

Driveline Abstracts



Southwest Research Institute[®]

San Antonio, Texas

www.swri.org

DRIVELINE Abstracts



SOUTHWEST RESEARCH INSTITUTE
San Antonio, Texas

August 2010

QUALITY CERTIFICATIONS

The Fuels and Lubricants Research Division is:

- Certified to ISO 9001: 2008, "Quality Management Systems - Requirements"
- Accredited to ISO/IEC 17025: 2005, "General Requirements for the Competence of Testing and Calibration Laboratories"
- Certified to ISO 14001: 2004, "Environmental Management Systems"
- The Division has also achieved Ford Tier 1 status for providing engineering services, and has received the Ford Q1 Quality Award.

In conjunction with these Divisional quality system accomplishments:

- The Petroleum Products Research Department is a Nuclear Procurement Issues Committee (NUPIC)-Approved Laboratory
- The Engine and Lubricants Research Department has maintained its status as an American Chemistry Council (ACC)-Approved Laboratory

Table of Contents

Automatic Transmission Fluids Procedures

Procedures Specified by DEXRON® III(H)

Color	3
Elemental Analysis	3
Miscibility.....	3
Density.....	3
Viscosity	4
Flash Point.....	4
Fire Point	4
Brookfield Viscosity.....	5
Copper Strip Procedure	5
Corrosion Procedure.....	5
Rust Protection	5
Vane Pump Wear Procedure.....	6
Foam Procedure.....	6
Fluid Effect on Seals – Comp. V1	6
Fluid Effect on Seals – Comp. V2.....	6
Fluid Effect on Seals – Comp. V3	7
Fluid Effect on Seals – Comp. P1	7
Fluid Effect on Seals – Comp. P2.....	7
Fluid Effect on Seals – Comp. P3	8
Fluid Effect on Seals – Comp. F1	8
Fluid Effect on Seals – Comp. F2	9
Fluid Effect on Seals – Comp. N1	9
Plate Clutch Procedure	10
Band Clutch Procedure	10
Oxidation Procedure.....	11
Cycling Procedure	11
Vehicle Performance Procedure.....	12

ECCC Vehicle Procedure	12
Sprag Clutch Overrunning Wear Proc. ..	13
Low-Speed Carbon Fiber Friction Proc.	13
Aeration Procedure	13

Procedures Specified by DEXRON® VI

Color	13
Elemental Analysis	14
Fluid Profile	14
Miscibility	14
Kinematic Viscosity.....	14
Viscosity Index.....	15
Flash Point	15
Fire Point	15
Brookfield Viscosity	15
Copper Strip Procedure	16
Corrosion.....	16
Rust Protection	16
Vane Pump Wear Procedure.....	16
Cold Crank Simulation	17
High Temperature, High Shear	17
NOACK Evaporation.....	17
Film Thickness.....	17
Tapered Roller Bearing Shear	18
Foam Procedure	18
Fluid Effect on Seals – Comp. V1.....	19
Fluid Effect on Seals – Comp. V2.....	19
Fluid Effect on Seals – Comp. V3.....	19
Fluid Effect on Seals – Comp. P1.....	20
Fluid Effect on Seals – Comp. P2.....	20
Fluid Effect on Seals – Comp. P3.....	20

Fluid Effect on Seals – Comp. F1	20
Fluid Effect on Seals – Comp. F2	21
Fluid Effect on Seals – Comp. N1	21
Plate Clutch Procedure	21
Band Clutch Procedure	21
Oxidation Procedure.....	22
Cycling Procedure	22
Vehicle Performance Procedure.....	23
ECCC Vehicle Procedure	23
Sprag Clutch Overrunning Wear Procedure	23
Low-Speed Carbon Fiber Friction Procedure	23
Aeration Procedure.....	24

Procedures specified by MERCON[®]

Miscibility.....	24
Viscosity	24
Shear Stability Procedure	24
NOACK Volatility Procedure	25
Color.....	25
Flash Point.....	25
Copper Strip Procedure	25
Non-corrosion & Non-rusting Prop.	26
Cleanliness Level Procedure	26
Vane Pump Wear Procedure.....	26
Anti-Foaming Properties	26
Elastomer Compatibility.....	27
Aluminum Beaker Oxidation Proc.....	27
Clutch Friction Durability	28
Anti-Shudder Durability.....	28

Procedures Specified by MERCON[®] V 28

Miscibility	28
Viscosity	29
NOACK Volatility Procedure.....	29
Color	29
Flash Point	30
Copper Strip Procedure	30
Non-corrosion & Non-rusting Prop.....	30
Cleanliness Level Procedure.....	30
Wear Procedures	31
Anti-Foaming Properties.....	31
Elastomer Compatibility.....	31
Aluminum Beaker Oxidation Proc.....	32
Friction Durability.....	32
Clutch	
Anti-Shudder Durability	32
Ford Over-Running Clutch (AXAN OWC) Wear Procedure	33

Procedures Specified by Caterpillar TO-4

Rust Control.....	33
Copper Corrosion	33
Low-Temp Storage and Fine Points.....	33
Homogeneity.....	34
Fluid Compatibility.....	34
Foaming.....	35
Flash Point	35
Pour Point.....	35
Water Content.....	35
Fluoroelastomer.....	36
Seals, O-Rings, and Other Elastomeric Materials	36
Oxidation Stability	37

Viscosity	37
Pump Anti-Wear Performance	387
FZG Wear	38
FZG Scuffing.....	38
Friction Properties Using Fluoroelastomer, Bronze, Paper Friction Material	38

Other Procedures:

Vickers Pump Wear Procedure.....	39
Specialized Automatic Transmission Fluid Evaluations	39

For Allison C-4:

(Note: Other Allison specifications are available in addition to C-4)

Chemical Analysis	39
Physical Properties.....	39
Viscosity Characteristics	40
Anti-Foaming Properties	40
Copper Strip Procedure	40
Non-corrosion and Non-rusting	40
Rust Protection	41
Fluid Effect on Seals – Comp. V1	41
Fluid Effect on Seals – Comp. V2	41
Fluid Effect on Seals – Comp. V3	42
Fluid Effect on Seals – Comp. P1	42
Fluid Effect on Seals – Comp. P2	43
Fluid Effect on Seals – Comp. P3	43
Fluid Effect on Seals – Comp. F1	44
Fluid Effect on Seals – Comp. F2	44
Fluid Effect on Seals – Comp. N1	45
Oxidation Procedure.....	45
Vane Pump Wear Procedure.....	46
Friction Performance Procedure	

(Graphite – Composite Clutches).....	46
Friction Performance Procedure (Paper – Composite Clutches).....	46
JASO T904:2006.....	46
JASO M348:2002.....	47

Fleet and Field Evaluations

Fuel Injector Plugging	51
Intake System Deposits	51
Road Evaluations for Turbocharger Engine Oils	51
Vehicle Driveability and Performance Procedures	51
Vehicle Octane Requirement and ORI Evaluations.....	51
In-Service Fleet and Field Procedure Evaluations.....	51
Intake Valve Sticking Evaluations.....	51
Combustion Chamber Deposit Evals.	51
Mileage Accumulation Dynamometers...	51

Gear Oil Procedures

L20 Performance of Gear Lubricants at Low Speed, High Torque.....	555
L33-1 Performance of Gear Lubricants While Subjected to Water Contamination and Elevated Temperature (ASTM D 7038)	55
L37 Perf. of Gear Lubricants at High Speed, Low Torque, Followed by Low Speed, High Torque (ASTM D6121).....	56
L42 Performance of Gear Lubricants in Axles Under High Speed and Shock Loading.....	56
L60-1 Thermal and Oxidative Stability of Gear Lubricants (ASTM D 5704).....	57

FZG Load Stage (ASTM D 5182)	57
FZG Tractor Hydraulic Fluid Wear (ASTM D 4998).....	58
SSP 180 Synchronizer End. Proc.	58
High-Temperature Cyclic Durability Procedure (ASTM D 5579).....	58
Mack Power Divider Snap Procedure	58
Gear Oil Fleet Procedures.....	59
Axle Efficiency Testing Procedure.....	59
Hydraulic Fluid Procedures	
Vickers/Eaton 35VQ25A (ASTM D6973) .	63
Vickers/Eaton 104-C	63
Parker/Denison T6H20C	64
Tractor Hydraulic Fluids Evaluations	
Tractor Hydraulic Fluids Field Procedure	67
JDQ-84 Sauer-Danfoss Dynamic Corrosion Procedure	67
JDQ-95 Spiral Bevel and Final Drive Gear Wear	67
JDQ-94 PST Clutch Procedure	67
John Deere JDQ-96 Performed Using 1400 Series Axle.....	68
Ford 8340 16x16 Transmission Driveline Stall Procedure	68
Noise and Performance Procedure for Transmission Oil.....	68
Modified Ford 8340 16x16 High-Energy Clutch Procedure	68
New Holland Jenkins Cycle Procedure	68
New Holland 16x16 Transmission, 400-Cycle Stall Procedure.....	68

For DEXRON® III(H)

- ◆ Color
- ◆ Elemental Analysis
- ◆ Miscibility
- ◆ Density
- ◆ Viscosity
- ◆ Flash Point
- ◆ Fire Point
- ◆ Brookfield Viscosity
- ◆ Copper Strip Procedure
- ◆ Corrosion Procedure
- ◆ Rust Protection
- ◆ Vane Pump Wear Procedure
- ◆ Foam Procedure
- ◆ Fluid Effect on Seals – Comp. V1
- ◆ Fluid Effect on Seals – Comp. V2
- ◆ Fluid Effect on Seals – Comp. V3
- ◆ Fluid Effect on Seals – Comp. P1
- ◆ Fluid Effect on Seals – Comp. P2
- ◆ Fluid Effect on Seals – Comp. P3
- ◆ Fluid Effect on Seals – Comp. F1
- ◆ Fluid Effect on Seals – Comp. F2
- ◆ Fluid Effect on Seals – Comp. N1
- ◆ Plate Clutch Procedure
- ◆ Band Clutch Procedure
- ◆ Oxidation Procedure
- ◆ Cycling Procedure
- ◆ Vehicle Performance Procedure
- ◆ ECCC Vehicle Procedure
- ◆ Sprag Clutch Overrunning Wear Procedure
- ◆ Low-Speed Carbon Fiber Friction
- ◆ Aeration Procedure

For DEXRON® VI

- ◆ Color
- ◆ Elemental Analysis
- ◆ Fluid Profile
- ◆ Miscibility
- ◆ Kinematic Viscosity
- ◆ Viscosity Index
- ◆ Flash Point
- ◆ Fire Point
- ◆ Brookfield Viscosity
- ◆ Copper Strip
- ◆ Corrosion
- ◆ Rust Protection
- ◆ Vane Pump Wear Procedure
- ◆ Cold Crank Simulation
- ◆ High Temperature, High Shear
- ◆ NOACK Evaporation
- ◆ Film Thickness
- ◆ Tapered Roller Bearing Shear
- ◆ Foam Procedure
- ◆ Fluid Effect on Seals – Comp. V1

- ◆ Fluid Effect on Seals – Comp. V2
- ◆ Fluid Effect on Seals – Comp. V3
- ◆ Fluid Effect on Seals – Comp. P1
- ◆ Fluid Effect on Seals – Comp. P2
- ◆ Fluid Effect on Seals – Comp. P3
- ◆ Fluid Effect on Seals – Comp. F1
- ◆ Fluid Effect on Seals – Comp. F2
- ◆ Fluid Effect on Seals – Comp. N1
- ◆ Plate Clutch Procedure
- ◆ Band Clutch Procedure
- ◆ Oxidation Procedure
- ◆ Cycling Procedure
- ◆ Vehicle Performance Procedure
- ◆ ECCC Vehicle Procedure
- ◆ Sprag Clutch Overrunning Wear Procedure
- ◆ Low Speed Carbon Fiber Friction Procedure
- ◆ Aeration Procedure

For MERCON®

- ◆ Miscibility
- ◆ Viscosity
- ◆ Shear Stability Procedure
- ◆ NOACK Volatility Procedure
- ◆ Color
- ◆ Flash Point
- ◆ Copper Strip Procedure
- ◆ Non-corrosion and Non-rusting
- ◆ Cleanliness Level Procedure
- ◆ Vane Pump Wear Procedure
- ◆ Anti-Foaming Properties
- ◆ Elastomer Compatibility
- ◆ Aluminum Beaker Oxidation Procedure
- ◆ Clutch Friction Durability
- ◆ Anti-Shudder Durability

(continued on next page)

For MERCON®V

- ◆ Miscibility
- ◆ Viscosity
- ◆ NOACK Volatility Procedure
- ◆ Color
- ◆ Flash Point
- ◆ Copper Strip Procedure
- ◆ Non-corrosion and Non-rusting
- ◆ Cleanliness Level Procedure
- ◆ Wear Procedures
- ◆ Anti-Foaming Procedure
- ◆ Elastomer Compatibility
- ◆ Aluminum Beaker Oxidation Procedure
- ◆ Friction Durability
- ◆ Clutch
- ◆ Anti-Shudder Durability
- ◆ Ford Over-Running Clutch Wear Procedure

