PERFORMANCE OF PLASTIC FUEL TUBE MATERIALS USED IN FLEX FUELS	**WSS-M98P14-A1**
PERFORMANCE OF ELASTOMERIC FUEL HOSE MATERIALS USED IN FLEX FUELS	**WSS-M98P14-A2**
PERFORMANCE OF PLASTIC MATERIALS USED IN FLEX FUELS	**WSS-M98P14-A3**
PERFORMANCE OF ELASTOMERIC MATERIALS USED IN FLEX FUELS	**WSS-M98P14-A4**
PERFORMANCE OF PLASTIC FUEL TUBE MATERIALS USED IN BIO-DIESEL FUELS	**WSS-M98P14-A5**
PERFORMANCE OF ELASTOMERIC FUEL HOSE MATERIALS USED IN BIO-DIESEL FUELS	**WSS-M98P14-A6**
PERFORMANCE OF PLASTIC MATERIALS USED IN BIO-DIESEL FUELS	**WSS-M98P14-A7**
PERFORMANCE OF ELASTOMERIC MATERIALS USED IN BIO-DIESEL FUELS	**WSS-M98P14-A8**
PERFORMANCE OF UREA SCR MATERIALS	**WSS-M98P14-A9**
PERFORMANCE OF PLASTIC FUEL TUBE MATERIALS USED IN CNG FUELS	**WSS-M98P14-A10**

1. SCOPE

The specification defines the minimum requirements for fuel system and urea components.

2. APPLICATION

This specification was released originally for materials used for fuel, urea selective catalyst reduction (SCR) systems, and compressed natural gas (CNG). This specification covers elastomeric and plastic materials. Fuel exposure includes flex fuels (for gasoline and alcohols fueled vehicles) and bio-diesel fuels (for mineral and bio sourced diesel fuel vehicles).

Refer to Appendix A for required testing unless specified otherwise by Ford Materials Engineering.

3. REQUIREMENTS

3.1 STANDARD REQUIREMENTS FOR PRODUCTION MATERIALS

Material suppliers and part producers must conform to the Company's Standard Requirements for Production Materials (WSS-M99P1111-A).

3.2 ACCEPTABILITY REQUIREMENTS

Test results must be approved by product engineering. If acceptable, Materials Engineering will add materials to the approved source list (ASL).

Fuels referenced in this document shall have the composition based on the following standards:

CM15A – SAE J1681 or FLTM AZ105-02
Fuel C – ISO 4639-3 Annex A
PN 180 – ISO 4639-3 Annex A

Date	Action	Revisions	Rev. 1
2014 08 15	Updates	See Summary of Revisions	G.Kowalski, A Reaume, NA
2011 12 08	Activated	Activated	G.Kowalski, A Reaume, NA

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3.3 EXTERNAL CHEMICAL RESISTANCE (Formerly MA-0110-V5)

3.3.1 Chemical Resistance – All materials and components
(Elastomeric Fuel Line Covers SAE J2027a paragraph 3.1.1, Plastic Fuel Line Protective Sleeves Covers SAE J2027b paragraph 3.1.2, and Plastic and Elastomeric parts FLTM BI168-01. Outer layer hose and tube assemblies ISO 19013)

Fluids for testing: (Commercially available fluids)

Gasoline (or Fuel C)
Bio-Diesel (B30)
Coolant (50/50 by wt, coolant/ distilled water)
Engine Oil
Transmission Fluid
Battery Acid (6% H_2SO_4 by volume in distilled water)
Brake Fluid
Urea SCR fluid (30% by wt Urea)

Requirement: No cracks, crazing, blistering, or irreversible softening (depolymerization) after chemical exposure and recovery after 24 hours at 23℃ and atmospheric pressure.

3.3.2 Properties after Fluid Exposure - plastic tubes
(See para 3.3.1 for fluids and requirement)

3.3.2.1	Cold Temperature Impact at -40 ℃ (SAE J2027 paragraph 5.2.5)	No Cracks

3.3.3 Properties after Fluid Exposure – molded plastic and elastomeric materials
(See para 3.3.1 for fluids and requirement)

3.3.3.1	Tensile Strength at Break (ISO R 527/ASTM D638M, 150 x 10 x 4.0 +/- 0.2 mm specimen, 50 mm/minute test speed)	-25% max change from initial
3.3.3.2	Tensile Elongation at Break (ISO R 527/ASTM D638M, 150 x 10 x 4.0 +/- 0.2 mm specimen, 50 mm/minute test speed)	-25% max change from initial

3.3.4 Properties after Fluid Exposure - Elastomeric hoses
(See para 3.3.1 for fluids and requirement)

3.3.4.1 Mandrel bend test after external chemical resistance – Elastomeric fuel hoses
Test Method: A 450 mm length of hose is required for testing. After fluid exposure testing has been completed examine under a 2X magnification after bending around a similarly cooled mandrel the radius of which is 12 times the nominal bore size of the hose.

