SAE International

# SURFACE VEHICLE INFORMATION REPORT

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## Defining Hydraulic Oil Compatibility with Hydraulic Hose Elastomers

### RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature.

### STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE Hydraulic Hose and Hose Fittings Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.





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## FOREWORD

Engine oils have had well defined and standardized tests for many years, using both laboratory and engine test cells. These tests describe and control the engine wear that is acceptable to automobile manufactures, as well as oil service periods. These engine oil test methods do not describe the compatibility of oils with elastomers used for hydraulic hose liners and due to a lack of test methods a project, by SAE/FCCTC/S2, to develop a process to determine a relational index for hydraulic fluid compatibility using a standard ISO formulation of two common polymers used in hydraulic hose, Nitrile and chloroprene rubber.

## 1. SCOPE

This SAE Information Report is intended to provide the hydraulic oil manufacturer and hydraulic equipment manufacturer with information that can be used predicting the relative impact that non petroleum based hydraulic oils may have on the hose elastomers in the existing system. This document contains the information necessary to perform the tests using standard elastomer formulations, representative of material used in hydraulic hose. The test methods used are defined within ASTM D471, standard test method for Rubber Property—Effect of Liquids. The physical properties measured, are volume swell, tensile strength, percent elongation, shore A hardness and load at 100% elongation. The properties were measured, after immersion, at 72 hours, 168 hours, 336 hours, 504 hours, 672 hours, 840 hours, and 1008 hours and the percent calculated as change from the unaged properties. The detail of the testing process is described in the following report.

## 2. REFERENCES

### 2.1 Applicable Publications

The following standards contain provisions which, through reference in this text, constitute provisions of this document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent edition of the standards indicated as follows. Members of IEC and ISO maintain registers of currently valid International Standards.

2.1.1 SAE Publications

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J343 Tests and Procedures for SAE 100R Series Hydraulic Hose and Hose Assemblies

SAE J517 Hydraulic Hose

2.1.2 ASTM Publications

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D 380 Standard Methods of Testing Rubber Hose

ASTM D 471 Standard Test Method for Rubber Property—Effect of Liquids

2.1.3 ISO Publications

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 13226 Standard reference elastomers

ISO 2393 Rubber test mixes—Preparation, mixing and vulcanization equipment and procedures

3. BACKGROUND

Current SAE J517 for hydraulic hose has defined for each 100R type of hose, an Oil Resistance Test. This test is performed using a industry standard reference fluid IRM 903 and is useful as a quality check relative to product consistency. The use of petroleum based hydraulic fluids in J517 products, is based on both long term use, as well as field testing performed with newly developed hydraulic applications. New biodegradable hydraulic fluids, based on non-petroleum fluids have come into the hydraulic industry within the last 5 years. These fluids are based on materials that have not been widely used with J517 hydraulic hoses, therefore little is know about the long term impact these fluids will have on the synthetic rubber formulations used in hydraulic hose.

3.1 Test Description

The original physical properties are measured and testing is performed after each time period to obtain the percent change. These results are used to determine the value as found in the Table 1.

TABLE 1 - RANGES AND VALUES FOR EACH PROPERTY

| Property | % Change | Value | Property | Range | Value |
|---|---|---|---|---|---|
| Tensile | 0 to 15% | 1 | Volume Swell | -5% to +10% | 1 |
| | >15% to 25% | 2 | | >+ 10% to +20% | 2 |
| | >25% to 40% | 3 | | >+20% to +30% | 3 |
| | >40% to 60% | 4 | | >+30% to +40% | 4 |
| | >60% | 5 | | >+40% | 5 |

| Property | % Change | Value | Property | Points changed | Value |
|---|---|---|---|---|---|
| Elongation | 0 to 15% | 1 | Hardness | 0 to 5 | 1 |
| | >15% to 25% | 2 | | >5 to 10 | 2 |
| | >25% to 40% | 3 | | >10 to 15 | 3 |
| | >40% to 60% | 4 | | >15 to 20 | 4 |
| | >60% | 5 | | >20 | 5 |

The tests results are weighted, giving higher multipliers to properties that have greater impact on hose life. Elongation at break, weight = 2, volume swell, weight = 2 all others are weighted at 1. A higher number ECI in comparison to a standard fluid ECI is a warning to evaluate the fluid in the application with the selected hydraulic hose.