For Caterpillar TO-4

- ◆ Rust Control
- ◆ Copper Corrosion
- ◆ Low-Temperature Storage
- ◆ Homogeneity
- ◆ Fluid Compatibility
- ◆ Foaming
- ◆ Flash Point
- ◆ Pour Point
- ◆ Water Content
- ◆ Fluoroelastomer
- ◆ Seals, O-Rings, and Other Elastomeric Materials
- ◆ Oxidation Stability
- ◆ Viscosity
- ◆ Pump Anti-Wear Performance
- ◆ FZG Wear
- ◆ FZG Scuffing
- ◆ Friction Properties Using Fluoroelastomer, Bronze, Paper Friction Material

Other Procedures

- ◆ Vickers Pump Wear Procedure
- ◆ Specialized ATF Evaluations

For Allison C-4

- ◆ Chemical Analysis
- ◆ Physical Properties
- ◆ Viscosity Characteristics
- ◆ Anti-Foaming Properties
- ◆ Copper Strip Procedure
- ◆ Non-corrosion and Non-rusting
- ◆ Oxidation Procedure
- ◆ Rust Protection
- ◆ Fluid Effects on Seals – Comp. V1
- ◆ Fluid Effects on Seals – Comp. V2
- ◆ Fluid Effects on Seals – Comp. V3
- ◆ Fluid Effects on Seals – Comp. P1
- ◆ Fluid Effects on Seals – Comp. P2
- ◆ Fluid Effects on Seals – Comp. P3
- ◆ Fluid Effects on Seals – Comp. F1
- ◆ Fluid Effects on Seals – Comp. F2
- ◆ Fluid Effects on Seals – Comp. N1
- ◆ Oxidation Procedure
- ◆ Vane Pump Wear Protection
- ◆ Friction Performance Procedure – Graphite
- ◆ Friction Performance Procedure - Paper

Miscellaneous Tests

- ◆ JASO T904:2006
- ◆ JASO M348:2002

Procedures Specified by DEXRON® III (H):

Color

Specifications

This procedure is specified by DEXRON® III(H) .

Objective

The objective is to determine the color of the tested fluid via ASTM D1500.

Field service simulated

This procedure simulates uniform identification by sight.

Procedure fixture

Performance of this procedure requires a sample container and a colorimeter consisting of light source, glass color standards, sample container housing with cover, and viewing piece.

Procedure parameters

Using a standard light source, the fluid is placed in the procedure container and compared with colored glass disks ranging in value from 0.5 to 8.0.

Procedure parts evaluated

The procedure fluid is evaluated.

Elemental Analysis

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the amount of additive elements present in the fluid in the following manners:

- (A) Al, Ba, B, Ca, Cr, Cu, Fe, Pb, Mg, Mn, Mo, Ni, P, K, Si, Ag, Na, S, Sn, Ti, V, Zn - ASTM D 5185
- (B) Cl, ASTM D 6443
- (C) N, ASTM D 4629

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture and procedure parameters

Procedure fixture and parameters are as required by ASTM procedure.

Procedure parts evaluated

The procedure fluid is evaluated.

Miscibility

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine whether the tested fluid is miscible with automatic transmission fluids.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires sample jars, ASTM cloud and pour point thermometers, refrigeration apparatus, metal sample jar holder, and hot oil bath.

Procedure parameters

Using three sample jars filled with a 50% mixture of the procedure fluid and reference fluids, one sample jar is filled with procedure fluid only. A series of cooling and heating is performed with observations at certain temperatures to determine pour point, separation, and color changes.

Procedure parts evaluated

The procedure fluid is evaluated.

Density

Specifications

This procedure is specified by Dexron® VI.

Objective

The objective is to determine the fluid density.

Field Service Simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure Fixture

As specified by ASTM D4052.

Procedure Parameters

As specified by ASTM D4052. Test is conducted at 15°C.

Procedure Parts Evaluated

The test fluid is evaluated.

Viscosity

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine viscosity of procedure fluid at 40°C, 100°C and 150°C by ASTM designation D 445.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires glass capillary-type viscometers, glass tube holders, viscometer thermostat and bath, temperature measuring and timing devices.

Procedure parameters

Charge glass capillary viscometer with procedure fluid. Place in bath and allow temperature to stabilize (100°C).

Measure the time for the procedure fluid to drain from the first timing mark to the second. Calculate kinematic viscosity using time and tube factor.

Procedure parts evaluated

The procedure fluid is evaluated.

Flash Point

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine flash point by ASTM designation D 92.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires a procedure cup, heating plate, procedure flame applicator, heater, shield, and thermometer.

Procedure parameters

Fill cup with proper amount of fluid. Heat fluid and, when approaching anticipated flash point, pass procedure flame over cup. Flash point is that temperature when the procedure fluid first flashes.

Procedure parts evaluated

The procedure fluid is evaluated.

Fire Point

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine fire point by ASTM designation D 92.

Field service simulated

This procedure simulates satisfactory performance in normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires a procedure cup, heating plate, procedure flame applicator, heater, shield and thermometer.

Procedure parameters

Fill cup with proper amount of procedure fluid. Heat fluid and, when approaching anticipated fire point, pass procedure flame over cup. Fire point is that temperature when the procedure fluid will sustain a flame for 5 seconds.

Procedure parts evaluated

The procedure fluid is evaluated.

Brookfield Viscosity

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine actual viscosity at -10, -20, -30, and -40°C of the new fluid and the used fluid from Oxidation and Cycling procedures via ASTM D2983.

Field service simulated

This procedure simulates satisfactory performance in normally functioning transmissions under service conditions.

Procedure fixture

Performance of this procedure requires a Brookfield viscometer (Model LVT), Brookfield viscometer stand, No. 4 spindle, procedure tube for fluids, cell rack and turntable, refrigerated cold box, and temperature readouts.

Procedure parameters

Place procedure fluid in oven at 50°C for half an hour, then remove and let stand at room temperature for half an hour. Put fluids in cold box and stabilize for 16 hours. Remove and immediately place in Brookfield viscometer. Attach spindle and run viscosity procedure at selected temperatures.

Procedure parts evaluated

The procedure fluid is evaluated.

Copper Strip Procedure

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine copper strip corrosion by ASTM designation D 130.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires a 125 ml bottle, heating oven or bath, and metal specimen conforming to ASTM D 130.

Procedure parameters

Place copper strip in bottle and cover with procedure fluid. Heat at 150°C for 3 hours.

Procedure parts evaluated

The copper strip is evaluated.

Corrosion Procedure

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine corrosion and rusting by ASTM designation D 665, Procedure A.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

This procedure requires an oil bath, 400 ml beaker, beaker cover, stirrer, and grinding and polishing equipment.

Procedure parameters

Polish specimens as per procedure. Fill beaker with 300 ml of procedure fluid and 20 ml of distilled water. Insert procedure specimen and spin at 1000 rpm for 24 hours. Remove and rate.

Procedure parts evaluated

The procedure specimens (pins) are evaluated.

Rust Protection

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine rust protection by ASTM designation D 1748.

Field service simulated

The procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires a humidity cabinet, air circulating supply, specimen holders, and temperature controls and readouts.

Procedure parameters

Prepare procedure panels and heat procedure oil to 23.3°C. Dip procedure panel in procedure fluid for 10 seconds. Place panel in humidity cabinet for 50 hours. Cabinet temperature is 40°C. Remove at 50 hours and rate.

Procedure parts evaluated

The procedure specimens (panels) are evaluated.

Vane Pump Wear Procedure

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the fluid anti-wear characteristics by ASTM designation D 7043 (modified).

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an electric motor-driven Vickers 104-C pump mounted on a stand capable of controlling speed, temperatures, and pressures.

Procedure parameters

The fluid is tested for 100 hours at 6.9 mPa and 80°C.

Procedure parts evaluated

The weight loss to ring and vanes, any unusual wear, scuffing, deposits, and deterioration to seals are evaluated.

Foam Procedure

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine anti-foaming characteristics in General Motors foam procedure.

Field service simulated

Performance of this procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires a pump, circulating system, heater, agitating device, and timer.

Procedure parameters

Fill apparatus with procedure fluid. Turn on agitator and heater, regulating pressure at 275 kPa. Make foam observations at 95°C and 135°C.

Procedure parts evaluated

The procedure fluid is evaluated.

Fluid Effect on Seals – Comp. V1

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (ethylene acrylic) Compound V1.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. V2

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (ethylene acrylic) Compound V2.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. V3

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (ethylene acrylic) Compound V3.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. P1

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (polyacrylate) Compound P1.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. P2

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (polyacrylate) Compound P2.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. P3

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (polyacrylate) Compound P3.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. F1

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (fluoroelastomer) Compound F1.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. F2 (Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (fluoroelastomer) Compound F2.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. N1 (Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (nitrile) Compound N1.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Plate Clutch Procedure

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the friction characteristics and friction durability of procedure fluid.

Field service simulated

This procedure simulates satisfactory performance in normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires the SAE No. 2 friction procedure machine.

Procedure parameters

27,000 cycles (150 hours) of 20 seconds duration are required. Clutches are engaged once each cycle absorbs 15,700 joules of total energy. Fluid temperature is maintained at 140°C and air is injected at 50 cc per minute.

Procedure parts evaluated*

The 3T40 steel and composition clutch plates are evaluated.

**(Due to the unavailability of DEXRON® III(H) hardware, DEXRON® VI hardware and pass/fail criteria are used.)*

Band Clutch Procedure

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the friction characteristics and friction durability of procedure fluid.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires the SAE No. 2 friction procedure machine.

Procedure parameters

24,000 cycles (100 hours) of 15 seconds duration are required. Band is engaged once each cycle absorbs 15,000 joules of total energy. Fluid temperature is maintained at 135°C, and air is injected at 50 ml per minute through a sparger. For Dexron VI, the procedure must be run 150 hours (36,000 cycles).

Procedure parts evaluated*

The 3T40 band and drum are evaluated.

**(Due to the unavailability of DEXRON® III(H) hardware, DEXRON® VI hardware and pass/fail criteria are used.)*

Oxidation Procedure

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the oxidation resistance, thermal stability, and corrosion protection characteristics of a procedure fluid.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

The procedure fixture consists of an electric motor-driven Hydra-matic 4L60E automatic transmission. The motor drives a converter with the stator installed in the reverse position.

Procedure parameters

The transmission is driven at 1755 rpm under no load, at 163°C converter-out temperature for 450 hours, with air introduced at 90 cc per minute and a fluid flow rate of 0.086 ± 0.003 L/s.

Procedure parts evaluated

All of the internal transmission parts are rated for sludge, varnish, deterioration, wear, or abnormal conditions.

Used lubricant analysis

The used lubricant analysis consists of viscosity, total acid number, elemental content (Al, Cu, Fe, Pb), insoluble resins, and carbonyl group absorbance increase.

Cycling Procedure

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine friction retention, oxidation stability, and corrosion protection characteristics of a procedure fluid.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires a Hydra-matic 4L60 automatic transmission that is driven by a GM 5.7L L-98 engine. The engine and transmission are mounted on a procedure stand capable of cyclic operation with control of speed, load, temperatures and pressures.

Procedure parameters

Thirty-two thousand (32,000) accelerations through the 1–2, 2–3, and 3–4 shifts are performed at 40% throttle. Transmission sump temperature is maintained at 135°C. Engine speed, output shaft speed, output shaft torque, and acceleration times are all controlled during the cycle.

Procedure parts evaluated

All of the internal transmission parts are rated for sludge, varnish, deterioration, wear, or abnormal conditions.

Used lubricant analysis

The used lubricant analysis consists of viscosity, total acid number, elemental content (Al, Cu, Fe, Pb), insoluble resins, and carbonyl group absorbance increase.

Vehicle Performance Procedure

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the effect of fluid on shift characteristics based on shift performance produced by a reference fluid in the same vehicle.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires the procedure be conducted in a 2005 Chevrolet Tahoe equipped with a 5.3-L engine and a Hydra-matic 4L60E automatic transmission.

Procedure parameters

The fluid is compared to the reference fluid at three throttle settings (50%, 75%, and 100% throttle) and four sump temperatures (65°C, 90°C, 105°C, and 120°C).

Procedure parts evaluated

The procedure fluid is evaluated.

ECCC Vehicle Procedure

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective of this procedure is to determine if a procedure fluid produces shudder or hunting in a vehicle with an electronically controlled capacity clutch.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires the procedure be conducted in a 1997 Buick Riviera equipped with a 3.8-L supercharged engine and a GM Powertrain 4T65-E automatic transmission.

Procedure parameters

The fluid is compared to the reference fluid on a chassis dynamometer at two different transmission sump temperatures, road load and high load, and at 20 and 80-rpm slip speed.

Procedure parts evaluated

The procedure fluid is evaluated.

Sprag Clutch Overrunning Wear Procedure

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective is to determine the fluid anti-wear characteristics in an overrunning sprag clutch.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

This procedure is conducted in an electric motor-driven sprag clutch procedure stand with the inner and outer races of the sprag turning in different directions.

