GM WORLDWIDE ENGINEERING STANDARDS	**Material Specification**	**GMW16709**

Fuel Hose – Small Diameter

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. The material content of the hose and stiffness of the hose are defined by the Construction and Temperature class designations for the hose. Hoses are defined by the Construction and temperature capability. Hoses are either suitable for applications subjected to maximum continuous operation temperatures of +90 °C with intermittent operation at temperatures up to +110 °C maximum, to maximum continuous operation temperatures of +125 °C with intermittent operation at temperatures up to +150 °C maximum, or for applications subjected to maximum continuous operation temperatures of +150 °C with intermittent operation at temperatures up to +175 °C, dependent on the Temperature Rating of the hose. The designation for the fuel hose is defined as GMW16709 Type YZ, where Y defines the temperature capability of the hose, and Z defines the Construction of the hose per 3.8.1 through 3.8.3 and Table 1.

1.2 Applicability. This standard covers the material requirements of fuel hoses for use with gasoline or diesel fuel in automotive fuel systems. All hoses shall be considered conductive, and must meet the conductivity requirements of this specification, unless otherwise noted on the part drawing.

2 References

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

2.1 External Standards/Specifications.

ASTM D380	ISO 34-1	ISO 48	ISO 1817
ASTM D412	ISO 36	ISO 188	ISO 23529
ASTM D413	ISO 37	ISO 1431-1	

2.2 GM Standards/Specifications.

GMW3059	GMW14291	GMW14680	GMW14914
GMW14270	GMW14292	GMW14681	GMW15423

2.3 Additional References.

- Component Technical Specifications (CTS)
- Subsystem Technical Specifications (SSTS)

3 Test Preparation and Evaluation

3.1 Resources.

3.1.1 Facilities. Facilities shall conform to the relevant test procedures.

3.1.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.1.2 Equipment. Equipment shall conform to the relevant test procedures.

3.1.3 Test Vehicle/Test Piece. Not applicable.

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3.1.4 Test Time. Shall conform to the relevant test procedures.

3.1.5 Test Required Information. Conforming to the relevant test procedures.

3.1.6 Personnel/Skills. Conform to company and/or laboratory requirements. Technician training records must be available upon request.

3.2 Preparation. Not applicable.

3.3 Conditions.

3.3.1 Environmental Conditions. The minimum time between vulcanization and testing of elastomers shall be 72 h. The test pieces shall be maintained at a temperature of 23 °C ± 5 °C for at least 8 h prior to test and shall be free from strain during this period.

3.3.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc. Ambient temperature test conditions shall be held to 23 °C ± 5 °C. All other temperatures shall be held to a ± 3 °C and all pressures to -0 kPa/+690 kPa unless otherwise noted.

3.4 Instructions. Not applicable.

3.5 Data. Not applicable.

3.6 Safety. This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3.7 Documentation. Samples of components or material released to this standard shall be tested for conformity with the requirements of this standard and approved by the responsible GM department prior to the start of delivery of production level components or materials.

Any change to the component or material, e.g., design, function, properties, manufacturing process and/or location of manufacture requires a new release of the product. It is the sole responsibility of the supplier to provide the customer, unsolicited, with documentation of any change or modification to the product/process, and to apply for a new release.

If not otherwise agreed to, the entire verification test shall be repeated and documented by the supplier prior to start of delivery of the modified or changed product. In some cases, a shorter test can be agreed to between the responsible GM department and the supplier.

3.7.1 Test Results. With reference to this standard, the test results shall be presented in a test report.

3.8 Material Description. Materials covered by this standard are divided into several sets of constructions and temperature rating categories. The hose is defined as GMW16709 Type YZ, where Y refers to the temperature rating of the hose, and Z refers to the construction of the hose.

3.8.1 Hose Construction.

3.8.1.1 Construction: The Construction of the hose defines the material content and construction of the hose. The following materials are used in the various constructions:

- Tetrafluoroethylene Hexafluoropropylene (THV)
- Chlorinated Polyethylene Elastomer (CM)
- Epichlorohydrin/ethylene Oxide Copolymer (ECO)
- Fluoroelastomer (FKM)
- Fluorocarbon Thermoplastic Vulcanizate (FTPV)
- Ethylene Acrylate Elastomer (AEM)
- Polyacrylate Rubber (ACM)
- Ethylene Vinyl Acetate Copolymer (EVM)

3.8.1.1.1 All hoses must have a reinforcement made of aramid fibers. Reinforcement to the tube of the hose may be applied by braiding, knitting, or circular weaving. The reinforcement is placed between the laminated tube and the cover of the hose.