The ECI is then the result of multiplying the property values.

For example Tensile value = 3 weighting is 1, Elongation value = 5 weighting is 2, Hardness value = 2 weighting is 1 and the Volume Swell value = 2 weighting is 2, this multiplication results in the ECI. Example 3 × 1 = 3, 5 × 2 = 10, 2 × 1 = 2, 2 × 2 = 4, and 3 × 10 × 2 × 4 = 240, as the elastomer compatibility index (ECI).

## 4. STANDARD TEST MATERIALS

This report provides formulation, mixing and vulcanization procedures for the following polymeric Formulas for use as test standards are in the following ISO standard.

a. acrilonitrile-butadiene rubber ISO 13226 SRE-NBR 28/SX

b. chloroprene rubber ISO 13226 SRE-CR/1

The reference formulations found in ISO 13226—Standard reference elastomers (SRE) for characterizing the effect of liquids on vulcanized rubber, are also in Appendix A of this document. The mixing of compounds and the vulcanization of test sheets shall be carried out in accordance with ISO 2393.

These formulations are sensitive to fluid variations and have comparatively high swelling characteristics. The changes in volume, hardness, tensile strength and elongation at break can be used to establish an elastomer compatibility index ECI, for the test fluid. The ECI, which can be established and documented by the hydraulic fluid suppliers, allows selection of standard hydraulic hoses if the specific hydraulic fluid ECI is in the range of existing OEM fill fluids. The ECI will also assist producers of additives and hydraulic fluids in the development of products compatible with common hydraulic hoses.

The following data sheets show ECI results of testing standard NBR and CR with ASTM test oils.

TABLE 2 - ELASTOMER COMPATIBILITY INDEX DEVELOPMENT

**Time = 168 HOURS**

**212 °F – NBR – ASTM #1 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 1 | 1 |
| % Elongation | 2 | 2 | 4 |
| Hardness | 1 | 1 | 1 |
| % Swell | 2 | 1 | 2 |
| | | **ECI =** | **8** |

**212 °F – NBR – ASTM 903 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 2 | 2 |
| % Elongation | 2 | 3 | 6 |
| Hardness | 1 | 2 | 2 |
| % Swell | 2 | 4 | 8 |
| | | **ECI =** | **192** |

**212 °F – CR – ASTM #1 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 2 | 2 |
| % Elongation | 2 | 1 | 2 |
| Hardness | 1 | 1 | 1 |
| % Swell | 2 | 1 | 2 |
| | | **ECI =** | **8** |

**212 °F – CR – ASTM 903 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 5 | 5 |
| % Elongation | 2 | 3 | 6 |
| Hardness | 1 | 4 | 4 |
| % Swell | 2 | 5 | 10 |
| | | **ECI =** | **1200** |

**250 °F – NBR – ASTM #1 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 1 | 1 |
| % Elongation | 2 | 2 | 4 |
| Hardness | 1 | 1 | 1 |
| % Swell | 2 | 1 | 2 |
| | | **ECI =** | **8** |

**250 °F – NBR – ASTM 903 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 3 | 3 |
| % Elongation | 2 | 3 | 6 |
| Hardness | 1 | 3 | 3 |
| % Swell | 2 | 4 | 8 |
| | | **ECI =** | **432** |

**250 °F – CR – ASTM #1 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 3 | 3 |
| % Elongation | 2 | 3 | 6 |
| Hardness | 1 | 2 | 2 |
| % Swell | 2 | 2 | 4 |
| | | **ECI =** | **144** |

**250 °F – CR – ASTM 903 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 5 | 5 |
| % Elongation | 2 | 4 | 8 |
| Hardness | 1 | 4 | 4 |
| % Swell | 2 | 5 | 10 |
| | | **ECI =** | **1600** |