Procedure parameters

The sprag clutch is driven at an overrunning speed of 16,800 rpm for one hour at 120°C.

Procedure parts evaluated

The various sprag clutch components are weighed and visually inspected for wear.

Low-Speed Carbon Fiber Friction Procedure

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective of this procedure is to determine the torque capacity and shudder tendency of automatic transmission fluid with ECCC carbon fiber friction material at low slip speeds. Both fresh and used fluid is evaluated.

Field service simulated

This procedure simulates the low slip speed operation of an ECCC clutch.

Procedure fixture

Performance of this procedure requires the SAE No. 2 friction procedure machine, modified to allow controlled clutch slipping at low speeds.

Procedure parameters

Friction coefficients are measured at 14 discreet slip speeds, at 40°C, 90 °C, and 120 °C, and 273, 683, and 1044 kPa for both fresh and used fluids. Torque sweeps and breakaways are also performed.

Procedure parts evaluated

The tested fluid and clutch plates are evaluated.

Aeration Procedure

Specifications

This procedure is specified by DEXRON® III(H).

Objective

The objective of this procedure is to determine the air entrainment and density properties of automatic transmission fluid as a function of temperature. Both fresh and used fluid is evaluated.

Field service simulated

This procedure simulates the entrainment of air into fluid used in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an electric motor-driven aeration stand, consisting of a heated simulation box with equipment for fluid agitation and measurement of fluid density.

Procedure parameters

Air entrainment is measured at 40°C, 90 °C, and 120 °C for both fresh and used fluids.

Procedure parts evaluated

The tested fluid is evaluated.

Procedures Specified by DEXRON® VI:

Color

Specifications

This procedure is specified by DEXRON® VI .

Objective

The objective is to determine the color of the tested fluid via ASTM D1500.

Field service simulated

This procedure simulates uniform identification by sight.

Procedure fixture

Performance of this procedure requires a sample container and a colorimeter consisting of light source, glass color standards, sample container housing with cover, and viewing piece.

Procedure parameters

Using a standard light source, the test fluid is placed in the sample container, then in the colorimeter, and compared with colored glass disks ranging in value from 0.5 to 8.0.

Procedure parts evaluated

The test fluid is evaluated.

Elemental Analysis

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the amount of additive elements present in the fluid in the following manners:

- (A) Al, Ba, B, Ca, Cr, Cu, Fe, Pb, Mg, Mn, Mo, Ni, P, K, Si, Ag, Na, S, Sn, Ti, V, Zn
ASTM D 5185
- (B) Cl, S, ASTM D 6443
- (C) N, ASTM D 4629

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture and procedure parameters

Procedure fixture and parameters are as required by ASTM D5185, D4629, & D6443 procedures.

Procedure parts evaluated

The procedure fluid is evaluated.

Fluid Profile

Specifications

This procedure is specified by DEXRON® VI.

Objective

Proprietary GM test.

Field service simulated

Proprietary GM test.

Procedure fixture

Proprietary GM test.

Procedure parameters

Proprietary GM test.

Procedure parts evaluated

The procedure fluid is evaluated.

Miscibility

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine whether the tested fluid is miscible with automatic transmission fluids.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires sample jars, ASTM cloud and pour point thermometers, refrigeration apparatus, metal sample jar holder, and hot oil bath, as specified in ASTM D 6922.

Procedure parameters

Using three sample jars filled with a 50% mixture of the test fluid and reference fluids, one sample jar is filled with test fluid only. A series of cooling and heating is performed with observations at certain temperatures to determine pour point, separation, and color changes.

Procedure parts evaluated

The test fluid is evaluated.

Kinematic Viscosity

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine viscosity of procedure fluid at 40°C, 100°C and 150°C by ASTM designation D 445.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires glass capillary-type viscometers, glass tube holders, viscometer thermostat and bath, temperature measuring and timing devices.

Procedure parameters

Charge glass capillary viscometer with test fluid. Place in bath; allow temperature to stabilize at appropriate test temperature. Measure time for test fluid to drain from first timing mark to second. Calculate kinematic viscosity using time/tube factor.

Procedure parts evaluated

The test fluid is evaluated.

Viscosity Index

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine viscosity index of procedure fluid at 40°C and 100°C by ASTM designation D 2270.

Field service simulated

This procedure is used to characterize the variation of kinematic viscosity of the test fluid due to temperature changes.

Procedure fixture

Performance of this procedure requires glass capillary-type viscometers, glass tube holders, viscometer thermostat and bath, temperature measuring and timing devices.

Procedure parameters

Determine the kinematic viscosities of test fluid at 40°C and 100°C, per ASTM designation D 445. Calculate viscosity index using these two values.

Procedure parts evaluated

The procedure fluid is evaluated.

Flash Point

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine flash point by ASTM designation D 92.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires a sample cup, heating plate, test flame applicator, heater, shield, and thermometer.

Procedure parameters

Fill cup with proper amount of fluid. Heat fluid and, when approaching anticipated flash point, pass test flame over cup. Flash point is that temperature when the flame first propagates across the surface of the test fluid.

Procedure parts evaluated

The test fluid is evaluated.

Fire Point

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine fire point by ASTM designation D 92.

Field service simulated

This procedure simulates satisfactory performance in normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires a procedure cup, heating plate, test flame applicator, heater, shield and thermometer.

Procedure parameters

Fill cup with proper amount of test fluid. Heat fluid and, when approaching anticipated fire point, pass procedure flame over cup. Fire point is temperature when the test fluid will sustain a flame for 5 seconds.

Procedure parts evaluated

The test fluid is evaluated.

Brookfield Viscosity

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine actual viscosity at -10, -20, -30, and -40°C of the new fluid and the used fluid from Oxidation and Cycling procedures via ASTM D2983.

Field service simulated

This procedure simulates satisfactory performance in normally functioning transmissions under service conditions.

Procedure fixture

Performance of this procedure requires a Brookfield viscometer, viscometer spindle, test cell, spindle clip, cell stopper, cell rack and turntable, cold box, cell holder, and temperature sensing devices as described in ASTM D 2983.

Procedure parameters

Place procedure fluid in oven at 50°C for 30 minutes, then remove and allow to cool to room temperature. Store test fluids in cold box at the test temperature for 16 hours. Remove sample and immediately place in cell holder for transfer to the viscometer. Attach the spindle and determine the Brookfield viscosity.

Procedure parts evaluated

The test fluid is evaluated.

Copper Strip Procedure

Specifications

This procedure is specified by DEXRON® VI

Objective

The objective is to determine copper strip corrosion by ASTM designation D 130.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires a 125 ml bottle, heating oven or bath, and metal specimen conforming to ASTM D 130.

Procedure parameters

Place copper strip in bottle and cover with test fluid. Heat at 150°C for 3 hours.

Procedure parts evaluated

The copper strip is evaluated.

Corrosion

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine corrosion and rusting by ASTM designation D 665, Procedure A.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

This procedure requires an oil bath, 400 ml beaker, beaker cover, stirrer, and grinding and polishing equipment.

Procedure parameters

Polish specimens as per procedure. Fill beaker with 300 ml of procedure fluid and 20 ml of distilled water. Insert procedure specimen and spin at 1000 rpm for 24 hours. Remove and rate.

Procedure parts evaluated

The procedure specimens (pins) are evaluated.

Rust Protection

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine rust protection by ASTM designation D 1748.

Field service simulated

The procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires a humidity cabinet, air circulating supply, specimen holders, and temperature controls and readouts.

Procedure parameters

Prepare procedure panels and heat procedure oil to 23.3°C. Dip procedure panel in procedure fluid for 10 seconds. Place panel in humidity cabinet for 50 hours. Cabinet temperature is 40°C. Remove at 50 hours and rate.

Procedure parts evaluated

The procedure specimens (panels) are evaluated.

Vane Pump Wear Procedure

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the fluid anti-wear characteristics by ASTM designation D 7043 (modified).

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an electric motor-driven Vickers 104-C pump mounted on a stand capable of controlling speed, temperatures, and pressures.

Procedure parameters

The fluid is tested for 100 hours at 6.9 MPa and 80°C.

Procedure parts evaluated

The weight loss to ring and vanes, any unusual wear, scuffing, deposits, and deterioration to seals are evaluated.

Cold Crank Simulation

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the apparent viscosity of the procedure oil by cold cranking simulator (CCS).

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an electric motor-driven rotor closely fitted inside a stator. Temperature is monitored at the inside wall of the stator and maintained by a refrigerated coolant.

Procedure parameters

Temperature at -30°C at shear stresses of approximately 50 to 100 kPa and shear rates of approximately 10^5 to 10^4 s⁻¹.

Procedure parts evaluated

The procedure fluid is evaluated.

High Temperature, High Shear

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the viscosity of the procedure fluid at 150°C and 1×10^6 s⁻¹ shear rate.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires use of a tapered bearing simulator-viscometer (TBS Viscometer) equipped with a refined thermoregulator system.

Procedure parameters

Temperature at 150°C and 1×10^6 s⁻¹ shear rate.

Procedure parts evaluated

The procedure fluid is evaluated.

NOACK Evaporation

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the evaporation loss of the procedure fluid.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires use of an electrically heated block unit (aluminum) and an evaporating crucible.

Procedure parameters

Hold procedure fluid at 200°C for 1 hour.

Procedure parts evaluated

The procedure fluid is evaluated.

Film Thickness

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the film thickness of the procedure fluid as designated in EHDPROC_11.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Test performed by Imperial College.

Procedure parameters

Test Performed by Imperial College.

Procedure parts evaluated

The procedure fluid is evaluated.

Tapered Roller Bearing Shear

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the shear stability (characterized by a reduction in the kinematic viscosity) of the procedure fluid as designated in CEC L-45-A-99 (modified).

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

A standard design Four-Ball EP Tester with thermostatic control and a test head to accommodate tapered roller bearings.

Procedure parameters

Test rig run at 1,475 rpm with 5,000 N load for 40 hours. The procedure fluid is held at 60°C. The kinematic viscosity is measured on the new and sheared fluids.

Procedure parts evaluated

The test fluid is evaluated.

Foam Procedure

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine anti-foaming characteristics by ASTM designation D 892 and ASTM D6082 foam procedure.

Field service simulated

Performance of this procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this test requires heating baths, graduated cylinders, diffusers, air source, and timer.

Procedure parameters

The sample is placed in a graduated cylinder in a heating bath at the appropriate test temperature for the sequence. Air is introduced into the sample through a diffuser for 5 minutes. At the end of the 5 minute period, the volume of foam is recorded, then the air is removed, and the time for the foam to dissipate is recorded. When Option A is used, the sample is placed in a high speed blender, then heated and cooled prior to performing the foaming tendency portion of the test. ASTM D892 is used for Sequences I-III. ASTM D6082 is used for Sequence IV.

Procedure parts evaluated

The test fluid is evaluated.

Fluid Effect on Seals – Comp. V1

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (ethylene acrylic) Compound V1.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. V2

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (ethylene acrylic) Compound V2.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. V3

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (ethylene acrylic) Compound V3.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. P1

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (polyacrylate) Compound P1.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. P2

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (polyacrylate) Compound P2.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. P3

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (polyacrylate) Compound P3.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. F1

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (fluoroelastomer) Compound F1.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. F2

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (fluoroelastomer) Compound F2.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. N1

(Total Immersion Procedure)

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (nitrile) Compound N1.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Plate Clutch Procedure

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the friction characteristics and friction durability of procedure fluid.

Field service simulated

This procedure simulates satisfactory performance in normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires the SAE No. 2 friction procedure machine.

Procedure parameters

36,000 cycles (200 hours) of 20 seconds duration are required. Clutches are engaged once per cycle and absorb 15,700 joules of total energy. Fluid temperature is maintained at 140°C and air is injected at 50 cc per minute.

Procedure parts evaluated

The SAE standard steel and composition clutch plates are evaluated.

Band Clutch Procedure

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the friction characteristics and friction durability of procedure fluid.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires the SAE No. 2 friction procedure machine.

Procedure parameters

36,000 cycles (150 hours) of 15 seconds duration are required. Band is engaged once per cycle and absorbs 16,000 joules of total energy. Fluid temperature is maintained at 135°C, and air is injected at 50 ml per minute through a sparger.

Procedure parts evaluated

The 4L60 band and drum are evaluated.

Oxidation Procedure

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the oxidation resistance, thermal stability, and corrosion protection characteristics of a procedure fluid.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

The procedure fixture consists of an electric motor-driven 4L60E automatic transmission. The motor drives a converter with the stator installed in the reverse position.

Procedure parameters

The transmission is driven at 1755 rpm under no load, at 163°C converter-out temperature for 450 hours, with air introduced at 90 cc per minute and a fluid flow rate of 0.086 ± 0.003 L/s.

Procedure parts evaluated

All of the internal transmission parts are rated for sludge, varnish, deterioration, wear, or abnormal conditions.

Used lubricant analysis

The used lubricant analysis consists of viscosity, total acid number, elemental content (Al, Cu, Fe, Pb), insoluble resins, and carbonyl group absorbance increase.

