



Specifications for Diesel Exhaust Fluid System

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1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. This specification provides standard technical requirements for Diesel Exhaust Fluid (DEF) systems. This specification shall be used in conjunction with CG2139 DEF Program Specific Component Technical Specification (CTS), Appendix C of the electronic Statement of Requirements (SOR). References to the CG2139 program specific CTS are included in this specification where program specific requirements are expected to exist.

Note: The CG2139 program specific CTS may include additional requirements that are not referenced in this specification and may supersede any requirements included in this specification. In the case of any conflicts between this specification and the CG2139 program specific CTS, the CG2139 program specific CTS takes precedence. This specification shall be used in conjunction with and complement other requirements documents included in the SOR.

The primary function of the DEF System is:

- To store the emission fluid
- Filter contaminants and supply fluid at pressure to the injector location
- Enable refilling of the tank
- Sense fluid properties in tank and provide signals to the Engine Control Module (ECM)
- Heat the fluid in tank and lines as required

The DEF System shall carry out these functions while meeting specific requirements of the customer, powertrain, other interfaces, mandated safety and emission standards, and corporate objectives.

1.2 Applicability. This specification applies only to diesel and biodiesel fueled vehicles equipped with a DEF System to meet Nitrogen Oxide (NOx) emissions.

1.3 Remarks. The system described and specified in this specification has differing naming nomenclature dependent on market. The system referred to in this specification stores, handles and delivers an aqueous mixture of 32.5% urea (AUS32). For this specification, it will be referred to as "DEF System". It is alternatively referred to as:

- Selective Catalytic Reduction (SCR) system
- AdBlue system
- Urea system
- Emission reduction fluid system
- Agente Reductor Liquido Automotivo (ARLA) 32

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASTM D903	ISO 1402	ISO 16750-5	SAE J400
ASTM D4169	ISO 1431-1	ISO 19438	SAE J1960
IEC 60068-2-38	ISO 3167	ISO 22241-1	SAE J2044
ISO 179-1	ISO 4020	ISO 22241-4	SAE J2045
ISO 527-1	ISO 9001	ISO 22241-5	

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2.2 GM Standards/Specifications.

GMW3059	GMW14055	GMW14857	GMW15570
GMW3091	GMW14264	GMW14872	GMW15573
GMW3097	GMW14270	GMW14889	GMW15760
GMW3103	GMW14291	GMW14911	GMW15862
GMW3110	GMW14476 (ID)	GMW15272	GMW15982
GMW3172	GMW14547	GMW15349	GMW16194
GMW3191	GMW14681	GMW15449	GMW16434
GMW4710	GMW14729	GMW15450	GMW17152
GMW8518	GMW14842	GMW15451	GMW17442

2.3 Additional References.

- CG2135 DEF Analysis Development Validation Plan and Report (ADVP&R), Appendix G of the SOR
- CG2139 DEF Program Specific CTS, Appendix C of the SOR
- CG2456 DEF Test Procedures (ID)
- DEF Controller CTS, Appendix C of the SOR
- GM Ergonomics Design Guidelines for Shipping Caps/Plugs, Appendix F of the SOR
- Platform Specific Vehicle Technical Specification (VTS) (ID)

(ID) = This standard is limited to internal distribution within General Motors and shall not be distributed outside this company. Contact the GM Lead Engineer for further instructions.

3 Requirements**3.1 System/Subsystem/Component/Part Definition.**

3.1.1 Appearance. Except for the DEF System fill opening and cap, the DEF System shall not be visible to the customer. In incomplete vehicle configurations and cab chassis models, the DEF System components that are expected to be exposed shall be black in color.

3.1.2 Content.

3.1.2.1 Physical Content. The DEF System consists of (but not limited to) 3.1.2.1.1. thru 3.1.2.1.7.

3.1.2.1.1 Tank Assembly.

- Fluid storage tank
- Tank fill spud
- Tank fill limit valve
- DEF Pump module closing system (mason jar, cam-lock or welded)
- Tank venting system
- DEF Controller mounting hardware
- Wiring harness
- Protection shield and/or insulation blanket
- Component mounting and restraint hardware

3.1.2.1.2 Tank Mounting Hardware.

- Straps (if straps are similar in appearance, then front/rear designation shall be shown)
- Brackets (if brackets are similar in appearance, then front/rear designation shall be shown)

3.1.2.1.3 DEF Pump Module.

- Filter
- Pump
- Pressure sensor

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- Tank heater
- Reservoir inside tank (pump module housing)
- Level sensor
- Temperature sensor
- Urea quality sensor (North America market region)
- Electrical connectors