**Summary**

| **ECI Ratings** | **#1** | **#3** |
|---|---|---|
| NBR – 212 °F | 8 | 192 |
| NBR – 250 °F | 8 | 432 |
| CR – 212 °F | 8 | 1200 |
| CR – 250 °F | 144 | 1600 |

| **Weighting Factors** | |
|---|---|
| Tensile | 1 |
| % Elongation | 2 |
| Hardness | 1 |
| % Volume Swell | 2 |

TABLE 3 - ELASTOMER COMPATIBILITY INDEX DEVELOPMENT

**Time = 1008 HOURS**

**212 °F – NBR – ASTM #1 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 3 | 3 |
| % Elongation | 2 | 4 | 8 |
| Hardness | 1 | 1 | 1 |
| % Swell | 2 | 1 | 2 |
| | | **ECI =** | **48** |

**212 °F – NBR – ASTM 903 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 5 | 5 |
| % Elongation | 2 | 5 | 10 |
| Hardness | 1 | 1 | 1 |
| % Swell | 2 | 4 | 8 |
| | | **ECI =** | **400** |

**212 °F – CR – ASTM #1 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 3 | 3 |
| % Elongation | 2 | 2 | 4 |
| Hardness | 1 | 1 | 1 |
| % Swell | 2 | 1 | 2 |
| | | **ECI =** | **24** |

**212 °F – CR – ASTM 903 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 5 | 5 |
| % Elongation | 2 | 3 | 6 |
| Hardness | 1 | 5 | 5 |
| % Swell | 2 | 5 | 10 |
| | | **ECI =** | **1500** |

**250 °F – NBR – ASTM #1 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 5 | 5 |
| % Elongation | 2 | 5 | 10 |
| Hardness | 1 | 1 | 1 |
| % Swell | 2 | 1 | 2 |
| | | **ECI =** | **100** |

**250 °F – NBR – ASTM 903 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 5 | 5 |
| % Elongation | 2 | 5 | 10 |
| Hardness | 1 | 2 | 2 |
| % Swell | 2 | 4 | 8 |
| | | **ECI =** | **800** |

**250 °F – CR – ASTM #1 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 4 | 4 |
| % Elongation | 2 | 4 | 8 |
| Hardness | 1 | 1 | 1 |
| % Swell | 2 | 3 | 6 |
| | | **ECI =** | **192** |

**250 °F – CR – ASTM 903 Oil**

| Property | Property Multiplier | Rating Factor | Property Index |
|---|---|---|---|
| Tensile | 1 | 5 | 5 |
| % Elongation | 2 | 4 | 8 |
| Hardness | 1 | 5 | 5 |
| % Swell | 2 | 5 | 10 |
| | | **ECI =** | **2000** |

**Summary**

| **ECI Ratings** | **#1** | **#3** |
|---|---|---|
| NBR – 212 °F | 48 | 400 |
| NBR – 250 °F | 100 | 800 |
| CR – 212 °F | 24 | 1500 |
| CR – 250 °F | 192 | 2000 |

| **Weighting Factors** | |
|---|---|
| Tensile | 1 |
| % Elongation | 2 |
| Hardness | 1 |
| % Volume Swell | 2 |



PREPARED BY THE SAE HYDRAULIC HOSE AND HOSE FITTINGS SUBCOMMITTEE
OF THE SAE FLUID CONDUCTORS AND CONNECTORS TECHNICAL COMMITTEE

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APPENDIX A

A.1 Formulations for ISO 13226 SRE-CR/1 and ISO 13226 SRE-NBR/SX test samples:

TABLE A1 - SRE-CR/1

| Ingredients | Parts by Mass |
|---|---|
| Chloroprene rubber(1) | 100 |
| Stearic acid | 0.5 |
| Light calcined magnesia | 4.0 |
| Zinc oxide | 5.0 |
| Carbon black N 550(2) | 20 (nominal) |
| Organic accelerator(3) | 0.75 to 1.0 |
| Antioxidant(4) | 2.0 |
| Total | 132.5 |

1. A slow crystaline form of an non-sulphur modified polymer is required. Neoprene WRT has been found to be suitable.
2. Corax N 550® from Degussa AG or equivalent.
3. Vulkacit CRV has been found to be suitable.
4. Octamine has been found to be suitable.