Cycling Procedure

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine friction retention, oxidation stability, and corrosion protection characteristics of a procedure fluid.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires a 4L60E automatic transmission that is driven by a GM 6.0L L-5.2 engine. The engine and transmission are mounted on a procedure stand capable of cyclic operation with control of speed, load, temperatures and pressures.

Procedure parameters

Forty-two thousand (42,000) accelerations through the 1–2, 2–3, and 3–4 shifts are performed at 40% throttle. Transmission sump temperature is maintained at 115°C. Engine speed, output shaft speed, output shaft torque, and acceleration times are all controlled during the cycle.

Procedure parts evaluated

All internal transmission parts are rated for sludge, varnish, deterioration, wear, or abnormal conditions.

Used lubricant analysis

The used lubricant analysis consists of viscosity, total acid number, elemental content (Al, Cu, Fe, Pb), insoluble resins, and carbonyl group absorbance increase.

Vehicle Performance Procedure

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the effect of fluid on shift characteristics based on shift performance produced by a reference fluid in the same vehicle.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires the procedure be conducted in a 2005 Chevrolet Tahoe equipped with a 5.3-L engine and a Hydra-matic 4L60E automatic transmission.

Procedure parameters

The fluid is compared to the reference fluid at three throttle settings (50%, 75%, and 100% throttle) and four sump temperatures (65°C, 90°C, 105°C, and 120°C).

Procedure parts evaluated

The procedure fluid is evaluated.

ECCC Vehicle Procedure

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective of this procedure is to determine if a procedure fluid produces shudder or hunting in a vehicle with an electronically controlled capacity clutch.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires the procedure be conducted in a 1997 Buick Riviera equipped with a 3.8-L supercharged engine and a GM Powertrain 4T65-E automatic transmission.

Procedure parameters

The fluid is compared to the reference fluid on a chassis dynamometer at two different transmission sump temperatures, road load and high load, and at 20 and 80-rpm slip speed.

Procedure parts evaluated

The procedure fluid is evaluated.

Sprag Clutch Overrunning Wear Procedure

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective is to determine the fluid anti-wear characteristics in an overrunning sprag clutch.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires procedure be conducted in an electric motor-driven sprag clutch procedure stand with the inner and outer races of the sprag turning in different directions.

Procedure parameters

The sprag clutch is driven at an overrunning speed of 16,800 rpm for one hour at 120°C.

Procedure parts evaluated

The various sprag clutch components are weighed and visually inspected for wear.

Low-Speed Carbon Fiber Friction Procedure

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective of this procedure is to determine the torque capacity and shudder tendency of automatic transmission fluid with ECCC carbon fiber friction material at low slip speeds. Both fresh and used fluid is evaluated.

Field service simulated

This procedure simulates the low slip speed operation of an ECCC clutch.

Procedure fixture

Performance of this procedure requires the SAE No. 2 friction procedure machine, modified to allow controlled clutch slipping at low speeds.

Procedure parameters

Friction coefficients are measured at 14 discreet slip speeds, at 40°C, 90 °C, and 120 °C, as well as at 273, 683, and 1044 kPa for both fresh and used fluids. Torque sweeps and breakaways are also performed.

Procedure parts evaluated

The tested fluid and clutch plates are evaluated.

Aeration Procedure

Specifications

This procedure is specified by DEXRON® VI.

Objective

The objective of this procedure is to determine the air entrainment and density properties of automatic transmission fluid as a function of temperature. Both fresh and used fluid is evaluated.

Field service simulated

This procedure simulates the entrainment of air into fluid used in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an electric motor-driven aeration stand, consisting of a heated simulation box with equipment for fluid agitation and measurement of fluid density.

Procedure parameters

Air entrainment is measured at 40°C, 90 °C, and 120 °C for both fresh and used fluids.

Procedure parts evaluated

The tested fluid is evaluated.

Procedures specified by MERCON®:

Miscibility

Specifications

This procedure is specified by MERCON®.

Objective

The objective is to determine whether a fluid is miscible with automatic transmission fluids.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires sample jars, ASTM cloud and pour point thermometers, refrigeration apparatus, metal sample jar holder, and hot oil bath.

Procedure parameters

Two jars are partially filled with procedure fluid and mixed with reference fluids while one jar is filled with procedure fluid only. A series of cooling and heating is performed with observations at certain temperatures to determine pour point, separation, and color changes.

Procedure parts evaluated

The procedure fluid is evaluated.

Viscosity

Specifications

This procedure is specified by MERCON®.

Objective

The objective is to determine viscosity of test fluid at 100°C, -20°C and -40°C for new fluids.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires apparatus as defined in ASTM D 445 and ASTM D 2983.

Procedure parameters

New fluid is tested at 100°C according to ASTM D 445, and at -20°C, and -40°C according to ASTM D 2983.

Procedure parts evaluated

The test fluid is evaluated.

Shear Stability Procedure

Specifications

This procedure is specified by MERCON®.

Objective

The objective is to determine the shear stability (Characterized by a reduction in the kinematic viscosity) of the procedure fluid as designated in CEC L-45-A-99 (modified).

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires a KRL machine and the fixturing necessary to perform viscosity measurements according to ASTM D445.

Procedure parameters

Test rig is run at 1,475 rpm with 5,000 N load for 20 and 40 hours. The procedure fluid is held at 60°C. The kinematic viscosity is measured on the new and the sheared fluids.

Procedure parts evaluated

The test fluid is evaluated.

NOACK Volatility Procedure

Specifications

This procedure is specified by MERCON®.

Objective

The objective is to determine evaporation of a procedure fluid at high temperature and -40°C Brookfield viscosity of used fluid.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

The fluid is evaluated using the NOACK volatility procedure machine.

Procedure parameters

The fluid is weighed initially, and then heated with slight vacuum to 150°C for one hour. After cooling, the fluid is reweighed.

Procedure parts evaluated

The procedure fluid is evaluated.

Color

Specifications

This procedure is specified by MERCON®.

Objective

The objective is to determine the color of the tested fluid via ASTM D 1500.

Field service simulated

This procedure simulates uniform identification by sight.

Procedure fixture

Performance of this procedure requires a sample container and a colorimeter consisting of light source, glass color standards, and sample container housing with cover and viewing piece.

Procedure parameters

Using a standard light source, the test fluid is placed in the sample container and then in the colorimeter, and compared with colored glass disks ranging in value from 0.5 to 8.0.

Procedure parts evaluated

The procedure fluid is evaluated.

Flash Point

Specifications

This procedure is specified by MERCON®.

Objective

The objective is to determine flash point by ASTM designation D 92.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires a sample cup, heating plate, test flame applicator, heater, shield, and thermocouple.

Procedure parameters

Fill cup with the proper amount of fluid. Heat fluid and, when approaching anticipated flash point, pass test flame over cup. Flash point is that temperature when the flame first propagates across the surface of the test fluid.

Procedure parts evaluated

The procedure fluid is evaluated.

Copper Strip Procedure

Specifications

This procedure is specified by MERCON®.

Objective

The objective is to determine copper strip corrosion by ASTM designation D 130.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires 125 ml bottle, heating oven or bath, and metal specimen conforming to ASTM D 130.

Procedure parameters

Place the copper strip in bottle and cover with procedure fluid. Heat at 150°C for 3 hours.

Procedure parts evaluated

The copper strip is evaluated.

Non-corrosion and Non-rusting Properties

Specifications

This procedure is specified by MERCON®.

Objective

The objective is to determine corrosion and rusting by ASTM designation D 665A.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an oil bath, 400 ml beaker, beaker cover, stirrer, grinding and polishing equipment.

Procedure parameters

Polish the specimens according to ASTM D 665A. Fill beaker with 300 ml of test fluid, place in bath, and insert the test specimen. Start the stirrer (1000 rpm). Add 30 ml of distilled water. Allow the test specimen to remain under these conditions for 24 hours. Remove and rate the specimens.

Procedure parts evaluated

The test specimens (pins) are evaluated.

Cleanliness Level Procedure

Specifications

This procedure is specified by MERCON®.

Objective

The objective is to determine the fluid cleanliness by the ISO 4406 procedure.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Particles are measured using an automatic particle counter that has been calibrated in accordance with ISO 11171.

Procedure parameters

The fluid is analyzed neat, unless the particle counts are outside the linear range of the detector. Under such conditions, dilutions are used.

Procedure parts evaluated

The procedure fluid is evaluated.

Vane Pump Wear Procedure

Specifications

This procedure is specified by MERCON®.

Objective

The objective is to determine the fluid anti-wear characteristics by ASTM designation D 7043 (modified).

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an electric motor-driven Vickers 104-C pump mounted on a stand capable of controlling speed, temperatures, and pressures.

Procedure parameters

The fluid is tested for 100 hours at 6.9 mPa psi and 80°C.

Procedure parts evaluated

The weight loss to ring and vanes, any unusual wear, scuffing, deposits, and deterioration to seals are evaluated.

Anti-Foaming Properties

Specifications

This procedure is specified by MERCON®.

Objective

The objective is to determine foaming characteristics of procedure fluid by ASTM designation D 892.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an ASTM D 892 foaming procedure apparatus.

Procedure parameters

Air is blown into the sample at a constant rate for 5 minutes. The sample is then allowed to settle for 1 minute. The volume of foam is measured at the end of both periods. The procedure is repeated for Sequences I-III of ASTM D 892. A fourth sequence is run at 150°C with an air flow rate of 200 ml/min.

Procedure parts evaluated

The procedure fluid is evaluated.

Elastomer Compatibility

Specifications

This procedure is specified by MERCON®.

Objective

The objective is to determine elastomer compatibility of the procedure fluid.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 471 equipment.

Procedure parameters

Specimens of each elastomer, ATRR-101, ATRR-201, ATRR-400, ATRR-500, ATRR-600, and ATRR-700 are cut per ASTM D 471 and are immersed in four tubes, three containing reference fluids and the other containing the candidate fluid. ATRR-101 is immersed at 150°C for 168 hours. ATRR-201 is immersed at 163°C for 70 hours, -400, and -500 are immersed at 163°C for 240 hours. ATRR-600 and ATRR-700 are immersed at 150°C for 168 hours.

Procedure parts evaluated

The aged elastomer materials are evaluated.

Aluminum Beaker Oxidation Procedure

Specifications

This procedure is specified by MERCON®.

Objective

The objective is to determine the oxidation stability of the procedure fluid.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an aluminum beaker and associated components, bushings for gear pump, gear pump, air flow control system, temperature control systems, aluminum, copper, and lead coupons.

Procedure parameters

The beaker is filled with procedure fluid, the circulation pump and heating element are turned on and the temperature is rapidly brought up to 155°C. At this point the procedure starts and airflow is introduced into the gear pump at 5 ml/min. Hot samples are removed periodically and the copper strip is inspected once after 50 hours and reinserted. After 300 hours at procedure temperature, the procedure is completed. The beaker and fluid are weighed before and after the procedure.

Procedure parts evaluated

The aluminum, copper, and lead coupons, the top of the pump housing, the beaker, and the procedure fluid are evaluated.

Clutch Friction Durability

Specifications

This procedure is specified by MERCON®.

Objective

The objective is to determine the friction characteristics and friction durability of the procedure fluid.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires the SAE No. 2 friction procedure machine.

Procedure parameters

Twenty thousand (20,000) cycles of 20 seconds duration are required. Clutches are engaged once each cycle absorbs $20,740 \pm 200$ joules of total energy. Fluid temperature is maintained at 115°C.

Procedure parts evaluated

The steel and composition plates are evaluated.

Anti-Shudder Durability

Specifications

This procedure is specified by MERCON®.

Objective

The objective of this procedure is to evaluate antishudder performance with time and fluid aging.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an S.A.E. #2 friction procedure machine modified for variable low-speed operation. The fixture utilizes a heated external reservoir and fluid circulation system.

Procedure parameters

Durability testing is performed for 999 cycles using Borg Warner SD-1777 friction plates. The test schedule includes low speed clutch drags at 180 rpm and 150 °C, as well as high speed (3600 rpm) clutch engagements, torque sweeps, and static breakaways, all conducted at 118 °C

Procedure parts evaluated

The steel and composition plates are evaluated.

Procedures Specified by MERCON® V: Miscibility

Specifications

This procedure is specified by MERCON®V.

Objective

The objective is to determine whether a fluid is miscible with automatic transmission fluids.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires sample jars, ASTM cloud and pour point thermometers, refrigeration apparatus, metal sample jar holder, and hot oil bath.

Procedure parameters

Two jars are partially filled with procedure fluid and mixed with reference fluids while one jar is filled with procedure fluid only. A series of cooling and heating is performed with observations at certain temperatures to determine pour point, separation, and color changes.

Procedure parts evaluated

The procedure fluid is evaluated.

Viscosity

Specifications

This procedure is specified by MERCON[®]V.

