle use in all vehicle and customer conditions.

Float Location

If a lever arm float-type level is used, it should be located at the tank's center of mass to minimize the I/P gauge pointer movement during excessive vehicle maneuvers.

Calibration

1. Match the fuel tank characteristics of fuel volume vs. fuel height.
2. Conform to Performance Specification PF-8474, unless otherwise specified.

Reservoir

1. A fuel reservoir should be provided so that the pump inlet is not starved for fuel during vehicle maneuvers.
2. Large enough to complete PG-13 and low fuel handling tests.

Tube Sizing

Must be adequate for maximum pump flow requirements without pressure drop. Recommended 5/16" supply and 1/4" return for metal tubes and 3/8" supply and 5/16" return for plastic tubes.

RFI

Sufficient RFI suppression should be provided to meet existing USA and export market regulations as outlined in Performance Specification PF-9326.

Impact

Designed to pass FMVSS 301 and 42G sled tests.

Indexing / Mounting / Sealing

1. A positive, mechanically indexed, mounting method should be used.
2. The sealing design should account for all tolerance stack-ups and service conditions.

General Packaging Clearances

Similar considerations used for exhaust components.

Permeation

Low permeation flange material should be used to meet the stricter EVAP regulations.

NVH

1. Pump mounting, reservoir suspension, and bottom referencing should take into account low noise transmission to the fuel tank and vehicle structure.
2. All noises must be reduced/attenuated to pass a jury evaluation in hot, cold, and high altitude conditions.

Contamination / Filtration

The size (area) and pore size (micron size) of the fuel pump filter should be selected such that the pump is protected for 11 years / 120,000 miles for the 95th percentile customer.

Material Handling

1. When assembled in the fuel tank, the module must withstand a 4 foot drop without damage and meet all performance criteria.
2. All openings must be plugged for shipping purposes.

Identification

The module flange should be identified with the Chrysler P/N per Process Specification PS-4480 and, if plastic, the general callout for recyclability

Fuel Filler Caps

1. Caps to comply with PS-7698 and PS-9095.
2. Pressure and vacuum relief set points for all corporate gas caps to be common to reduce complexity for emission certification. Relief set points are specified in the performance standard.
3. Caps to comply with Part 581 and FMVSS 301 impact testing.
4. Gas caps need to demonstrate durability mileage of 100,000 miles (160,000 km) passenger car and 120,000 miles (192,000km) truck general endurance.
5. If subject to impacts, caps are to retain their sealing capabilities.
6. Caps for foreign country sales must meet homologation wording requirements.
7. Caps may require a tether. Check with product planning or vehicle synthesis.

Fuel Tubes / Vapor Tubes / Hoses

Basic Configuration

1. Bundles - The fuel and vapor tubes shall be bundled for ease of assembly. The lines must be isolated from each other and from the floorpan to prevent NVH concerns.
2. Tube Size - The fuel supply tube shall be of maximum size to reduce pressure drop and pump loading. The vapor tube size shall be directed by emission requirements (purge).
3. Quick Connectors - Quick connectors should be used to connect lines to tanks, engines and sub-assemblies. Color coding, reverse connection or ID size differences shall be incorporated to prevent adjacent connectors from mis-builds.
4. Clips - The use of production type (standardized) clips should be used whenever possible. Clips should be fastened to the vehicle by screws, weld studs or integrally molded plastic christmas trees and/or barbs. All clips must be isolated for NVH concerns.
5. Permeation - Permeation limits are established by governmental regulations, individual vehicle applications and total emissions break-down. The over-all fuel permeation level must be below the corporate target. Individual component permeation may be a percentage of the total.
6. Impact - All fuel lines, vapor lines and hoses must pass the current regulated impact tests. Lines shall not be routed between components that will cause leaks. An acceptable test result is no leaks present following impact.
7. Service - The vehicle components from the fuel tank, engine, and fuel filter must be serviceable without kinking or damaging lines/hoses. All lines/tubes/hoses to be replaced must be so without excessive vehicle disassembly.
8. Corrosion - Steel fuel lines incorporating a coating must be capable of 10 year / 100,000 mile life expectancy (PS-8688). Steel quick connects must be made with 300 series stainless steel or coated with Zn-Ni electroplate. Mud packing requirements must also be considered (spacing of bundles from each other and from the floor pan).
9. Assembly - A 25mm decking clearance is recommended between tubes and body components. The use of quick connectors will allow assembly without special tools.
10. Packaging - All lines should be routed or shielded from tire stone impingement or adjacent component failures to prevent leaks. A 10mm clearance to body or individual component movement envelope should be enforced. Bend radius is recommended at 2 times diameter (minimum). Jumper lines (nylon, rubber) require adequate clearance to connect and disconnect from components and should be routed to avoid failed exhaust component gas impingement.
11. Electrostatic Discharge - A grounding mechanism shall be used to dissipate any charge build-up caused by the movement of fuel in the line/tube/hose.
12. Handling / Packaging - Design for palletized assembly.