TABLE A2 - SRE-NBR/SX

| Ingredients | Parts by Mass |
|---|---|
| NBR with (28 ± 0.5%) by mass of Acrylonitrile(1) | 100 |
| 2,2,4-trimethy-1,2-dihydroquinoline polymerized (TMQ)(2) | 2.0 |
| Zinc oxide, precipitated(3) | 5.0 |
| Stearic acid | 10 |
| Carbon black N 550(4) | 65.0 |
| Tetra methyl thiuram disulfide (TMTD)(5) | 2.5 |
| Benzothiazyl-2-cyclohexyl-sulphenamide (CBS)(6) | 1.5 |
| Sulphur | 0.2 |
| Total | 177.2 |

1. Perbunan NT 2845® from Bayer AG or equivalent.
2. Vulkanox HS/LG from Bayer AG or equivalent.
3. Zinkoxyd aktiv® from Bayer AG or equivalent.
4. Corax N 550® from Degussa AG or equivalent.
5. Vulkacit Thiuram/C® from Bayer AG or equivalent.
6. Vulkacit CZ/C® from Bayer AG or equivalent.

APPENDIX B

TABLE B1 - AGED TEST DATA FROM FACTORY FILL FLUID
TYPE CAT 8T-9580 STANDARD NITRILE

| | 212 °F | | | | | 250 °F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| hrs | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI |
| 72 | -35.6 | -58.1 | -3 | +7.6 | 48 | -50.4 | -63.8 | -3 | +8.5 | 80 |
| 168 | -48.7 | -68.1 | -1 | +7.5 | 80 | -56.4 | -69.5 | -2 | +7.8 | 80 |
| 336 | -55.2 | -74.6 | -1 | +7.1 | 80 | -67.2 | -75.7 | +2 | +7.4 | 100 |
| 504 | -51.2 | -75.4 | +2 | +7.0 | 80 | -80.9 | -83.0 | +1 | +7.2 | 100 |
| 672 | -49.8 | -74.5 | +5 | +7.0 | 80 | -84.5 | -85.2 | +5 | +7.0 | 100 |
| 840 | -53.5 | -77.3 | +6 | +7.1 | 160 | -88.4 | -89.9 | +8 | +6.8 | 200 |
| 1008 | -59.1 | -79.1 | +4 | +6.9 | 80 | -87.9 | -94.2 | +11 | +6.6 | 300 |

TABLE B2 - AGED TEST DATA FROM FACTORY FILL FLUID
TYPE CAT 8T-9580 STANDARD CHLOROPRENE

| | 212 °F | | | | | 250 °F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| hrs | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI |
| 72 | -24.0 | -8.6 | -11 | +33.7 | 96 | -47.3 | -29.0 | -11 | +37.9 | 576 |
| 168 | -37.8 | -19.7 | -10 | +34.2 | 192 | -54.5 | -38.9 | -11 | +37.8 | 576 |
| 336 | -35.2 | -22.7 | -10 | +32.6 | 192 | -65.9 | -53.7 | -11 | +37.3 | 960 |
| 504 | -42.0 | -22.6 | -9 | +32.4 | 256 | -75.3 | -65.2 | -6 | +34.6 | 800 |
| 672 | -44.3 | -31.5 | -11 | +31.8 | 576 | -78.0 | -72.0 | -5 | +32.3 | 400 |
| 840 | -52.6 | -38.4 | -10 | +31.4 | 384 | -80.8 | -81.7 | -4 | +30.3 | 400 |
| 1008 | -45.3 | -36.4 | -9 | +31.2 | 384 | -80.1 | -85.5 | -6 | +29.1 | 600 |