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3.4 MAXIMUM RECOMMENDED CONTINUOUS USAGE TEMPERATURE (MCUT) (Formerly MA-0151-V4)

Note: test only standard liquid size hose or tube diameter, not every size manufactured. Consult materials engineering for hose or tube diameter.

Note: Specimens can be annealed for 48 hours as described in the method prior to establishment of the baseline physical properties. Data shall be supplied as support points derived from original test data and also plotted as a regression line with extrapolations from 50 through 9000 hours (See ISO 2578 Annex). Use methods listed below to establish MCUT temperature

3.4.1	Plastic and Elastomer Materials, ISO 2578 (ASTM D3045), (The lowest exposure temperature should be chosen so that the time to reach 50% loss properties is at least 5040 hours.)	Report MCUT temperature

Note: Relative temperature index (RTI) is not applicable.

Plastic MCUT: The MCUT for unfilled and plasticized materials is the temperature at which a 50% loss in impact energy occurs (notched Charpy per 3.4.1.1). The MCUT for reinforced plastics is the temperature at which a 50% loss in un-notched Charpy impact occurs unless no break occurs whereby notched impact would be employed (per 3.4.1.1).

The following tests are used to determine the MCUT. Individual test results do not need to be reported.

3.4.1.1 Impact Strength - Charpy
(ISO 179-1eA)

Elastomer MCUT: The MCUT for elastomers is the temperature at which a 50% loss in tensile elongation occurs (para 3.4.1.2)

3.4.1.2 Tensile Elongation
(ISO R 527, type II/ASTM D412,
Die C, 115 x 6 x 2.0 +/- 0.2 mm
specimen, 500 mm/minute test speed)

3.4.2	Plastic Tubing and Elastomeric Hose Components ISO 2578 (ASTM D3045), (test at least four temperatures with the lowest exposure temperature chosen such that the time to reach 25% loss properties is at least 5040 hours.)	Report MCUT Temperature

Plastic Tubing MCUT: The MCUT for tubing is the temperature at which the tube retains more than 75% of its initial burst (para 3.4.2.3). Properties tested include cold impact (para 3.4.2.1) followed by burst.

Elastomeric Hose MCUT: The MCUT for hoses is the temperature at which the hose retains more than 75% of its initial burst (para 3.4.2.3). Properties tested include cold flex over a 10X diameter mandrel (para 3.4.2.2) followed by burst.

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Samples (tubing and hose constructions) removed at test intervals during the heat aging, shall be maintained at room temperature for 16 to 96 hours prior testing. Samples shall be free of cracks, crazing, blistering or softening.

3.4.2.1. Cold Impact of Tubing at -40 °C (SAE J2260, paragraph 7.5)	Report results
3.4.2.2 Cold Flexibility of Hoses (SAE J30/SAE J2405 - Age hose at -40 °C for 5 hrs)	No splitting, cracking, or layer separation.

Hoses should be bent over a mandrel 10X the OD of the hose. The flex shall be within 4 seconds of removal from aging at -40 °C.

Note: Prior to cold flex testing soak interior of tubing in CE10 fuel (SAE J1681/ FLTM AZ 105-02), for 72 hours at room temp.

Note: For hoses over 17.28 mm ID, prepare strips from the aged hose 13 mm wide. Bend strips over a 130 +/- 3 mm mandrel with cover side outward.