3.1.2.1.4 DEF Controller. Requirements per DEF Controller CTS, Appendix C of the SOR.

3.1.2.1.5 DEF Fill Pipe Assembly.

- Fill pipe
- Vent line
- Fill pipe cap
- Quick connector
- Mounting provisions (bracket, clips, etc.)
- Thermal protection (as required)
- Fill head (with expansion chamber)

3.1.2.1.6 Feed Line

- Feed hose
- Electrical wire for heating
- Heated quick connector at tank end
- Heated quick connector at injector end
- Heated quick connector for intermediate connection of the feed line joints
- Electrical connector(s) at tank end and intermediate connection (if equipped)
- Mounting provisions (bracket, clips, etc.)
- Abrasion protection
- Thermal protection (as required)

3.1.2.1.7 Injector Assembly. GM Global Propulsion Systems (GPS) released.

3.1.2.2 Functional Content. The DEF System shall provide the following primary functions while meeting specific requirements of the vehicle and powertrain electrical and hydraulic interfaces, while respecting the safety and emission standards:

- Store DEF, avoiding any leakage and/or evaporation
- Seal the system from water and dust intrusion when not filling to prevent contamination
- Allow DEF filling with the specified equipment and via the specified interfaces
- Ventilate the DEF Tank, avoiding any over and/or under pressure
- Allow for DEF contraction and expansion due to cold weather and heat
- Pump DEF on request through the dosing line to the injector at required pressure and flow rate
- Filter the contaminants in the DEF
- Heat and thaw the DEF on request, fulfilling the given cold weather startup times
- Measure DEF outlet pressure and transmit the signal to the ECM
- Measure DEF temperature and transmit the signal to the ECM
- Measure DEF level and transmit the signal to the ECM
- Measure DEF quality and transmit signals to the ECM (if required by program)

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3.1.3 Ambient Environment. The environmental conditions that the DEF System will be exposed to during its lifetime are given in 3.1.3.1 thru 3.1.3.10. The values in Table 1 should be used in the selection of materials and application of engineering judgment throughout the design process.

3.1.3.1 Operating Environment. The DEF System shall be capable of exposure to temperatures for their sales regions as defined in Table 1 and operating in the environments described in Table 2 without adverse effect to functional performance.

3.1.3.1.1 Continuous Temperature. The DEF System shall be designed to work without any performance or durability issues for 3020 h/30 000 cycles per the temperatures in Table 2 during continuous vehicle operation, based on 321 900 km (200 000 mi) vehicle life. System functionality and performance shall not be compromised under continuous thermal conditions.

3.1.3.1.2 Excursion Temperature. The DEF System shall be designed to work without any durability issues for 120 h/800 cycles at 110 °C underbody or 150 °C underhood temperature during vehicle operation on an infrequent basis, based on 321 900 km (200 000 mi) vehicle life. If the vehicle Reliability Evaluation Point (REP) is other than 321 900 km (200 000 mi), then scale the required cycles accordingly. No single excursion event shall be longer than 20 minutes. Occupant safety shall not be compromised during excursion thermal conditions.

Table 1: Ambient Temperature

Region	Minimum Temperature	Maximum Temperature
Worldwide Default	-48 °C (-55 °F)	52 °C (125 °F)
Russia (Siberia)	-51 °C (-60 °F)	Not applicable
Middle East	Not applicable	55 °C (130 °F)

Table 2: Operating Environment

Area/Condition	Requirement
Underbody	-40 °C to 90 °C (continuous)
Underhood	-40 °C to 125 °C (continuous)
Relative Humidity	2% to 100%
Fluid Temperature in Tank (bulk fluid)	-40 °C to 65 °C (continuous)
Fluid Temperature at Injector (feed line interface)	100 °C (continuous)
Barometric Pressure	56.9 kPa to 106.3 kPa
Precipitation	≤ 4.6 mm/minute
Grade/Inclination	≤ 15%
Electromagnetic	GMW3091, GMW3097
Ozone	≤ 0.40 Parts Per Million (PPM)
Altitude	-150 m to 4600 m
Input Voltage	0 VDC to 16 VDC
Operating Voltage (system function)	9 VDC to 16 VDC
Operating Voltage (system communication)	6 VDC to 16 VDC
Nominal Voltage	13.5 VDC, per GMW3172

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3.1.3.2 Non-Operating Environment. The DEF System shall meet all operating performance requirements, without loss of function or degradation of service life, after exposure to transport by airplane at altitudes up to 13 700 m, validated per ASTM D6653-01.