TABLE B3 - AGED TEST DATA FROM FACTORY FILL FLUID
TYPE JDM J21A STANDARD NITRILE

| | 212 °F | | | | | 250 °F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| hrs | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI |
| 72 | +19 | -7 | -7 | +12 | 32 | +16 | -21 | -10 | +14 | 64 |
| 168 | +15 | -21 | -9 | +14 | 32 | +14 | -25 | -7 | +13 | 32 |
| 336 | +13 | -21 | -7 | +13 | 64 | +4 | -39 | -4 | +14 | 24 |
| 504 | +14 | -34 | -7 | +13 | 86 | -34 | -66 | -5 | +13 | 120 |
| 672 | +4 | -38 | -7 | +13 | 48 | -58 | -78 | -2 | +13 | 160 |
| 840 | +10 | -43 | -5 | +13 | 32 | -67 | -83 | -1 | +12 | 200 |
| 1008 | +13 | -40 | -2 | +12 | 40 | -75 | -89 | -2 | +12 | 200 |

TABLE B4 - AGED TEST DATA FROM FACTORY FILL FLUID
TYPE JDM J21A STANDARD CHLOROPRENE

| | 212 °F | | | | | 250 °F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| hrs | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI |
| 72 | -45 | -24 | -11 | +51 | 480 | -42 | -18 | -11 | +51 | 480 |
| 168 | -44 | -22 | -13 | +50 | 480 | -59 | -34 | -11 | +51 | 720 |
| 336 | -43 | -17 | -11 | +50 | 480 | -49 | -20 | -18 | +53 | 640 |
| 504 | -47 | -18 | -15 | +49 | 480 | -53 | -30 | -12 | +51 | 720 |
| 672 | -51 | -15 | -18 | +50 | 320 | -48 | -23 | -11 | +52 | 480 |
| 840 | -47 | -23 | -14 | +48 | 480 | -50 | -42 | -10 | +50 | 640 |
| 1008 | -48 | -17 | -15 | +43 | 480 | -53 | -55 | -11 | +47 | 960 |

TABLE B5 - AGED TEST DATA FROM FACTORY FILL FLUID
TYPE CASE MS-1209 STANDARD NITRILE

| | 212 °F | | | | | 250 °F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| hrs | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI |
| 72 | | | | | | | | | | |
| 168 | -2 | -20 | -6 | +10.1 | 32 | -9 | -26 | -5 | +11.3 | 24 |
| 336 | -7 | -33 | -4 | +10.3 | 24 | -20 | -51 | -7 | +11.5 | 128 |
| 504 | -1 | -35 | -5 | +9.8 | 12 | -38 | -68 | -2 | +9.3 | 60 |
| 672 | -3 | -33 | -4 | +9.7 | 12 | -48 | -73 | -1 | +9.9 | 80 |
| 840 | -3 | -33 | -1 | +9.4 | 12 | -51 | -83 | +4 | +9.2 | 80 |
| 1008 | -1 | -30 | -2 | +9.8 | 12 | -68 | -88 | +6 | +7.5 | 200 |

TABLE B6 - AGED TEST DATA FROM FACTORY FILL FLUID
TYPE CASE MS-1209 STANDARD CHLOROPRENE

| | 212 °F | | | | | 250 °F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| hrs | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI |
| 72 | | | | | | | | | | |
| 168 | -49 | -29 | -13 | +19.2 | 288 | -44 | -22 | -16 | 36 | 512 |
| 336 | -46 | -32 | -12 | +31.2 | 576 | -43 | -33 | -16 | +36 | 768 |
| 504 | -46 | -33 | -14 | +30.4 | 576 | -49 | -37 | -14 | +33 | 576 |
| 672 | -38 | -21 | -13 | +30.8 | 480 | -55 | -49 | -13 | +31.4 | 768 |
| 840 | -44 | -23 | -14 | +31.5 | 384 | -59 | -49 | -13 | +31.4 | 768 |
| 1008 | -38 | -17 | -14 | +31.3 | 288 | -58 | -62 | -6 | +31.1 | 640 |