Objective

The objective is to determine the viscosity of new fluid at 100°C, -20°C and -40°C and of used fluid at 100°C (after KRL) and -40°C (after modified NOACK). The new test fluid is also evaluated for shear stability after 20- and 40-hour CEC L-45-A-99 (KRL), and for apparent viscosity by ASTM D 6616 and D 4683 after CEC L45-T-93.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of these procedures requires the apparatus as defined in ASTM D 445, ASTM D 2983, ASTM D4683 and ASTM D 6616.

Procedure parameters

New fluid is tested at 100°C according to ASTM D 445, at -20°C, and -40°C according to ASTM D 2983. The kinematic viscosity of the used NOACK fluid is determined at -40°C. The apparent viscosities of the new and sheared fluids are determined by ASTM D 4683. The apparent viscosity of the sheared fluid is determined by ASTM D 6616.

Procedure parts evaluated

The test fluid is evaluated.

NOACK Volatility Procedure

Specifications

This procedure is specified by MERCON[®]V.

Objective

The objective is to determine evaporation of a procedure fluid at high temperature and -40°C Brookfield viscosity of used fluid.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

The fluid is evaluated using the NOACK volatility procedure machine.

Procedure parameters

The fluid is weighed initially, and then heated with slight vacuum to 150°C for one hour. After cooling, the fluid is reweighed.

Procedure parts evaluated

The test fluid is evaluated.

Color

Specifications

This procedure is specified by MERCON[®]V.

Objective

The objective is to determine the color of the procedure fluid.

Field service simulated

This procedure simulates uniform identification by sight.

Procedure fixture

Performance of this procedure requires a sample container and a colorimeter consisting of light source, glass color standards, and sample container housing with cover and viewing piece.

Procedure parameters

Using a standard light source, the test fluid is placed in the sample container, then in the colorimeter, and compared with colored glass disks ranging in value from 0.5 to 8.0.

Procedure parts evaluated

The test fluid is evaluated.

Flash Point

Specifications

This procedure is specified by MERCON[®]V.

Objective

The objective is to determine flash point by ASTM designation D 92.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires a procedure cup, heating plate, procedure flame applicator, heater, shield, and thermocouple.

Procedure parameters

Fill cup with proper amount of fluid. Heat fluid and, when approaching anticipated flash point, pass test flame over cup. Flash point is that temperature when the flame first propagates across the surface of the test fluid.

Procedure parts evaluated

The procedure fluid is evaluated.

Copper Strip Procedure

Specifications

This procedure is specified by MERCON[®]V.

Objective

The objective is to determine copper strip corrosion by ASTM designation D 130.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires 125 ml bottle, heating oven or bath, and metal specimen conforming to ASTM D 130.

Procedure parameters

Place the copper strip in bottle and cover with test fluid. Heat at 150°C for 3 hours.

Procedure parts evaluated

The copper strip is evaluated.

Non-corrosion and Non-rusting Properties

Specifications

This procedure is specified by MERCON[®]V.

Objective

The objective is to determine corrosion and rusting by ASTM designation D 665.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an oil bath, 400 ml beaker, beaker cover, stirrer, grinding and polishing equipment.

Procedure parameters

Polish the specimens according to ASTM D 665. Fill beaker with 300 ml of test fluid, place in bath, and insert the test specimen. Start the stirrer (1000 rpm). Add 30 ml of distilled water. Allow the test specimen to remain under these conditions for 24 hours. Remove and rate the specimens.

Procedure parts evaluated

The test specimens (pins) are evaluated.

Cleanliness Level Procedure

Specifications

This procedure is specified by MERCON[®]V.

Objective

The objective is to determine the fluid cleanliness by the ISO 4406 procedure.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Particles are measured using an automatic particle counter that has been calibrated in accordance with ISO 11171.

Procedure parameters

The fluid is analyzed neat, unless the particle counts are outside the linear range of the detector. Under such conditions, dilutions are used.

Procedure parts evaluated

The test fluid is evaluated.

Wear Procedures

Specifications

This procedure is specified by MERCON[®] V.

Objective

The objective of this procedure is to determine the fluid anti-wear characteristics by ASTM D 7043 modified (80°C, 6.9 mPa), ASTM D 5182 (1,450 rpm, 150° start temperature), ASTM D 4172 (40 Kg load, 2 hours, 600 rpm), ASTM D 3233 (Method B), and ASTM D 2782 (4 kg. load, 150°C, 10 minutes).

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of these procedures requires all necessary equipment and hardware to procedure the fluid according to ASTM D 7043, ASTM D 5182, ASTM D 4172, ASTM D 3233, and ASTM D 2782.

Procedure parameters

The fluid is tested at various loads, pressures, and temperatures in different wear procedures.

Procedure parts evaluated

Vane pumps, gears, and bench wear procedure parts are evaluated for weight loss/wear patterns.

Anti-Foaming Properties

Specifications

This procedure is specified by MERCON[®] V.

Objective

The objective is to determine foaming characteristics of procedure fluid by ASTM designation D 892.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an ASTM foaming procedure apparatus.

Procedure parameters

Air is blown into the sample at a constant rate for 5 minutes. The sample is then allowed to settle for 1 minute. The volume of foam is measured at the end of both periods. The procedure is repeated for Sequences I-III of ASTM D 892. A fourth sequence is run at 150°C with an airflow rate of 200 ml/min.

Procedure parts evaluated

The procedure fluid is evaluated.

Elastomer Compatibility

Specifications

This procedure is specified by MERCON[®] V.

Objective

The objective is to determine elastomer compatibility of the procedure fluid.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 471 equipment.

Procedure parameters

Strips of each elastomer, ATRR-101, ATRR-201, ATRR-300, ATRR-400, ATRR-500, ATRR-600, and ATRR-700 are cut per ASTM D 471 and are immersed in four tubes, three containing reference fluids and the other containing the candidate fluid. ATRR-101 is immersed at 150°C for 168 hours. ATRR-201 is immersed at 163°C for 70 hours, ATRR-300, -400, and -500 are immersed at 163°C for 240 hours. ATRR-600 and ATRR-700 are immersed at 150°C for 168 hours.

Procedure parts evaluated

The elastomer materials are evaluated.

Aluminum Beaker Oxidation Procedure

Specifications

This procedure is specified by MERCON® V.

Objective

The objective is to determine the oxidation stability of the procedure fluid.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an aluminum beaker and associated components, bushings for gear pump, gear pump, air flow control system, temperature control systems, aluminum, copper, and lead coupons.

Procedure parameters

The beaker is filled with procedure fluid, the circulation pump and heating element are turned on and the temperature is rapidly brought up to 155°C. At this point the procedure starts and airflow is introduced into the gear pump at 5 ml/min. Hot samples are removed periodically and the copper strip is inspected once after 50 hours and reinserted. After 300 hours at procedure temperature, the procedure is completed. The beaker and fluid are weighed before and after the procedure.

Procedure parts evaluated

The aluminum, copper, and lead coupons, the top of the pump housing, the beaker, and the procedure fluid are evaluated.

Friction Durability

Specifications

This procedure is specified by MERCON® V.

Objective

The objective is to determine the friction characteristics and friction durability of the procedure fluid.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires the SAE No. 2 friction procedure machine.

Procedure parameters

Thirty thousand (30,000) cycles of 20 seconds duration are required. Clutches are engaged once each cycle absorbs 20,740 ± 100 joules of total energy. Fluid temperature is maintained at 135°C.

Procedure parts evaluated

The steel and composition plates are evaluated.

Anti-Shudder Durability

Specifications

This procedure is specified by MERCON® V.

Objective

The objective of this procedure is to evaluate antishudder performance with time and fluid aging.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an S.A.E. #2 friction procedure machine modified for variable low-speed operation. The fixture utilizes a heated external reservoir and fluid circulation system.

Procedure parameters

Durability testing is performed for 999 cycles using Dynax D-531-70H friction plates. The test schedule includes low speed clutch drags at 180 rpm and 150 °C, as well as high speed (3600 rpm) clutch engagements, torque sweeps, and static breakaways, all conducted at 118 °C

Procedure parts evaluated

The steel and composition plates are evaluated.

Ford Over-Running Clutch (AX4N OWC) Wear Procedure

The goal of this procedure is to determine if the oil can protect the inner race of the over-running clutch in a free-wheeling situation. The procedure result will be “no trenching” which means inner race intact or “trenching” which means that the rollers have worn a visible groove in the inner race.

Procedures Specified by Caterpillar TO-4: **Rust Control**

Specifications

This procedure is specified by Caterpillar TO-4.

Objective

The objective is to determine the corrosion protection offered by a lubricating oil using International Harvester Procedure Method BT-9.

Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

Procedure fixture

Performance of this procedure requires test equipment as specified by International Harvester Procedure Method BT-9.

Procedure parameters

Three steel rod test specimens are sanded, cleaned, dipped in the test fluid, drained vertically for 30 minutes, then placed partially in a flask with distilled water, with the rods exposed to the vapors of distilled water. The assembly is placed in a bath maintained at 32°C, with a water jacket covering the exposed three inches of the rod, with water circulated at 27°C.

Copper Corrosion

Specifications

This procedure is specified by Caterpillar TO-4.

Objective

The objective is to evaluate the corrosiveness of lubricating oils to copper.

Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmission, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

Procedure fixture

Performance of this procedure requires procedure equipment as specified by ASTM D 130.

Procedure parameters

The copper strip is immersed in procedure oil for two hours at 100°C.

Low-Temperature Storage

Specifications

This procedure is specified by Caterpillar TO-4.

Objective

This test method will be used to evaluate the low-temperature storage stability of fluids.

Field Service Simulated

Procedure Fixture

Test jar made of clear cylindrical glass with a flat bottom 30 to 33.5 mm inside diameter and 115 to 125 mm in height is used. To indicate the height of the sample, the jar should be marked with a line 54±3 mm above the inside bottom.

Procedure parameters

Fluid sample is poured into the test jar to level marked on outside. Sample is heated to 50°C for 30 minutes. Sample is removed from oven and cork is placed onto the jar. Sample is cooled to room temperature. Sample is checked following each 24-hour period for fluidity and appearance of precipitate and particles.

Homogeneity

Specifications

This procedure is specified by Caterpillar TO-4.

Objective

The objective is to evaluate the compatibility of the additive with its base stock.

Procedure fixture

Performance of this procedure requires 100 ml centrifuge tube and a 6,000 g high-speed centrifuge.

Procedure parameters

35 ml of test fluid is placed into a 50-ml centrifuge tube, stoppered, and stored for 24 hours at -32°C. After storage, the sample is allowed to reach room temperature, then is centrifuged at 6,000 for 30 minutes. The sample is examined for sedimentation or separation of insoluble material..

Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

Fluid Compatibility

Specifications

This procedure is specified by Caterpillar TO-4.

Objective

The objective is to evaluate the compatibility of different lubricating oil additive formulations with one another.

Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

Procedure fixture

Performance of this procedure requires 100 ml centrifuge tubes and a 6,000 g high-speed centrifuge.

Procedure parameters

50 ml of procedure oil and 50 ml of referenced oil are poured into a 100 ml centrifuge tube, mixed and heated to 204°C, and then cooled to room temperature. The tube is centrifuged for 30 minutes at 6,000 g. The oil in the tube is examined for precipitation of insoluble residue and separated components.

Foaming

Specifications

This procedure is specified by Caterpillar TO-4.

Objective

The objective is to determine the foaming characteristics of lubricating oils at specified temperatures.

Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

Procedure fixture

Performance of this procedure requires procedure equipment as specified by ASTM D 892.

Procedure parameters

The test consists of two parts: D 892 without water added to the test fluid, and D 892 with 0.1 volume percent of distilled water added to a separate aliquot of test fluid. The water and oil mixture are blended at low speed (1,000 rpm) for five minutes, and then for an additional one minute at high speed (1,300 rpm). The foam generated by the blending is allowed to dissipate prior to testing with the D 892 procedure.

Flash Point

Specifications

This procedure is specified by Caterpillar TO-4.

Objective

The objective is to evaluate the flash and fire points of lubricating oils.

Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

Procedure fixture

Performance of this procedure requires procedure equipment as specified by ASTM D 92.

Procedure parameters

Test fluid is heated in device and exposed to an open flame, as specified by ASTM D 92, Cleveland Open-Cup Method, until the flash and fire points are determined.

Pour Point

Specifications

This test method will be used to determine the minimum temperature at which fluids remain fluid

Field service simulated

Procedure fixture

ASTM D97 standard test method should be followed.

Procedure parameters

ASTM D97 standard test method should be followed.

Water Content

Specifications

The Karl Fischer test method is used to determine the amount of water in a candidate fluid.

Field service simulated

Procedure fixture

ASTM D6304 standard test method should be followed.

Procedure parameters

ASTM D6304 standard test method should be followed.

Fluoroelastomer

Specifications

This procedure is specified by Caterpillar TO-4.

Objective

The objective is to evaluate the compatibility of lubricating oils with fluoroelastomer friction material.

Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, torque converters, hydrostatic transmissions, and hydraulic systems.

Procedure fixture

Performance of this procedure requires an oil bath or aluminum block aging oven capable of maintaining temperature $\pm 1^\circ\text{C}$, incremental extensometer capable of measuring elongation in 10% increments, ASTM D 412 and D 471 equipment, and Caterpillar 1Y0530 procedure material.

