| | | | |
|---|---|---|---|
| GM | WORLDWIDE ENGINEERING STANDARDS | Material Specification | GMW16954 |

# Low Viscosity Automatic Transmission Fluid (LV-ATF)

## 1 Scope

**1.1 Material Description.** This standard covers Automatic Transmission Fluid (ATF) primarily for use in General Motors automatic transmissions. This specification describes, in terms of laboratory and simulated service test results, the requirements for a minimum-performance fluid. The primary requirement is satisfactory performance in normally functioning transmissions under normal and severe conditions.

**1.2 Symbols.** Not applicable.

**1.3 Typical Applications.** This lubricant shall be used in GM Automatic Transmissions and other specified applications.

**1.4 Remarks.**

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

**1.4.2** This standard uses the International System of Units (SI) as standard per IEEE/ASTM SI 10, except for certain components, which are commercially available only in American conventional units.

**1.4.3** This standard uses the Rounding-Off Method according to ASTM E29 for significant figures to determine conformance to specification requirements.

**1.4.4** Unless otherwise noted, part numbers of this standard refer to those of General Motors Powertrain.

## 2 References

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

**2.1 External Standards/Specifications.**

| | | | |
|---|---|---|---|
| IEEE/ASTM SI 10 | ASTM E29 | ASTM D4629 | ASTM D6922 |
| ASTM D92 | ASTM E168 | ASTM D4683 | ASTM D7043 |
| ASTM D97 | ASTM D1418 | ASTM D4927 | CEC L-084-02 |
| ASTM D130 | ASTM D1500 | ASTM D4951 | CEC L-45-99 |
| ASTM D412 | ASTM D1748 | ASTM D5185 | CEC L-48 |
| ASTM D445 | ASTM D2240 | ASTM D5800 | ISO 37 |
| ASTM D664 | ASTM D2270 | ASTM D6082 | SAE J2643 |
| ASTM D665 | ASTM D2983 | ASTM D6304 | |
| ASTM D892 | ASTM D4052 | ASTM D6443 | |
| ASTM D893 | ASTM D4289 | ASTM D6594 | |

**2.2 GM Standards/Specifications.**

GMW3059

**2.3 Additional References.**

TMC003 Material Safety Data Sheet guidance documents (available at www.gmsupplypower.com).

**2.3.1 Society of Automotive Engineers (SAE) Papers.**

- Caracciolo, F. Development of a Sprag Wear Test Procedure for Evaluating the Antiwear Performance of ATFs, SAE Paper 902149.

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- Jones, C. and Linden, J. L. Development of a Vehicle Test for Determining ATF Performance in an Electronically Controlled Capacity Clutch. SAE Paper 982667.
- Morgan, C., Cummings, J.M., Fewkes, R., Jackson, J.M. A New Method of Measuring Aeration and Deaeration of Fluids, SAE Paper 2004-01-2914. (See Appendix K.)
- Morgan, C., Fewkes, R., McCombs, T., Tersigni, S.H., Jackson, J.M. Low-Speed Carbon Fiber Torque Capacity and Frictional Properties Test for ATFs, SAE Paper 2004-01-3026.

**2.3.2 Test Method Sources.**

- ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA, 19428-2959, USA. (available at: www.enterprise.astm.org.)
- EHDPROC_11 is available from Southwest Research Institute, 6220 Culebra Road, San Antonio, TX, USA.
- LR4 procedure is available from Southwest Research Institute, 6220 Culebra Road, San Antonio, TX, USA.
- MERCON SP procedure 3.14 Specification. Ford Motor Company, ATF Committee, 36200 Plymouth Road, Livonia, MI, 48150, USA.
- Test Methods CEC L-45-99 Co-ordinating European Council, Madou Plaza, 25th Floor, Place Madou 1, B-1030 Brussels, Belgium. (available at: www.cectests.org.)

**2.3.3 Forms.**

- A spreadsheet is available from the GM ATF Committee that contains all report formats. (See Appendix K.)
- All GM testing forms including Form A are available from the Team Leader for Service Parts Engineering and Licensing or the GM ATF and Gear Oil Committee Chairman, via GM Supply Power. Folders/ENGINEERING/Powertrain Product Engineering/Transmission. (gmsupplypower.covisint.com/c/document_library/get_file?p_l_id=4211828&folderId=4501165&name=DLFE-188908.docx).

**2.3.4 Other.**

- Chevrolet Service Manual ST368-92
- Part drawings, including material specifications, are available from Southwest Research Institute (San Antonio, Texas) (See Appendix K.)

## 3 Requirements

**3.1 Test Requirements.** Form A (refer to paragraph 2.3.3) is required for testing to be started on ATF pursuing ATF approval.

**3.2 Mechanical Requirements.** Test procedures shall be conducted as specified, with no deviation, unless express written authorization is obtained from the General Motors ATF and Gear Oil Committee. Test transmissions and parts shall be used as received. Replacement or modification of any part shall be made only if directed in this specification or to replace damaged parts. The laboratory must target to the mean of the specified test conditions.