APPENDIX C

TABLE C1 - AGED TEST DATA FROM ASTM REFERENCE
OIL #1 STANDARD NITRILE

| | 212 °F | | | | | 250 °F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| hrs | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI |
| 72 | -3.5 | -20.3 | -3 | +0.6 | 8 | +3.3 | -17.4 | -3 | +1.2 | 8 |
| 168 | +1.0 | -25.5 | -2 | +1.1 | 12 | +1.3 | -26.5 | -3 | +1.4 | 12 |
| 336 | +4.4 | -30.2 | -2 | +1.1 | 12 | -14.4 | -47.3 | -2 | +1.3 | 16 |
| 504 | -0.7 | -37.2 | 0 | +1.0 | 12 | -30.5 | -58.0 | 0 | +0.9 | 48 |
| 672 | +0.9 | -31.5 | +3 | +0.6 | 12 | -43.6 | -69.5 | +1 | +1.1 | 80 |
| 840 | -1.3 | -42.4 | +3 | +0.6 | 16 | -66.4 | -82.5 | -3 | +1.0 | 100 |
| 1008 | +0.5 | -38.2 | +4 | +0.6 | 12 | -59.1 | -82.2 | +3 | +0.5 | 80 |

TABLE C2 - AGED TEST DATA FROM FACTORY ASTM REFERENCE
OIL #1 STANDARD CHLOROPRENE

| | 212 °F | | | | | 250 °F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| hrs | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI |
| 72 | -15.1 | -9.7 | -8 | +12.0 | 32 | -9.1 | -8.2 | -9 | +15.6 | 16 |
| 168 | -20.8 | -18.1 | -8 | +13.2 | 64 | -24.1 | -27.0 | -8 | +16.1 | 96 |
| 336 | -20.8 | -22.3 | -9 | +12.9 | 64 | -31.0 | -37.1 | -8 | +15.8 | 144 |
| 504 | -12.8 | -15.6 | -7 | +12.8 | 32 | -44.8 | -51.2 | -5 | +15.5 | 256 |
| 672 | -17.9 | -15.1 | -8 | +13.0 | 64 | -64.9 | -68.1 | -7 | +15.6 | 400 |
| 840 | -26.8 | -32.4 | -6 | +12.8 | 144 | -53.7 | -64.3 | -7 | +16.7 | 320 |
| 1008 | -25.1 | -26.1 | -6 | +12.4 | 144 | -61.2 | -77.4 | +2 | +16.8 | 200 |

TABLE C3 - AGED TEST DATA FROM ASTM REFERENCE
OIL IRM 903 STANDARD NITRILE

| | 212 °F | | | | | 250 °F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| hrs | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI |
| 72 | -14.5 | -27.2 | -13 | +21.7 | 108 | -18.9 | -39.8 | -15 | +24.1 | 216 |
| 168 | -13.4 | -32.0 | -13 | +21.5 | 108 | -24.5 | -34.8 | -17 | +25.7 | 288 |
| 336 | -17.6 | -39.5 | -13 | +20.7 | 216 | -63.8 | -55.7 | -23 | +28.2 | 120 |
| 504 | -12.9 | -37.2 | -13 | +21.7 | 108 | -84.7 | -78.9 | -18 | +29.1 | 150 |
| 672 | -24.2 | -43.2 | -12 | +22.3 | 288 | -89.0 | -86.1 | -18 | +29.8 | 150 |
| 840 | -31.2 | -51.3 | -11 | +23.1 | 432 | -89.8 | -88.2 | -18 | +29.5 | 150 |
| 1008 | -42.9 | -55.7 | -13 | +23.7 | 576 | -91.0 | -83.8 | -14 | +30.3 | 160 |