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3.8.1.2 The thickness of the barrier layer shall be sufficient to fulfill gasoline permeation requirements and to ensure resistance to gasoline and biodiesel fuels. Based on the various constructions of hose used for this application the possible combinations are shown in Table 1.

3.8.2 Fuel Compatibility. Hoses are suitable for gasoline and diesel/biodiesel applications unless otherwise determined in Table 1.

3.8.3 Temperature Rating. The hose is placed into one (1) of three (3) classes defining the hose heat exposure limits. Those hoses that are approved for Temperature Limit B and C, are automatically approved for lower Temperature Limits.

3.8.3.1 Temperature Limit A. This hose has a continuous operation temperature limit of 90 °C and an excursion temperature limit of +110 °C.

3.8.3.2 Temperature Limit B. This hose has a continuous operation temperature limit of +125 °C and an excursion temperature limit of +150 °C.

3.8.3.3 Temperature Limit C. This hose has a continuous operation temperature limit of +150 °C and an excursion temperature limit of +175 °C.

3.8.4 Dimensions and Tolerances. Hoses designed to this specification shall conform to the requirements of Table 2; unless other otherwise specified on the drawing.

Table 1: Construction, Temperature Limit and Coding

Lining	Intermediate Layer		Cover	Usage [Note 1]	Coding
Temperature Limit A - 90 °C/110 °C					
THV	ECO	Reinforcement	ECO	G, D	A1
Temperature Limit B - 125 °C/150 °C					
FKM	ECO	Reinforcement	ECO	G, D	B1
FKM	ECO		ACM	G, D	B2
FKM	ECO		CM	G, D	B3
FKM	-----		ECO	G, D	B4
FKM	CM		CM	D	B5
FTPV	ECO		ECO	G, D	B6
FTPV	ECO		AEM	G, D	B7
FTPV	ECO		ACM	G, D	B8
Temperature Limit C - 150 °C/175 °C					
FKM	ECO	Reinforcement	AEM	G, D	C1
FKM	ECO		ACM	G, D	C2
FKM	-		AEM	G, D	C3
FKM	AEM		AEM	D	C4
FKM	AEM		EVM	D	C5

Note 1: D = Diesel Application, **G** = Gasoline Application

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Table 2: Dimensions and Tolerances

Table 1A - Metric (SI) Units					Table 1B - Customary Units				
Size	Inside dia (mm)		Outside dia (mm)		Size	Inside dia (in)		Outside dia (in)	
(mm)	max	min	max	min	(in)	max	min	max	min
3.97	4.37	3.57	9.71	8.55	5/32	.172	.140	.383	.337
4.76	5.16	4.36	10.91	9.74	3/16	.204	.172	.429	.383
5.56	5.96	5.16	11.69	10.53	7/32	.235	.203	.461	.415
6.35	6.75	5.95	13.28	12.12	1/4	.266	.234	.523	.477
7.14	7.54	6.74	14.07	12.91	9/32	.297	.265	.554	.508
7.94	8.34	7.54	14.87	13.71	5/16	.328	.296	.585	.539
8.73	9.13	8.33	15.66	14.50	11/32	.360	.328	.617	.571
9.53	9.93	9.13	16.46	15.30	3/8	.391	.359	.648	.602
11.11	11.69	10.53	19.05	17.47	7/16	.461	.415	.750	.688
12.70	13.28	12.12	20.63	19.05	1/2	.523	.477	.812	.750
15.88	16.67	15.09	24.60	23.02	5/8	.656	.594	.969	.907
19.05	19.84	18.26	29.37	27.79	3/4	.781	.719	1.156	1.094

in = Inch, **max** = Maximum, **min** = Minimum, **mm** = Millimeter

3.8.5 Coupling Construction. If the fuel hose is to be crimped or clamped into an assembly, the design and test requirements shall meet specification GMW16709, Fuel Hose - Small Diameter.