Procedure parameters

Three test tubes with 150 ml of the procedure oil with three elastomer specimens submerged in the oil in each tube are aged at 150°C for 240 hours. After the aging period, the elastomer specimens are cooled for two hours, then the percent elongation at rupture is determined and compared with the nine specimens, which have not been heat aged, to determine the percent change in elongation.

Seals, O-Rings, and Other Elastomeric Materials

Specifications

This procedure is specified by Caterpillar TO-4.

Objective

The objective is to evaluate the compatibility of lubricating oils with various elastomer materials used in lip seals, O-rings, hydraulic piston seals, gaskets, etc.

Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

Procedure fixture

Performance of this procedure requires ASTM D 471 equipment, oil bath, test tubes, balance, and the 1E2827 elastomer material.

Procedure parameters

The initial volume and hardness values of the seal material are determined prior to aging in oil. In each of three tubes, one specimen of the seal material is immersed in 150 ml of test fluid and aged at 150°C for 70 hours. The % volume change, point hardness change, % tensile strength change, and % elongation change are determined.

Procedure parts evaluated

The seal material is evaluated.

Oxidation Stability

Specifications

This procedure is specified by Caterpillar TO-4 and references General Motors GM 6137, October 1990, Appendix E.

Objective

The objective is to evaluate the thermal oxidation stability of lubricating oils.

Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

Procedure fixture

Performance of this procedure requires a Hydramatic 4L60E automatic transmission be driven by an electric motor. The motor-driven converter has the stator installed in the reverse position. These components are mounted on a procedure stand capable of controlling temperatures and pressures.

Procedure parameters

The transmission is driven at 1755 rpm under no load at 163°C converter-out temperature for 300 hours, with air introduced at 90 cc per minute and a fluid flow rate of 0.086 ± 0.003 L/s.

Procedure parts evaluated

All of the internal transmission parts are rated for sludge, varnish, deterioration, wear, or abnormal conditions.

Used lubricant analysis

The used lubricant analysis consists of viscosity at 40°C and 100°C, Brookfield viscosity at -20°C, Total Acid Number, carbonyl group absorbance, elemental analysis (iron, copper, lead, aluminum), and insoluble resins. Also included is viscosity at the maximum temperature specified in Section 4, Table 3.0 of the Caterpillar TO-4 Procedure for the appropriate viscosity grade using ASTM procedures D 2983 and D 4684, as well as viscosity at 150°C (ASTM D 4683).

Viscosity

Specifications

This procedure is specified by Caterpillar TO-4.

Objective

The objective is to evaluate the ability of a lubricant to provide acceptable viscometric properties in cold and hot ambient conditions when used in powershift transmissions and hydraulic systems.

Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, Hydro-static transmissions, torque converters, and hydraulic systems.

Procedure fixture

Performance of this procedure requires equipment as specified in the test procedures indicated by SAE J300.

Procedure parameters

Using the test procedures indicated in SAE J300, low-temperature and high-temperature high shear requirements are determined.

Pump Anti-Wear Performance

Specifications

This procedure is specified by Caterpillar TO-4.

Objective

The objective is to evaluate the ability of a lubricant to provide acceptable fluid pump anti-wear characteristics for powershift transmission and hydraulic pumps.

Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

Procedure fixture

Performance of this procedure requires equipment as specified in Vickers® form M-2952-S and Eaton Engineering Standard # ATS-373 Rev. C (ASTM D 6973). The pump used is a model 35VQ25A.

Procedure parameters

The procedure duration for each cartridge is 50 hours with a pump outlet pressure of 3,000 psi and an inlet oil temperature of 203°F.

FZG Wear Test

Specifications

This procedure is specified by Caterpillar TO-4.

Objective

The objective is to evaluate the ability of a lubricant to provide acceptable gear anti-wear performance in powershift transmissions and final drives.

Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

Procedure fixture

Performance of this procedure requires equipment as specified by ASTM D 4998.

Procedure parameters

An FZG gear oil procedure machine is operated for 20 hours under controlled conditions of speed (100 rpm), load (tenth stage), and temperature (121°C).

FZG Scuffing

Specifications

This test method will be used to determine the scuffing load capacity of TO-4 fluids

Field service simulated

Procedure fixture

ASTM D5182 standard test method should be followed.

Procedure parameters

ASTM D5182 standard test method should be followed.

Friction Properties Using Fluoroelastomer, Bronze, Paper Friction Material

Specifications

This procedure is specified by Caterpillar TO-4.

Objective

The objective is to evaluate a fluid's friction performance characteristics and determine whether they are acceptable in use with various oil-cooled friction mechanisms in Caterpillar transmissions/final drives. Materials tested are fluoroelastomer, bronze, paper.

Field service simulated

This procedure simulates satisfactory operation of transmissions and drivetrains when operating under the conditions specified by the manufacturer.

Procedure apparatus

The procedure uses the Link M1158 oil/friction machine w/ oil circulating system & external air pressure source.

Procedure parameters

A full procedure consists of six short sequences and one 25,100-cycle friction retention procedure. Duration of a short sequence procedure is a function of phase numbers for that sequence/fluid/material used and is between 1,000 and 1,200 cycles. Each phase contains computer-to-stand control parameters (load, speed, etc.) Short sequence procedure parameters are dynamic coefficients of friction vs cycle, dynamic/static coefficients of friction vs load and speed, energy. The energy pass/fail criteria are based on rotational speed at which engagement of disk and reaction plate results in specified percent change in dynamic coefficient compared to average dynamic coefficient of previous phase. The friction retention procedure concerns itself with static and dynamic coefficients of friction vs cycle.

Procedure parts evaluated

The measurement of plates for wear is evaluated.

Biodegradable applications

One special sequence and a brake paper material are also used in testing fluids for conformance to Caterpillar's BF-1 specification. This specification relates to biodegradable fluids.

Other procedures include:

Vickers Pump Wear Procedure

Specifications

This procedure is specified by ASTM D 7043.

Objective

The objective is to determine fluid anti-wear characteristics.

Procedure fixture

Performance of this procedure requires an electric motor-driven Vickers 104-C pump. A pressure regulator is used to control pump pressure.

Procedure parameters

The fluid is tested for 100 hours at 13.8 MPa and either 66°C or 80°C, depending on fluid viscosity.

Procedure capacity

Three procedure stands are available.

Specialized Automatic Transmission Fluid Evaluations

In addition to standardized ATF evaluations, Southwest Research Institute offers service in the areas of specialized laboratory and field evaluations. Specialized testing can be in the form of bench rigs, engine-transmission-dynamometer stands, or vehicle procedures. Vehicles can be instrumented for pressures, speeds, and torques. Testing can involve fluid shift quality or durability evaluations.

Testing may be carried out on mileage accumulation dynamometers, using the local roadways or the on-site procedure track. The track may be utilized as a single oval or dual straightaway, permitting several different evaluations to be conducted concurrently. Both domestic and foreign front-wheel or rear-wheel drive vehicles can be utilized.

Procedures specified by Allison C-4:

(Note: Other Allison specifications are available in addition to C-4.)

Chemical Analysis

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to record significant chemical characteristics of C-4 candidate fluids in order to obtain a chemical fingerprint. This fingerprint is used as a reference baseline for checking blend values against analytically defined blend limits. Four separate evaluations are performed:

- (A) Additive Metals Content – Emission Spectroscopy: ICP
- (B) Non-metals Content
 - 1. Chlorine – ASTM D 6443
 - 2. Nitrogen – ASTM D 4629
 - Sulfur – ASTM D 6443
- (C) Acidity and Base
 - 1. Acid Number – ASTM D 664
 - 2. Base Number – ASTM D 2896
- (D) Infrared Spectra
 - 1. Carbonyl Absorbance – ASTM E 168
 - 2. Infrared Spectrum – ASTM E 168

Field service simulated

This procedure simulates satisfactory operation of a heavy-duty transmission when operating under the conditions specified by the manufacturer.

Procedure parts evaluated

The procedure fluid is evaluated.

Physical Properties

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine flash and fire points of procedure fluid by ASTM designation D 92.

Field service simulated

This procedure simulates typical transmission operating temperatures plus a safety factor.

Procedure fixture

Performance of this procedure requires equipment as specified in ASTM D 92.

Procedure parameters

The procedure parameters are as specified in ASTM

D 92.

Procedure parts evaluated

The procedure fluid is evaluated.

Viscosity Characteristics

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine viscosity of procedure fluid in the following manners:

- (A) Kinematic Viscosity at 40°C, ASTM D 445
- (B) Kinematic Viscosity at 100°C, ASTM D 445
- (C) Stable Pour Point, FTM 203C
- (D) Brookfield Viscosity, ASTM D 2983
- (E) Apparent Viscosity, ASTM D 5293

Field service simulated

This procedure simulates satisfactory operation of heavy-duty transmissions when operating under the conditions specified by the manufacturer.

Procedure fixture

Performance of this procedure requires equipment specified in Procedures.

Procedure parameters

The procedure parameters are specified in Procedures.

Procedure parts evaluated

The procedure fluid is evaluated.

Anti-Foaming Properties

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine anti-foaming characteristics in foam procedure per GM 6297M, Test M (Appendix A)

Field service simulated

This procedure simulates satisfactory operation of heavy-duty transmissions when operating under the conditions specified by the manufacturer.

Procedure fixture

Performance of this procedure requires a pump, circulating system, heater, and agitating device.

Procedure parameters

Fill apparatus with procedure fluid. Turn on agitator and heater, regulating pressure at 275 kPa. Make foam observations at 95°C. Restart procedure rig and heat to 135°C. Record height of foam and break

time.

Procedure parts evaluated

The procedure fluid is evaluated.

Copper Strip Procedure

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine copper strip corrosion by ASTM designation D 130.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires 125 ml bottle, heating oven or bath, and metal specimen conforming to ASTM D 130.

Procedure parameters

Place copper strip in bottle and cover two-thirds with procedure fluid. Heat to 150°C for 3 hours.

Procedure parts evaluated

The copper strip is evaluated.

Non-corrosion and Non-rusting

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine corrosion and rusting by ASTM designation D 665A.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an oil bath, 400 ml beaker, beaker cover, stirrer, grinding and polishing equipment.

Procedure parameters

Polish specimens according to ASTM D 665. Fill beaker with 300 ml of test fluid, place in bath, and insert the test specimen. Start the stirrer (1000 rpm). Add 30 ml of distilled water. Allow the test specimen to remain under these conditions for 24 hours. Remove and rate.

Procedure parts evaluated

The procedure specimens (pins) are evaluated.

Rust Protection

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid..

Objective

The objective is to determine rusting by ASTM designation D 1748.

Field service simulated

This procedure simulates satisfactory operation of commercial hydraulic transmission when operating under the conditions specified by the manufacturer.

Procedure fixture

Performance of this procedure requires a humidity cabinet, air circulating supply, specimen holders, and temperature controls and readouts.

Procedure parameters

Prepare procedure panels. Heat procedure oil to 23.3°C. Dip procedure panel in procedure fluid for 10 seconds. Place panel in humidity cabinet for 50 hours. Cabinet temperature is 38°C. Remove at 50 hours and rate.

Procedure parts evaluated

The procedure specimens (panels) are evaluated.

Fluid Effect on Seals – Comp. V1

(Total Immersion Procedure)

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (ethylene acrylic) Compound V1.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours.

Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. V2

(Total Immersion Procedure)

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (ethylene acrylic) Compound V2.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat fluid to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. V3 (Total Immersion Procedure)

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (ethylene acrylic) Compound V3.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. P1 (Total Immersion Procedure)

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (polyacrylate) Compound P1.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. P2

(Total Immersion Procedure)

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (polyacrylate) Compound P2.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. P3

(Total Immersion Procedure)

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (polyacrylate) Compound P3.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. F1

(Total Immersion Procedure)

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (fluoroelastomer) Compound F1.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. F2

(Total Immersion Procedure)

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (fluoroelastomer) Compound F2.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Fluid Effect on Seals – Comp. N1

(Total Immersion Procedure)

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine the procedure fluid's effect on seal elastomers.

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires ASTM D 2240 equipment, oil bath, procedure tubes, reflux condensers, balance, wetting agent, durometer, reference fluids, and seal material (nitrile) Compound N1.

Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to 150°C for 70 hours. Determine volume and durometer change.

Procedure parts evaluated

The seal material is evaluated.

Oxidation Procedure

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine the thermal oxidative stability of C4 candidate fluids. The test is also used to investigate viscosity stability, seal and material compatibility, and copper corrosion protection.

Field service simulated

This procedure simulates satisfactory operation of a hydraulic transmission when operating under the conditions specified by the manufacturer.

Procedure fixture

A 4L60E automatic transmission is driven by an electric motor. The motor-driven converter has the stator installed in the reverse position. The components are mounted on a procedure stand capable of controlling temperatures and pressures.

Procedure parameters

The transmission is driven at 1755 rpm under no load at 163°C converter-out temperature for 300 hours, with air introduced at 90 cc per minute, and a fluid flow rate of 0.086 ± 0.003 L/s.