3.1.3.3 Ultraviolet Radiation. Ultraviolet radiation, accelerated weathering, applies for incomplete vehicles (cab chassis trucks, cutaway vans, etc.) and any exterior exposed components, i.e., fill caps in fill pocket, etc. The exposed materials shall retain 75% of the original properties for ISO 527-1/2 Tensile Strength and ISO 179-1 Notched Charpy Impact after 2500 kJ/m² of accelerated exposure using Xenon arc weathering apparatus as described in SAE J1960. Tensile bars shall be prepared using ISO 3167, 4 mm thick Type A. Charpy Impact bars shall be 80 mm × 10 mm × 4 mm Machined V notch, r = 0.25 mm. For complete vehicle applications, this requirement does not apply.

3.1.3.4 Robustness to Ozone. This requirement applies to parts made of highly unsaturated materials such as diene rubber (polyisoprene, styrene-butadiene rubber, etc.) that have exposure to the external ambient environment. The parts shall be checked for stabilization against ozone per ISO 1431-1, 100 Parts Per Hundred Million (PPHM), test duration = 336 h.

3.1.3.5 Type of Fluid and Material Compatibility. The DEF System shall work with the fluid as per ISO 22241-1 quality requirements. Materials used in the system shall be compatible with this fluid, and shall work in the operating environment listed in Table 2.

3.1.3.6 Corrosives: Chloride Exposure. Polymers exposed to the underbody and lower underhood atmosphere must be compared against Table 3 to determine the need for further testing (defined in 3.1.3.6.1 and 3.1.3.6.2). If the polymer is not identified within the list, GM Materials Engineering shall be consulted to determine the appropriate disposition.

Table 3: Chloride Exposure

Test Required	Test NOT Required
Polyamide (PA), e.g., P6, PA66, PA12, etc.	Polyacetal (POM)
Polyketone (PK)	Polyethylene (PE)
	Polyester Polybutylene (PBT)
	Polyethylene Terephthalate (PET)
	Polypropylene (PP)
	Polyphenylene Sulfide (PPS)

3.1.3.6.1 Resistance to Calcium Chloride. This requirement applies to components with external exposure. The sample shall be fixtured during the test such that a simulated 44 N side load is applied to the part, representative of the part's usage in the assembly. The external surfaces of the fixtured assembly are immersed in a 50% aqueous solution (by weight) of calcium chloride for 200 h at 60 °C ± 2 °C with the ports sealed. The sample is then stored out of solution for 200 h at 60 °C ± 2 °C. The sample may be rinsed with fresh water to clear salt residue. There shall be no cracking, crazing, or other damage to the plastic parts. Parts need to pass leak and functional tests after exposure.

3.1.3.6.2 Resistance to Zinc Chloride. This requirement applies to components with external exposure. The sample shall be fixtured during the test such that a simulated 44 N side load is applied to the part, representative of the part's usage in the assembly. The external surfaces of the fixtured assembly are immersed in a 50% aqueous solution (by weight) of zinc chloride for 200 h at 23 °C ± 2 °C with the ports sealed. The sample may be rinsed with fresh water to clear salt residue. There shall be no cracking, crazing, or other damage to the plastic parts. Parts need to pass leak and functional tests after exposure.

3.1.3.7 Stone Impingement. The DEF System components exposed to impingement due to packaging location shall be capable of withstanding stone and gravel impact as tested per SAE J400 at an angle of attack of 45 degrees below the bottom surface of the DEF System in the driving direction. After the test, components shall meet leak requirements and functional checks. Following a teardown and a detail analysis of every exposed

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component there shall be no indication of perforation and no damage that could impact the functionality of the components.

3.1.3.8 Gravel Entrapment. The DEF System shall successfully comply with the criteria for vehicle-level gravel entrapment test when tested per GMW14889 with no degradation to component functions or visible damage. Parts need to pass leak and functional tests after exposure and have no visible damage to component that will contribute to noise and or vibration or squeak and rattle concerns.

3.1.3.9 Automotive Fluids Compatibility. The DEF System shall be designed to withstand prolonged exposure to automotive fluids as outlined in ISO 16750-5 and exposure to DEF. Components must meet leak test requirements post-test and must exhibit no visible cracking or crazing.

3.1.3.10 Thermal Integrity. The DEF System shall be designed to avoid autoignition conditions involving components of the DEF System as evaluated per GMW14911.

3.1.4 Interfaces. Interface between the DEF System and other vehicle subsystems is depicted at a high level in Figure 1. These interfaces may constrain or drive the design of the system and, therefore, must be addressed during design and development. The entire DEF System implementation and operation in the vehicle must also successfully accommodate the identified interfaces. These physical interface requirements are further detailed in the CG2139 program specific CTS.