TABLE C4 - AGED TEST DATA FROM ASTM REFERENCE
OIL IRM 903 STANDARD CHLOROPRENE

| | 212 °F | | | | | 250 °F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| hrs | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI |
| 72 | -51.7 | -48.9 | -19 | 81.6 | 1280 | -48.4 | -51.2 | -20 | 86.4 | 1280 |
| 168 | -63.4 | -55.6 | -19 | 80.3 | 1600 | -55.7 | -44.9 | -22 | 88.2 | 1600 |
| 336 | -72.5 | -62.6 | -20 | 81.1 | 2000 | -57.8 | -44.0 | -23 | 113.5 | 1600 |
| 504 | -66.9 | -58.8 | -20 | 86.5 | 2000 | -71.0 | -48.7 | -39 | 138.0 | 2000 |
| 672 | -77.2 | -60.1 | -20 | 93.9 | 2000 | -77.9 | -50.8 | -39 | 148.0 | 2000 |
| 840 | -72.1 | -55.2 | -26 | 99.4 | 2500 | -90.1 | -67.5 | -30 | 140.7 | 2500 |
| 1008 | -78.4 | -54.6 | -26 | 99.8 | 2500 | -88.1 | -65.4 | -31 | 152.5 | 2500 |

APPENDIX D

D.1 Aged test data from OEM fill oils and Dayco, Gates and Parker's hose liners:

TABLE D1 - AGED TEST DATA FROM CASE FILL OIL
CASE MS-1209 AND DAYCO NITRILE

| | 212 °F | | | | | 250 °F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| hrs | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI |
| 72 | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. |
| 168 | N.A. | N.A. | N.A. | N.A. | N.A. | -2 | -45 | +2 | +3 | 16 |
| 336 | N.A. | N.A. | N.A. | N.A. | N.A. | +1.2 | -69 | +5 | +3 | 20 |
| 504 | N.A. | N.A. | N.A. | N.A. | N.A. | +11 | -80 | +7 | +2 | 40 |
| 672 | N.A. | N.A. | N.A. | N.A. | N.A. | -6 | -88 | +10 | +2 | 40 |
| 840 | N.A. | N.A. | N.A. | N.A. | N.A. | -8 | -81 | +10 | +2 | 40 |
| 1008 | N.A. | N.A. | N.A. | N.A. | N.A. | -1 | -95 | +13 | +2 | 60 |

TABLE D2 - AGED TEST DATA FROM CASE FILL OIL
CASE MS-1209 AND DAYCO CHLOROPRENE

| | 212 °F | | | | | 250 °F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| hrs | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI |
| 72 | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. | N.A. |
| 168 | N.A. | N.A. | N.A. | N.A. | N.A. | -20 | -27 | -13 | +14 | 144 |
| 336 | N.A. | N.A. | N.A. | N.A. | N.A. | -29 | -46 | -9 | +13 | 192 |
| 504 | N.A. | N.A. | N.A. | N.A. | N.A. | -44 | -73 | -3 | +11 | 160 |
| 672 | N.A. | N.A. | N.A. | N.A. | N.A. | -46 | -80 | +0 | +12 | 160 |
| 840 | N.A. | N.A. | N.A. | N.A. | N.A. | -55 | -91 | +2 | +11 | 160 |
| 1008 | N.A. | N.A. | N.A. | N.A. | N.A. | -53 | -95 | +3 | +11 | 160 |

TABLE D3 - AGED TEST DATA FROM CATERPILLAR FILL OIL
CAT 8T-9580 AND GATES NITRILE

| | 212 °F | | | | | 250 °F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| hrs | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI | ΔTB% | ΔEB% | ΔIRC% | % Vol. inc | ECI |
| 72 | -22 | -61 | +3 | +0 | 40 | -55 | -71 | +3 | +0 | 80 |
| 168 | -31 | -69 | +4 | +0 | 60 | -71 | -79 | +4 | +0 | 100 |
| 336 | -45 | -80 | +6 | +0 | 160 | -76 | -85 | +7 | +0 | 200 |
| 504 | -53 | -84 | +7 | +0 | 160 | -79 | -90 | +9 | -1 | 200 |
| 672 | -61 | -87 | +8 | +0 | 200 | -83 | -91 | +10 | -1 | 200 |
| 840 | -59 | -88 | +9 | +0 | 160 | -83 | -94 | +10 | -1 | 200 |
| 1008 | -64 | -90 | +11 | -1 | 300 | -82 | -96 | +11 | -1 | 300 |