Procedure parts evaluation

All of the internal transmission parts are rated for sludge, varnish, deterioration, wear, or abnormal conditions.

Vane Pump Wear Procedure

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine the fluid anti-wear characteristics by ASTM designation D 7043 (modified).

Field service simulated

This procedure simulates satisfactory performance in a normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires an electric motor-driven Vickers 104-C pump mounted on a stand capable of controlling speed, temperatures, and pressures.

Procedure parameters

The fluid is tested for 100 hours at 6-9 MPa and 80°C.

Procedure parts evaluated

The weight loss to ring and vanes, any unusual wear, scuffing, deposits, and deterioration to seals are evaluated.

Friction Retention Procedure

(Graphite – Composite Clutches)

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine fluid friction retention characteristics.

Field service simulated

This procedure simulates satisfactory operation of commercial hydraulic transmission when operating under the conditions specified by the manufacturer.

Procedure fixture

Performance of this procedure requires the SAE No. 2 friction procedure machine.

Procedure parameters

After 1000 cycles at 14.5 kJ, 4500 cycles of 15 seconds duration at 18.7 kJ are required. Clutches are engaged once each cycle. Fluid temperature is maintained at $93.3 \pm 3^\circ\text{C}$ for the first phase and $112.7 \pm 3^\circ\text{C}$ for second phase.

Procedure parts evaluated

The procedure fluid is evaluated.

Miscellaneous Procedures

Friction Retention Procedure

(Paper – Composite Clutches)

Specifications

This procedure is specified by Allison Transmission Type C-4 Heavy-Duty Transmission Fluid.

Objective

The objective is to determine fluid friction retention characteristics.

Field service simulated

This procedure simulates satisfactory operation of a commercial hydraulic transmission when operating under the conditions specified by the manufacturer.

Procedure fixture

Performance of this procedure requires the SAE No. 2 friction procedure machine.

Procedure parameters

The system provides 18.70 ± 0.40 KJ for 10,000 cycles of testing. Fluid temperature is maintained at $93.3 \pm 3^\circ\text{C}$.

Procedure parts evaluated

The procedure fluid is evaluated.

JASO T904:2006

Specifications

This procedure is specified by JASO T904:2006. It is modified to run using a 750-ml test charge.

Objective

The objective is to determine the friction characteristics and durability of the tested fluid.

Field service simulated

This procedure simulates satisfactory performance in normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires the SAE # 2 friction machine.

Procedure parameters

1,000 cycles, each 30 seconds in duration, are required. Clutches are engaged once each cycle and absorb 24.5 kJ of total energy. Fluid temperature is maintained at 100 degrees C.

Procedure parts evaluated

The steel and composition plates are evaluated for wear. Indices for dynamic friction, static friction, and stop time are also determined.

JASO M348:2002

Specifications

This procedure is specified by JASO T904:2006. It is modified to run using a 750-ml test charge.

Objective

The objective is to determine the friction characteristics and durability of the tested fluid.

Field service simulated

This procedure simulates satisfactory performance in normally functioning transmission under service conditions.

Procedure fixture

Performance of this procedure requires the SAE # 2 friction machine.

Procedure parameters

5,000 cycles, each 30 seconds in duration, are required. Clutches are engaged once each cycle and absorb 24.5 kJ of total energy. Fluid temperature is maintained at 100 degrees C.

Procedure parts evaluated

The steel and composition plates are evaluated for wear. Indices for dynamic friction, static friction, and stop time are also determined.

- ◆ Fuel Injector Plugging
- ◆ Intake System Deposits
- ◆ Road Evaluations for Turbocharger Engine Oils
- ◆ Vehicle Driveability and Performance Procedures
- ◆ Vehicle Octane Requirement and ORI Evaluations
- ◆ In-Service Fleet and Field Procedure Evaluations
- ◆ Intake Valve Sticking Evaluations
- ◆ Combustion Chamber Deposit Evaluations
- ◆ Mileage Accumulation Dynamometers

Fleet and Field Evaluations:

Fuel Injector Plugging

Current production vehicles equipped with MPFI systems have encountered injector plugging problems associated with the use of gasolines that do not contain adequate amounts of detergents. In severe cases, this problem can render a vehicle inoperative. The major effort of this procedure is to reproduce fuel injector plugging under controlled conditions and assess the effect of fuel additives as they relate to injector "clean-up" and "keep-clean." The keep-clean procedure is now available as ASTM Procedure D 5598. The Sequential Central Port Injection evaluation required for top tier gasoline additive certification is also available. Evaluations of injector flows and spray patterns are conducted during the procedure. Subjective evaluations of vehicle driveability and performance can also be performed. Fuel injector spray patterns can be photo-documented to provide a visual record of procedure results.

Intake System Deposits

Various vehicle procedure programs are conducted in order to assess the effect of fuels and fuel additives on intake and combustion system deposits, particularly on intake valve deposits. The ability of unleaded gasolines to control intake valve deposit formation can be evaluated with fleet procedures, the most popular of which is the BMW 10,000-Mile Intake Valve Deposit Procedure, ASTM D 5500. An engine dyna-mometer based test procedure, D-6201, is also available.

Road Evaluations for Turbocharger Engine Oils

The use of turbocharger-equipped vehicles has led to the development of highly specialized engine lubricants. SwRI developed an over-the-road, in-service Procedure to evaluate the performance of new oils as they relate to turbo and engine component wear.

Vehicle Driveability and Performance Procedures

SAE and CRC-type vehicle driveability and performance procedures are used to measure vehicle operation as it relates to the evaluation of fuels, additives, and vehicle components. On-site track facilities, trained personnel, and specialized equipment necessary for the procedures are immediately available.

Vehicle Octane Requirement and ORI Evaluations

Fleet programs for octane requirement and octane requirement increase are conducted as an assessment of engine operating parameters as related to fuel octane number and combustion requirements. The CRC-E 15 road procedure is used for these evaluations.

In-Service Fleet and Field Procedure Evaluations

SwRI routinely provides its clients a broad base of commercial fleets to evaluate fuels, lubricants, hardware, and aftermarket components. These evaluations are tailored, in many instances, to meet specific research and marketing requirements of the industry. These fleets include heavy- and light-duty commercial trucks, buses, taxis, municipal police, and individually owned vehicles.

Intake Valve Sticking Evaluations

Vehicle procedure programs are conducted to assess the effect of fuels and fuel additives on intake valve sticking. The ability of fuels to prevent intake valve stem deposits from causing the intake valves to stick at cold temperatures (-20°C) can be evaluated.

Combustion Chamber Deposit Evaluations

Fleet studies are conducted evaluating the tendency of various fuels to form deposits on the piston tops and cylinder head combustion chambers of various automobile engines. The capability of fuel additives to remove previously formed combustion chamber deposits can also be evaluated. The deposit levels are determined by both thickness and weight following cylinder head removal.

Mileage Accumulation Dynamometers

For rapid, cost-effective automotive testing, SwRI offers around-the-clock mileage accumulation at speeds up to 100 mph. To complement its fleet testing capabilities, SwRI has installed 20 mileage accumulation dynamometers (MADs) that accommodate most cars and light trucks up to 7,000 pounds. Any transient or steady-state driving cycle can be accurately reproduced in this facility. Using this equipment, SwRI can evaluate the durability and performance of various automotive fluids, fuels, components, and emissions control systems.

- ◆ L20 Performance of Gear Lubricants at Low Speed, High Torque
- ◆ L33-1 Performance of Gear Lubricants While Subjected to Water Contamination and Elevated Temperature
- ◆ L37 Performance of Gear Lubricants at High Speed, Low Torque, Followed by Low Speed, High Torque
- ◆ L42 Performance of Gear Lubricants in Axles Under High Speed and Shock Loading
- ◆ L60-1 Thermal and Oxidative Stability of Gear Lubricants
- ◆ FZG Load Stage
- ◆ FZG Tractor Hydraulic Fluid Wear
- ◆ SSP 180 Synchronizer Endurance Procedure
- ◆ High-Temperature Cyclic Durability Procedure
- ◆ Mack Power Divider Snap Procedure
- ◆ Gear Oil Fleet Procedures
- ◆ Axle Efficiency Testing

Gear Oil Procedures:

L20 Performance of Gear Lubricants at Low Speed, High Torque

Specifications

This procedure is specified by GL-4 and Federal Procedure Method 5317.

This procedure is no longer part of U.S. requirements. It has been replaced by the L37 procedure, although the L20 procedure is used for some foreign clients and for screening and research in the U.S.

Objective

This method is used for determining the load carrying, wear, and extreme pressure characteristics of gear lubricants in hypoid axle assemblies under conditions of low speed and high torque.

Procedure fixture

A specially selected rear axle assembly, engine, transmission, and two large dynamometers serve as the procedure apparatus.

Procedure parameters

The procedure axle is operated at 62 axle rpm and 600 lb-in of torque with no cooling water until the lubricant temperature reaches 140°F. The axle is then operated for 30 hours at 62 axle rpm and 32,311 lb-in of torque with the lubricant temperature being cycled between 200°F and 250°F.

Procedure parts evaluated

The ring and pinion gears are evaluated.

L33-1 Performance of Gear Lubricants While Subjected to Water Contamination and Elevated Temperature (ASTM D 7038)

Specifications

This procedure is specified by Federal Procedure Method Standard No. 791, SAE J2360, MIL-PRF-2105E (replaced by SAE J2360), GL-5, PG-2, and Federal Procedure Method 5326, and individual original equipment manufacturers' specifications.

Objective

This method is used for evaluating the rust and corrosion inhibiting properties of a gear lubricant while subjected to water contamination and elevated temperature.

Procedure fixture

An electric motor, specially selected hypoid differential housing assembly, cooling fan, heating lamps, and heated storage box serve as the procedure apparatus.

Procedure parameters

The differential housing assembly is operated for 4 hours at 2,500 input rpm and 180°F lubricant temperature with 1 fl. oz. of distilled water mixed in the lubricant. The procedure unit is then placed in the storage box and stored for 162 hours at 125°F. At the end of the procedure, the procedure parts of the assembly are rated for the presence of rust.

Procedure parts evaluated

All internal moving parts (ring, pinion, bearings, differential gears, etc.) are evaluated.

L37 Performance of Gear Lubricants at High Speed, Low Torque, Followed by Low Speed, High Torque (ASTM D 6121)

Specifications

This procedure is specified by the Federal Procedure Method Standard No. 791, MIL-PRF-2105E (replaced by SAE J2360), GL-5, PG-2, Federal Procedure Method 6507.1, and individual original equipment manufacturers' specifications.

Objective

This method is used for determining the load-carrying, wear, and extreme pressure characteristics of gear lubricants in hypoid axle assemblies under conditions of high-speed, low-torque, and low-speed, high-torque operation.

Procedure fixture

A specially selected rear axle assembly, engine, and transmission, and two large dynamometers serve as the procedure apparatus.

Procedure parameters

The procedure axle is operated for 100 minutes at 440 axle rpm, 297°F lubricant temperature, and 9460 lb-in of torque. The axle is then operated for 24 hours at 80 axle rpm, 275°F lubricant temperature, and 41,800 lb-in of torque.

Procedure parts evaluated

The ring and pinion gears are evaluated.

L42 Performance of Gear Lubricants in Axles Under High Speed and Shock Loading

Specifications

This procedure is specified by the Federal Procedure Method Standard No. 791, MIL-PRF-2105E (replaced by SAE J2360), GL-5, PG-2, Federal Procedure Method 6507.1, and individual original equipment manufacturers' specifications.

Objective

The objective of this procedure is to evaluate the anti-scoring properties of gear lubricants under high-speed and shock conditions. The performance of procedure lubricants is compared to that of reference oils.

Procedure fixture

A specially selected rear axle assembly, engine, transmission, special axle-mounting assembly, and two large dynamometers serve as the procedure apparatus.

Procedure parameters

A break-in is conducted at moderate speed and load at a lubricant temperature of 225°F. This is followed by a series of moderate accelerations and decelerations with temperatures approaching 280°F. The final series of runs consists of high-speed accelerations with rapid decelerations.

Procedure parts evaluated

The ring and pinion gears are evaluated.

L60-1 Thermal and Oxidative Stability of Gear Lubricants (ASTM D 5704)

Specifications

This procedure is specified by SAE J2360, MIL-PRF-2105 (replaced by SAE J2360), MT-1, PG-2, and original equipment manufacturers' specifications. This procedure has replaced the CRC L-60 procedure, which was part of GL-5, Federal Procedure Method Standard No. 791, and Federal Procedure Method 2504.

Objective

This method is used for determining the deterioration of lubricants under severe thermal and oxidative conditions.

Procedure fixture

A gear case assembly (updated from the L-60 model), two spur gears, two copper strips, a bearing, a temperature control system, an alternator, a motor, and a regulated air supply serve as major parts of the procedure fixture.

Procedure parameters

The spur gears are rotated under load at 1750-rpm input for 50 hours. The lubricant temperature is maintained at 325°F. Airflow through the lubricant is controlled at 22.1 mg/min for the procedure's duration.