3.4.2.3 Burst of Tubing and Hose at 23 +/- 2 °C (SAE J2260 paragraph 7.1)	>75% retention from initial burst

3.5 SHORT TERM ELEVATED HEAT AGE STABILITY (Formerly MA-0112-V4)

3.5.1 Plastic and Elastomer Materials
(Heat age samples for 1000 h at MCUT then for 48 h at 15 °C above the MCUT determined per para 3.4.1)

3.5.1.1 Impact Strength – Charpy (Plastic) (ISO 179-1eA)	- 25% from original
3.5.1.2 Elongation at Yield (Plastic) (ISO R 527/ASTM D638M, 150 x 10 x 4.0 +/- 0.2 mm specimen, 50 mm/minute test speed)	- 25% from original
3.5.1.3 Tensile Elongation (Elastomers) (ISO R 527, type II/ASTM D412, Die C, 115 x 6 x 2.0 +/- 0.2 mm specimen, 500 mm/minute test speed)	- 25% from original

3.5.2 Plastic Tube Heat Aging
(Heat age tubing for 1000 h at MCUT then for 48 h at 15 °C above the MCUT determined per para 3.4.2)

Requirement: No cracks, crazing, blistering, or softening.

3.5.2.1 Cold Impact at -40 °C (SAE J2260 paragraph 7.5) . Save sample for para 3.5.2.3.	No cracks
3.5.2.2 Adhesion (multi-layer tubes only) (SAE J2260 paragraph 7.13)	

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3.5.2.2.1	Initial (original, as received)	Report only
3.5.2.2.2	Change after 1000 h heat aging at MCUT	- 25% max from original
3.5.2.2.3	Change after 1000 h heat aging at MCUT plus 48 h at 15 °C above MCUT	- 25% max from original

3.5.2.3 Burst Strength after Cold Impact
(SAE J2260 paragraph 7.1 and 7.5)

3.5.2.3.1	Initial (original, as received)	Report only
3.5.2.3.2	Change after 1000 h heat aging at MCUT	- 25% max from original
3.5.2.3.3	Change after 1000 h heat aging at MCUT plus 48 h at 15 °C above MCUT	- 25% max from original

3.5.3 Elastomeric Hose
(Heat age assemblies per ISO 180 (ASTM D573) for 1000 h at MCUT then 48 h at 15 °C above the MCUT per para 3.4.2)

Sample Prep: Plug the ends of 300 mm hose samples with stainless steel plugs inserted 25mm into each end of the tube.

After testing, allow assemblies to cool to room temperature for a minimum period of 16 hours. Cut hoses in half, length wise. Examine ID and OD at 7X for cracking and delamination.

3.5.3.1 Bend Test
(Bend the hose over a mandrel at 10X the nominal OD of the hose within 4 seconds, cover side outward.)

Note: For hoses over 17.28 mm ID, prepare strips from the aged hose 13 mm wide. Bend strips over a 130 +/- 3 mm mandrel with cover side outward.

Requirement: No cracks, breaks, or layer delamination (multi-layer hoses only) are permitted on the ID or OD of the hose.

3.6 FUEL HOSE/TUBE EXTRACTABLES (Formerly MA-0137-V5, MA-167)
(FLTM BP 154-01, except replace drying procedure with ASTM D381. Evaporation over a steam bath using a gentle current of filtered air to prevent boiling. Remove the container just prior to the disappearance of the last traces of solvent to prevent loss of extract. Continue to pass air over container for 10 minutes to remove remaining solvent. Dry container for 2 h at 70+/- 5 °C in an oven.)

Residue/insolubles for fuels/flex fuels	3 g/100ml/m^2 max
Residue/insolubles for CNG	10 g/100ml/m^2 max
Perform FTIR on unwashed residue	Report
Gel formation	No Gel

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3.7 PLASTIC MATERIALS RESISTANCE TO CHLORIDES (Formerly MA-0150-V4)

3.7.1 Plastic Material
(FLTM BO 127-03, except immerse for 96 h at 23 °C,
remove and allow to dry for 24 hours at 40+/-2 °C,
then cool to room temperature)

Repeat the testing with each of the contact materials –

50% by weight aqueous zinc chloride solution
50% calcium chloride solution
50% magnesium chloride solution

Requirement: No evidence of cracking/crazing.

Note: If additional in-use stresses are expected, perform key life, vibration, or vehicle simulation testing on the salt exposed component (Contact core fuel systems engineering to determine any additional in-use stresses).

3.7.2 Plastic Tubing Strength
(SAE J2260 Zinc Chloride mandrel insertion procedure)

3.7.2.1 Cold Impact
(SAE J2260 paragraph 7.5)

Requirement: No cracking/crazing on outside diameter, tubing ends, inner layer visible from ends (multi-layer tubing), or in the area of cold impact.