3.9 Basic Test Requirements.

3.9.1 Required Tests. Fuel hose shall be tested to the requirements as specified in Table 3.

Table 3: Test Table

Test	Number of Samples	
	Design Validation (DV) Note 1	Process Validation (PV) Note 2
Material Properties to Table 4, Table 5	6	

Note 1: DV – Hose Design Validation
Note 2: PV – Hose Process Validation

3.9.2 Engineering Approval Factors. Engineering source approvals generated through testing to prove compliance to this specification are specific for combinations per 3.9.2.1 through 3.9.2.4.

3.9.2.1 Type. Refer to Table 1.

3.9.2.2 Size of hose.

3.9.2.3 Hose material and construction.

3.9.2.4 Supplier specifications and manufacturing procedures, supplier (both hose and assembly) manufacturing sites.

3.9.3 Design Level Requirements. All hoses manufactured for testing to this specification for engineering source approval purposes shall be completely representative of production level materials, components, processes and tooling. Any deviation from these requirements must be discussed with the GM Materials Engineer generating the approval to the specification prior to the initiation of the test program.

3.10 Deviations from Test Procedure. Elastomer material properties must be measured on samples taken from hose unless appropriate samples cannot be taken from the hose. Samples prepared from slab stock must be documented as such and the cure state of the slab stock must be shown to be equivalent to the cure state of the hose elastomer. Other deviations from the requirements of the test procedures shall have been agreed upon by the GM Materials Engineer generating the engineering source approval. Such requirements shall be specified on component drawings, test certificates, reports, etc.

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3.11 Material and Performance Requirements. These requirements for testing are specific to this specification for the purpose of hose suppliers to become qualified to supply hose assemblies to GM, and to stay qualified. Sample sizes and preparation are described in Table 3 for Design Validation Testing, Process Validation and Audit/Inspection Testing.

3.11.1 Hose Design Validation Testing. Material properties (material/compound approval) are summarized in Table 4, performance requirements (construction approval) are summarized in Table 5. For full approval of a hose, compliance to the requirements of Table 4 and Table 5 is needed.

3.11.2 Hose Process Validation Testing. If not defined otherwise, the following testing should be done for production validation testing.

- **Material Properties** (For hose manufacturing site production validation testing.) All tests per Table 4 except Ozone Resistance, Deposits, and all Fuel Resistance tests.
- **Hose Performance Tests** (For hose manufacturing site production validation testing.) All tests per Table 5, except all Fuel Exposure and Fuel Recirculation tests, Dry Heat Resistance.

3.11.3 Audit/Inspection Testing (Hose Process Validation Audit Testing). If not defined otherwise, the following testing should be done for production audit testing.

- **Material Properties.** Tests per Table 4: Elongation at Break, Tensile Strength for all layers, short term aging for cover and adhesion for construction.
- **Hose Performance Tests.** Tests per Table 5: Burst, Fuel Permeability, Push-on/Pull-off.

4 Requirements and Procedure

See Table 4 and Table 5.

Table 4: Material Properties Requirements for the Tube

Properties for the Inner FKM Liner [Note 1]

Property	Test Procedure	Unit	Value
Hardness			
Construction B and Construction C	ISO 48, Method M	IRHD	70 to 80
Elongation at Break			
Construction B and Construction C	ASTM D412 or ISO 37, Type 4 dumb-bell, 200 mm ± 20 mm/minute	%	200 minimum
Tensile Strength			
Construction B and Construction C	ASTM D412 or ISO 37, Type 4 dumb-bell, 200 mm ± 20 mm/minute	MPa	8 minimum
Fuel Resistance Biodiesel Compatible [Note 2]			
Construction B and Construction C Diesel Application	ISO 1817, Diesel fuel to GMW14914, +125 °C ± 3 °C, 168 h -2 h Change in Hardness Elongation at break Tensile strength Change in Mass	 IRHD % MPa %	 0 to -10 200 minimum 8 minimum 0 to +5 maximum
Construction B and Construction C Diesel Application	ISO 1817, Diesel fuel to GMW14914, +125 °C ± 3 °C, 1008 h -2 h Change in Hardness Elongation at break Tensile strength Change in Mass	 IRHD % MPa %	 0 to -15 150 minimum 6 minimum 0 to +10 maximum

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