Assembly effort, pull-apart effort and side load capability testing as per SAE J2044 shall be conducted at room temperature (23 °C), high temperature (50 °C) and low temperature (-30 °C).

The quick connector at pump end shall be heated to prevent freezing. The tank system should be capable of thawing the indicated region 'A' in Figure 2 independently (with feed line connected but not energized) per the thaw times and conditions indicated in Table 4. The heated delivery line system shall be capable of thawing the indicated region 'B' in Figure 2 independently (connected to tank system but tank system not energized) per the thaw times and conditions indicated in Table 4.

3.1.4.1 Tank to Fill Pipe. The tank to fill pipe interface shall be a 24 mm SAE J2044 quick connect design, unless otherwise indicated in the CG2139 program specific CTS. Quick connectors shall meet SAE J2044 requirements, with DEF as the test medium.

3.1.4.2 Vent Lines. Vent line interface shall be a 12 mm SAE J2044 quick connect design, unless otherwise indicated in the CG2139 program specific CTS. Quick connectors shall meet SAE J2044 requirements, with DEF as the test medium.

3.1.4.3 Feed Line. Feed line interface to pump module in the DEF Tank shall be a 9.53 mm SAE J2044 quick connect design, unless otherwise indicated in the CG2139 program specific CTS. Quick connectors shall meet SAE J2044 requirements, with DEF as the test medium.

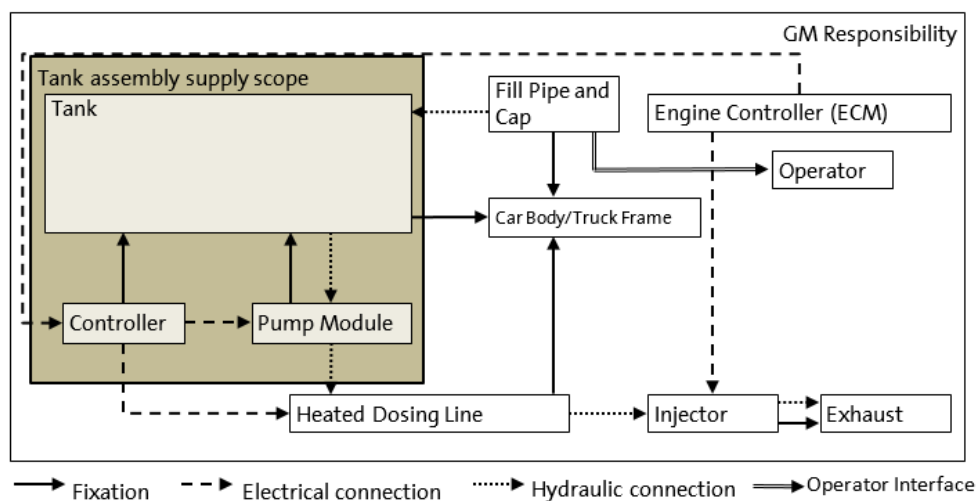


Figure 1: DEF System Interfaces

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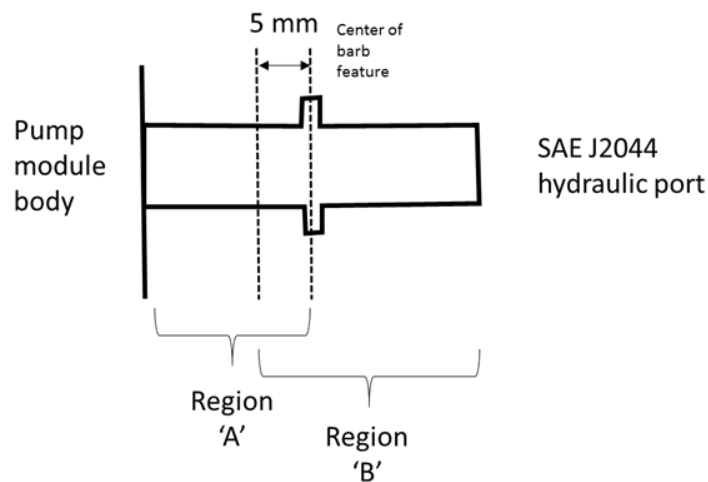


Figure 2: Thawing Performance Responsibility: Tank to Feed Line Interface

Table 4: Dosing Start Time

Ambient and Tank Temperature	Vehicle Requirement	Subsystem Requirement	Minimum Dosing Rate (mg/s)	Voltage (V) at the Controller Input
$\geq -9\text{ }^{\circ}\text{C}$	15 s	15 s	Maximum Dosing	12
$-18\text{ }^{\circ}\text{C}$	20 minutes	18 minutes	50	12
$-20\text{ }^{\circ}\text{C}$	37 minutes	32 minutes	40	12
$-25\text{ }^{\circ}\text{C}$	52 minutes	45 minutes	30	12
$-30\text{ }^{\circ}\text{C}$	64 minutes	55 minutes	20	12
$\geq -9\text{ }^{\circ}\text{C}$	15 s	15 s	Maximum Dosing	12

3.1.4.4 Assembly Plant Tooling/Fixtures. The DEF System shall be designed such that the components clear GM assembly plant tools and fixtures.