3.7.2.2 Burst - 25% max change
(SAE J2260 paragraph 7.1) from original

3.8 PRE-TEST DETERMINATION OF WORST CASE FUEL FOR FLEXIBLE FUEL AND ALCOHOL APPLICATIONS OVER 10% ETHANOL

(SAE J1681/ FLTM AZ 105-02, 336 h exposure at 60 °C to each of the fuels below)

Testing needs to be performed on the following market fuels to determine worst case fuel:

- CM15A (SAE J1681)
- CM30A (SAE J1681)
- CM50A (SAE J1681)
- CM85A (SAE J1681)
- CE22A (FLTM AZ 105-02)
- CE93A (FLTM AZ 105-02)
- CM20AME15 (FLTM AZ 105-02)

3.8.1 Tensile Strength and Elongation (Plastic and Elastomeric materials only)

3.8.1.1 Tensile and Elongation at Yield, (Plastic only)
(ISO R 527/ASTM D638M,
150 x 10 x 4.0 +/- 0.2 mm
specimen, 50 mm/minute test speed)

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3.8.1.1.1	Initial	Report
3.8.1.1.2	After 336 h soak at 60 °C	Report

3.8.1.2 Tensile and Elongation, (Elastomers only)
(ISO R 527, type II/ASTM D412,
Die C, 115 x 6 x 2.0 +/- 0.2 mm
specimen, 500 mm/minute test speed)

3.8.1.2.1	Initial	Report
3.8.1.2.2	After 336 h soak at 60 °C	Report

Worst case fuel is determined to be the fuel that causes the greatest reduction in properties.

3.8.2 Volume Swell (Elastomers only)
(ISO 1887/ASTM D471)

3.8.2.1	Initial	Report
3.8.2.2	After 336 h soak at 60 °C	Report

Worst case fuel is determined to be the fuel that causes the greatest amount of swelling.

3.8.3 Burst (Hoses and tubes)
(SAE J2260 paragraph 7.1)

3.8.3.1	Initial	Report
3.8.3.2	After 336 h soak at 60 °C	Report

3.9 FUEL COMPATIBILITY OF MULTI LAYER PLASTIC TUBING (Formerly MA-0152-V4)

Note: Fuel change intervals, sample conditioning, and fuel exposure outlined in Table 1.

3.9.1 Gasoline and Flexible Fuel and Alcohol over 10% Ethanol
(SAE J1737 for 5040 h at 60 °C using CM15A)

To be run on LEVII or emissions equivalent certification applications. Liquid carrying fuel lines must utilize the recirculation (SAE J1737) method.

Repeat the testing below with the worst case fuel as identified in section 3.8. In-tank applications must immerse complete hose end cross sections in fuel

3.9.1.1 Adhesion
(SAE J2260 paragraph 7.13)

3.9.1.1.1	Initial	Report only
3.9.1.1.2	After 3.9.1	- 25% max Change from 336 h test interval

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3.9.1.2 Cold Impact at -40 °C
(SAE J2260 paragraph 7.5)

3.9.1.2.1 After 3.9.1 (save hose for 3.9.1.3.2)	No cracks
3.9.1.2.2 360 h Fuel C at 60 °C following 3.9.1 (save tube for 3.9.1.3.3)	No cracks

3.9.1.3 Burst
(SAE J2260 paragraph 7.1)

3.9.1.3.1 Initial	Report Only
3.9.1.3.2 After 3.9.1.2.1	-30% max change from 336 h test interval
3.9.1.3.3 After 3.9.1.2.2	-30% max change from 336 h test interval

3.9.2 Biodiesel Applications
(5040 h, temperature and fuel(s) for local regions per FU1060)

Liquid carrying lines must utilize recirculation (SAE J1737). * Fuel(s) and temperature outlined in FU1060.

3.9.2.1 Adhesion
(SAE J2260 paragraph 7.13)

3.9.2.1.1 Initial	Report Only
3.9.2.1.2 Liquid carrying lines 5040h	-25% max change
3.9.2.1.3 Fuel conditioning module to tank Applications, 5040h	-25% max change

3.9.2.2 Cold Impact at -40 °C
(SAE J2260 paragraph 7.5)

3.9.2.2.1 Liquid carrying lines 5040h (save tube for 3.9.2.3.2)	No cracks
3.9.2.2.2 Fuel conditioning module to tank Applications, 5040h (save tube for 3.9.2.3.3)	No cracks

3.9.2.3 Burst
(SAE J2260 paragraph 7.1)

3.9.2.3.1 Initial	Report only

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