The physical and chemical properties of the oil and deposits on the gears are evaluated at the end of procedure.

Procedure parts evaluated

The large and small gears are evaluated, as well as the used oil.

Pass/fail criteria

The pass/fail criteria are as follows:

Viscosity Increase	≤ 100%
Pentane Insolubles	≤ 3.0%
Toluene Insolubles	≤ 2.0%
Carbon/Varnish Rating	≥ 7.5
Sludge Rating	≥ 9.4

FZG Load Stage (ASTM D 5182)

Specifications

This procedure is specified by API MT-1, US steel 224, MERCON® V, and future ATF specifications (modified D 5182).

Objective

The objective is to evaluate the anti-scuffing properties of a lubricant.

Procedure fixture

Performance of this procedure requires a Strama 4-square electric motor-driven procedure machine and "A" profile FZG procedure gears.

Procedure parameters

The procedure machine is operated at 1446 rpm for 12 different 15-minute load stages. Each load stage is started with the procedure lubricant at 90°C. This procedure can be routinely conducted at higher speeds and temperatures.

Procedure parts evaluated

The procedure gears are evaluated.

FZG Tractor Hydraulic Fluid Wear (ASTM D 4998)

Specifications

This procedure is specified by MIL-L-2104E (to be replaced by SAE J2360 as of January 1, 2004) and Caterpillar TO-4.

Objective

The objective is to evaluate the low-speed anti-wear properties of a lubricant.

Procedure fixture

Performance of this procedure requires a Strama 4-square electric motor-driven procedure machine and "A" profile procedure gears.

Procedure parameters

The procedure machine is operated at 100 rpm, 120°C, and load stage 10 for 20 hours.

Procedure parts evaluated

The procedure gears are evaluated.

SSP 180 Synchronizer Endurance Procedure

Specifications

This procedure is based on CEC L-66-T-99.

Objective

The objective is to evaluate a lubricant's ability to protect the brass synchronizer from wear while providing enough friction to allow for proper synchronizer operation.

Procedure fixture

This procedure is conducted in an SSP-180 procedure machine. Inside are adapters that hold the first and second speed gears in place. The synchronizer mechanism is mounted between these gears.

Procedure parameters

The procedure oil is maintained at 80°C while the synchronizer is cycled once every 4.5 seconds. A 0.04 kgm² flywheel loads the synchronizer and is accelerated and decelerated between 0 and 1100 rpm.

Procedure parts evaluated

The synchronizer cone height is measured pre- and post-procedure to determine wear.

High-Temperature Cyclic Durability Procedure (ASTM D 5579)

Specifications

This procedure is specified by Mack GO-G, GO-H, GO-J, API MT-1, and MIL-PRF-2105E (replaced by SAE J2360).

Objective

The objective is to evaluate the thermal stability of gear oils by determining number of cycles to unsynchronized shift.

Procedure fixture

Mack synchronizer with new friction and reaction disks, oil heater, Mack T-2180 transmission, and electric motor are required to perform this procedure.

Procedure parameters

The high-low range synchronizer of a Mack T-2180 18-speed transmission is shifted through a 12-second cycle (6 seconds in low range, 6 seconds in high range) until an unsynchronized shift occurs. The shift pressure is held at 90 psi, the procedure lubricant temperature is controlled at 250°F, and the tail shaft speed is held at 750 rpm throughout the procedure. The countershafts speed ranges from 459 rpm to 1756 rpm during the shift.

Procedure parts evaluated

The clutch disks, and shifter fork are evaluated.

Mack Power Divider Snap Procedure

Specifications

This procedure is specified by the Mack GO-J.

Objective

The objective is to evaluate the wear protection of a gear lubricant.

Procedure fixture

Mack truck tractor and trailer loaded to 98,000 lbs. are required to perform this procedure.

Procedure parameters

The Mack truck tractor and trailer are driven in a 100-foot diameter circle for 500 laps. Abnormal noise ("snapping", "popping", etc.) is noted and cams and wedges of power divider are rated for wear and distress.

Procedure parts evaluated

The cams and wedges are evaluated.

Gear Oil Fleet Procedures

Heavy-Duty

In-service testing of heavy-duty axles is typically related to MIL-PRF-2105e (to be replaced by SAE J2360 as of January 1, 2004) gear oil qualification programs. Three or four trucks are operated for 200,000 miles. Performance of the oils is judged from the appearance of gears, bearings, and related components. Periodic oil samples are analyzed for wear metals, additives, and contaminants.

Light-Duty

In-service evaluation of gear oils in light-duty vehicles, such as pickups and full-size passenger sedans are common. Performance of the oils is judged from the appearance of gears, bearings, and related components. Mileage accumulation is 100,000 miles.

Custom Fleet Evaluations

Procedures are designed for the special needs of a client.

GM Big Wheel/Little Wheel

A car equipped with limited slip differential is operated for specified miles with different diameter tires on each side of the drive axle. Periodic checks of axle noise and torque bias retention are conducted.

Rear Axle Scoring Procedure

A Chevrolet sedan equipped with an automatic transmission, 305 CID V-8 engine, and 3.25:1 ratio rear axle is driven for a series of full-throttle accelerations from a standing start. The transmission is shifted into low at 70 mph during the coast-down. The stress on the coast side of axle gear can produce excessive scoring with different lubricants.

Axle Efficiency Testing Procedure

Specifications

Various. OEM and client specific. No industry standard.

Objective

The objective is to evaluate gear lubricant and axle hardware effects on axle efficiency.

Procedure fixture

SwRI has an "L" type test stand with a variable speed electric drive motor for testing light duty SUV beam type axles.

Procedure parameters

Conducted to suit customer's needs. 100 to 2800 pinion rpm and up to 350 lb-ft pinion torque.

Procedure parts evaluated

None. Test is usually a flush and run type with one axle used for several oil tests.

Hydraulic Fluids Procedures

- ◆ Vickers/Eaton 35VQ25A
- ◆ Vickers/Eaton 104-C
- ◆ Parker/Denison T6H20C
- ◆ Hydraulic Efficiency Testing

Hydraulic Fluid Procedures:

Vickers/Eaton 35VQ25A (ASTM D 6973)

Specifications

This procedure is specified by anti-wear hydraulic fluid (Form M-2952-S).

Objective

The objective of this procedure is to evaluate the anti-wear characteristics of hydraulic oil by means of weight loss on the cam ring and the vanes of a Model 35VQ25A pump.

Procedure fixture

A variable speed electric drive motor drives a vane pump. Associated flow control, reservoir and heat exchanger equipment combine to provide substantial flexibility for various operating conditions.

Procedure parameters

Procedure duration is 50 hours per cartridge with a pump outlet pressure of 3,000 psi and an inlet oil temperature of 203°F.

The first three, or four out of five cartridges, must pass (less than 90 mg combined vane and cam ring weight loss).

Vickers/Eaton 104-C

Specifications

The Vickers/Eaton 104-C vane pump is used for several ATF and hydraulic fluid testing applications.

Objective

This test is used to screen for fluid anti-wear characteristics using a vane pump.

Example: ASTM D 7043 procedure

Procedure fixture

The fixture is an electric motor driven pump stand with temperature and output pressure control. Has data logging and flow monitoring.

Procedure parameter

Operational parameters vary by test procedures used. Several versions exist. Test stands can be configured to accommodate each.

Hydraulic Efficiency Testing

Specifications

None at this time

Objective

SwRI maintains a test stand with variable speed drive, precision flow and torque sensing equipment. It can be used for fluid evaluations relative to efficiency of power transmission. SwRI can also design and conduct field testing for the same purpose.

Procedure Fixture

Customizable to specific needs.

Procedure Parameter

Per specific requirements.

Parker/Denison T6H20C

Specifications

This procedure is specified by Denison HF-O high performance fluid suitable for both axial-flow piston pumps and vane pumps. It is also applicable to HF-1, HF-2, and HF-6.

Objective

The objective of this procedure is to determine the effect of a hydraulic fluid on flow, deposits, wear, and filter plugging in a T6H20C hybrid pump under cyclic conditions.

Procedure fixture

Parker/Denison T6H20C certified test stand is used; electric motor driver, cyclic pressure conditions, Parker/Denison pre-measured hybrid test pumps, computer-controlled with automated high-speed data logging.

Procedure parameters

Dry and wet, phase of 608 hours total length, 1700 rpm at pump shaft, outlet pressures from 0 to 300 bar, fluid temperature from 80 to 110 degrees C.

Tractor Hydraulic Fluids Evaluations

- ◆ Tractor Hydraulic Fluids Field Procedure
- ◆ JDQ-84 Sauer-Danfoss Dynamic Corrosion Procedure
- ◆ JDQ-95 Spiral Bevel and Final Drive Gear Wear
- ◆ JDQ-94 PST Clutch Procedure
- ◆ John Deere JDQ-96 Performed Using 1400 Series Axle
- ◆ Ford 8340 16x16 Transmission Driveline Stall Procedure
- ◆ Noise and Performance Procedure for Transmission Oil
- ◆ Modified Ford 8340 16x16 High-Energy Clutch Procedure
- ◆ New Holland Jenkins Cycle Procedure
- ◆ New Holland 16x16 Transmission, 400-Cycle Stall Procedure

Tractor Hydraulic Fluids Evaluations:

Tractor Hydraulic Fluids Field Procedure

Field testing of tractor hydraulic fluids has been a continual activity at SwRI since the mid 60's.

SwRI personnel monitor tractors operating with procedure oils in all sections of the United States. Techniques for evaluating filter plugging and performance in the field have been developed.

Lubricant-related testing is conducted on New Holland, John Deere, Massey-Ferguson, and Case tractors.

JDQ-84 Sauer-Danfoss Dynamic Corrosion Procedure

Specifications

This procedure is specified by John Deere J20C and J20D.

Objective

The objective of this procedure is to identify oils that, when contaminated with limited amounts of water, can still serve as a suitable fluid for hydrostatic transmissions and hydraulic pumps found on agricultural and industrial off-highway equipment.

Procedure fixture

A Sauer-Danfoss Series 90 axial piston pump is driven by electric motor. Associated relief valves, heat exchangers, and a reservoir provide substantial flexibility for various operating conditions.

Procedure parameters

Procedure duration is 225 hours. 1% water is added at 25 hours. The pump is run at 38,395 kPa (5,500psi), 2.0 liters per second (32 gpm), and main loop temperature of 82°C (180°F).

JDQ-95 Spiral Bevel and Final Drive Gear Wear

Specifications

This procedure is specified by John Deere JDM J20.

Objective

Performance of procedure oil is compared to reference oil with respect to the scoring of the spiral bevel ring/pinion gears. The wear and surface distress of sun pinion gears are also evaluated.

Procedure fixture

The procedure fixture is a final-drive axle assembly powered by a six-cylinder diesel engine through a powershift transmission. A special low-speed/high-torque brake dynamometer absorbs the axle output power.

Procedure parameters

Output speeds vary from 24 to 14 axle rpm with axle torques of 23,730 Nm (17,400 lb-ft). Oil temperature is 121°C (250°F). Procedure duration is 50 hours.

JDQ-94 PST Clutch Procedure

Specifications

This procedure is specified by John Deere J20.

Objective

The objective of this procedure is to assess the effect of transmission/hydraulic oils on powershift transmission (PST) clutch stall time, dynamic friction coefficient, and clutch disc wear.

Procedure fixture

A modified John Deere transmission that is powered by a six-cylinder diesel engine serves as a procedure apparatus. A dynamometer coupled to the output shaft of the transmission provides the loading.

Procedure parameters

A typical cycle consists of a partial engagement in which the clutches absorb 1,100 kJ of energy followed by a cool-down period in which the clutches are fully engaged. This cycle is repeated every 28.5 seconds for a total of 2,000 cycles. Lube oil temperature is controlled at 50°C (122°F).

John Deere JDQ-96 Performed Using 1400 Series Axle

Specifications

This procedure is specified by John Deere JDM J20 and JDM J27.

Objective

The objective of this procedure is to assess the effect of the procedure oil on brake noise and brake capacity compared to that demonstrated with a reference.

Procedure fixture

A modified, full-sized John Deere agricultural tractor powers a John Deere industrial axle in the laboratory. The sun pinion shaft is equipped with strain gages in order to measure dynamic torque changes as the brakes are applied over a wide range of axle speeds and loads.

Procedure parameters

Chatter is evaluated at 32, 49, 60, and 71°C (90, 120, 140, and 160°F) oil temperature. Brake chatter is measured at different brake apply pressures and wheel speeds.

Ford 8340 16x16 Transmission Driveline Stall Procedure

Details of this procedure are confidential to Case New Holland.

Noise and Performance Procedure for Transmission Oil

Details of this procedure are confidential to Case New Holland.

Modified Ford 8340 16x16 High-Energy Clutch Procedure

Details of this procedure are confidential to Case New Holland.

New Holland Jenkins Cycle Procedure

Details of this procedure are confidential to Case New Holland.

New Holland 16x16 Transmission, 400-Cycle Stall Procedure

Details of this procedure are confidential to Case New Holland.