Electrostatic Discharge

1. The DC resistance from a metal fuel filler tube to the vehicle chassis should not exceed 100 ohm, measured using a 10v source, if the ground path consists of a mechanically fastened ground strap, metal bracket, or other hard metal connection between the filler tube and the vehicle chassis. The DC resistance from a metal fuel filler tube to the vehicle chassis should not exceed 100,000 ohms, measured using a 500v source, if the ground path is through a conductive plastic housing, plastic bracket or plastic clip.
2. The DC resistance from a fuel filer casing to the vehicle chassis should not exceed 100 ohm, measured using a 10v source if the filter casing is metal and the ground path consists of a mechanically fastened ground strap, metal bracket or other hard metal connection between the filter casing and the vehicle chassis. The DC resistance between the filter casing and the vehicle chassis should not exceed 100,000 ohm, measured using a 500v source if the filter casing is made of conductive plastic, and the ground path is through a conductive plastic bracket or clip. Additionally, if the fuel filter casing is made of conductive plastic , the casing should be designed so that the material is uniformly conductive (the inner and outer surfaces are equally conductive and in good electrical contact with each other).
3. The DC resistance from metal supply and return fuel lines and the vehicle chassis should not exceed 100 ohms, measured using a 10v source, if the ground path consists of a mechanically fastened metal bracket, metal clip, or other metal connection. The DC resistance between metal

supply and return fuel lines should not exceed 100,000 ohms, measured using a 500v source. if the ground path is through conductive plastic brackets or clips.

4. The length of non-conductive plastic or rubber jumper fuel lines and hoses should be minimized. Such components should be routed so that they do not lie within 2.5cm of metal floor pans, fenders, stone shields, or other metal chassis components.
5. If the velocity of fuel through a non-metalic filler tube component, fuel line, or fuel line jumper is in excess of 5.0m/s, the resistivity of the layer of the component which is in contact with the fuel should not exceed 10,000 ohm per square, measured using a 500v source, and the DC resistance from the conductive layer to the vehicle chassis should not exceed 100,000 ohm, measured using a 500v source.
6. The number and degree of bends in the fuel filler tube should be minimized.
7. The cross-section of the filler tube should be nearly circular and nearly constant along the length of the tube. Any changes in the cross-sectional area should be gradual.
8. The junction between the fuel filler tube and the plastic fuel tank should be designed to minimize turbulence.
9. The resistivities of non-metal materials should be measured in bulk in accordance with ASTM documents D257, D4496 or other acceptable consensus standard, and should be verified on an appropriate sample of finished components.
10. Filler tube inlet, restrictor and trap door components should be designed so that when a fuel nozzle is inserted into the vehicle in such a way as to allow fuel to be dispensed safely, the DC resistance between the fuel nozzle and the vehicle chassis does not exceed 100 ohms, measured with a 10v source, if the electrical path from the nozzle to the chassis lies through metal components. If the ground path from the fuel nozzle to the vehicle chassis lies through conductive plastic components, the DC resistance from the fuel nozzle to the vehicle chassis should not exceed 1,000,000 ohms measured using a 500v source.
11. Clamps need not be grounded (capacitance is small) All metal shields within 2.5 cm of non-conductive (>10 to the 6th power ohm/sq) fuel bearing components (filler tubes, fuel tanks, fuel lines and jumper lines) must be grounded to the vehicle chassis.

Government Standards

- FMVSS 301 - Fuel System Integrity
- 49 CRF Part 581 - Low speed bumper impact
- Canadian MVSS 215 - Low speed bumper impact
- Gulf Cooperative Council #41 - Low speed bumper impact
- Michigan Public Act 1988 #414 - Identification of Plastic Parts for Recycling