3.1.4.5 Electrical Devices. The complete DEF System shall meet GMW3172 requirements, GMW3172 component classification: B-H-D-J-F-IP6K9K and IP6K8.

3.1.4.6 Serial Data Requirements. All serial data shall comply with the requirements outlined in DEF Controller CTS, Appendix C of the SOR.

3.1.4.7 Diagnostics/Calibration. The DEF System shall meet any program specific diagnostic and calibration requirements as part of CG2139 program specific CTS.

3.1.4.8 Electrical Connector Interface.

3.1.4.8.1 All electrical connectors in the DEF System shall meet GMW3172 and GMW3191 requirements:

- GMW3172 component classification: B-H-D-J-F-IP6K9K and IP6K8 (defined in GMW3172)
- GMW3191 connector classification:
 - Temperature Class: 2
 - Vibration Class: 1
 - Sealing Class: 3
 - Mating Force Classification: 3

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3.1.4.8.2 All electrical connectors used on DEF liquid carrying components shall have capillary barrier (silicone blocking agent or completely sealed connector) to prevent fluid travel through connectors and wiring harness in case of leakage in the system.

3.1.4.8.3 Electrical connectors of the DEF System shall include Connection Position Assurance (CPA) features unless otherwise agreed in writing from GM Engineering.

3.1.4.8.4 All connectors, including internal connectors in the tank assembly, shall be GM released ones.

3.1.4.9 Fill Equipment Interface. The DEF System shall be designed to allow for DEF refilling with either an automatic shutoff nozzle or canister in accordance with ISO 22241-5. In addition, the DEF System shall be designed to provide clearance to the automatic shutoff nozzle envelope per ISO 22241-4.

3.1.5 Usage Definition. Not applicable.

3.2 Product Characteristics.

3.2.1 Performance Requirements.

3.2.1.1 System Performance Requirements. Unless otherwise specified, 3.2.1.1 thru 3.2.1.7 valid for the whole product life. Unless otherwise specified the system must meet the performance requirements in the static and dynamic (driving) states.

3.2.1.1.1 System Operating Parameters.

- Average flow rate in operation: 50 mL/h
- Continuous maximum flow rate: 2.8 L/h
- Excursion maximum flow rate: 3.1 L/h (maximum 60 s every 10 minutes)
- Refill flow rate (North America): 40 L/minute
- Refill flow rate (Europe): 10 L/minute
- Plant first filling: See Appendix E of SOR.
- Maximum fluid temperature in the tank: 65 °C
- Maximum fluid temperature in the dosing line: 100 °C

3.2.1.1.2 Fluid Quantity Determination. The following requirements apply to the signal sent from the DEF Controller to the ECM and is not intended to represent only the performance of a single component of the DEF System used for the determination of DEF quantity:

- Measured signal: Useable fluid volume
- Measurement range: 3% to 100% of tank volume
- Measurement resolution: < 0.03 L
- Measurement accuracy (includes dynamics and filtering time impact): $\pm 0.5\%$ for 0% to 50% quantity range and $\pm 1\%$ for 50% to 100% quantity range
- Response time after 5 L refill, to reach signal within accuracy: < 60 s
- Response time during operation, to reach signal within accuracy: < 60 s
- Refill detection of a 2 L customer refill with stopped vehicle: < 1 s
- Refill detection of a full customer refill with stopped vehicle: < 0.5 s

The requirements need to be met in all conditions per Table 2 with vehicle stationary or moving with the system power mode "RUN".

For communication and diagnostic requirements, see the DEF Controller CTS, Appendix C of the SOR.

3.2.1.1.3 Pressure Regulation Requirements. At the outlet of the dosing line:

- Nominal fluid pressure: 500 kPa (5 bar)
- Maximum allowed pressure overshoot: 800 kPa (8 bar)
- Transition time from 50 kPa (0.5 bar) to commanded regulated pressure: < 5 s
- Maximum pressure regulation variation: ± 20 kPa (± 0.2 bar)
- Regulation band pressure average to be within tolerance band: ± 30 kPa (± 0.3 bar)

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