**3.3 Physical Requirements.** Fluids qualified under this standard shall conform to the test methods and requirements as listed in Table 1.

**3.4 Approved Additive Chemistries.**

**3.4.1** Fluids meeting this specification shall be manufactured using additive chemistries listed in Table 2, Approved Low Viscosity ATF Additive Chemistry Combinations.

**3.5 Requirements for new LV ATF Additive Chemistry Combinations.**

**3.5.1** Successful completion of a complete LV ATF Qualification Program (see Table 1).

**3.5.2** Successful completion of a complete LV ATF Qualification Program (see Table 1) using the fluid blends in a thru d.

a. 75 % Candidate, 25 % Reference Fluid.

b. 50 % Candidate, 50 % Reference Fluid.

c. 25 % Candidate, 75 % Reference Fluid.

d. If applicable, 50 % Candidate, 50 % any previously approved chemistry other than the Reference Fluid.

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**3.5.3** Successful completion of tests listed in Table 3.

**3.5.4** Successful completion of a 241 400 km (150 000 miles) fleet test using the new candidate chemistry and blends of fluids from paragraph 3.5.2. A proposal for the fleet test shall be submitted to and approved by the GM ATF and Gear Oil Committee before commencing the fleet test.

**3.5.5** Any additional testing as directed by the GM ATF and Gear Oil Committee.

**3.6 Additional Requirements.**

**3.6.1** The test requirements given in this specification are minimum or maximum acceptance limits for valid tests. No adjustments for test precision shall be applied as test variability was taken into account in the determination of the requirements.

**3.6.2** The General Motors ATF and Gear Oil Committee reserves the right to require any additional tests that may be deemed necessary to ensure satisfactory performance of fluids submitted for qualification as ~~LV~~ ATF Automatic Transmission Fluids.

**Table 1: LV ATF Test Methods and Requirements**

| Test | Method | Requirement |
|---|---|---|
| A. Color | ASTM D1500 | 6.0 to 8.0 |
| B. Elemental Analysis | ASTM D5185 | Report, ppm (parts per million): Al, Ba, B, Ca, Cr, Cu, Fe, Pb, Mg, Mn, Mo, Ni, P, K, Si, Ag, Na, S, Sn, Ti, V, Zn |
| | ASTM D6443 | Report, ppm: Cl |
| | ASTM D4629 | Report, ppm: N |
| | ASTM D4927 | Report, ppm: S |
| C. Fluid Profile | Proprietary GM Test | Report, Committee Decision |
| D1. Miscibility & Homogeneity | ASTM D6922 | No separation or color change at end of test using Reference Fluid |
| D2. FE-STD-791 | 3430-Compatibility<br>3440-Storage Solubility | PASS<br>PASS |
| E. Density | ASTM D4052: +15 °C | Report |
| F. Kinematic Viscosity | ASTM D445 | 22 $mm^2/s$ (cSt) at +40 °C maximum |
| | | (4.4 to 4.6) $mm^2/s$ (cSt) at +100 °C |
| | | +150 °C (Report) |
| F2. Base Oil Viscosity (BOV) | | 3.2 $mm^2/s$ (cSt) at +100 °C minimum for base oil blend |
| G. Viscosity Index | ASTM D2270 | 145 minimum |
| H. Flash Point | ASTM D92 | +180 °C minimum |
| I. Fire Point | ASTM D92 | +200 °C minimum |
| Pour Point | ASTM D97 | -60 °C maximum |
| J. Brookfield Viscosity | ASTM D2983 | 1) Report, cP at -10 °C (1 cP = 1 mPa·s)<br>2) 10000 cP maximum at -40 °C (1 cP = 1 mPa·s) |
| K. Copper Strip Corrosion Test | ASTM D130<br>Modified: 3 h at +150 °C | 1b |

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| Test | Method | Requirement |
|---|---|---|
| L. Corrosion Test | ASTM D665:<br>Procedure A; 4 h | Pass |
| Water content | ASTM D6304 | (0 to 5) % weight maximum |
| M. Rust Protection Test | ASTM D1748<br>a) Sandblasted surface<br>b) +40 °C<br>c) 50 h<br>d) New coupon for each test | No rust or corrosion on any test surface |
| N. Wear Test | ASTM D7043 Modified:<br>a) (+80 ± 3) °C<br>b) 6.9 MPa<br>c) 11.356 l (3 gal)<br>d) Conestoga pump parts | 10 mg maximum weight loss |
| FZG-Scuffing | CEC L-084-02 | A 10/16.6R/90 C, Load Stage 4 |
| O. Cold Crank Simulation<br>CCS -30<br>CCS -35 | ASTM D5293 | 2000 cP maximum at -30 °C (1 cP = 1 mPa·s)<br>3000 cP maximum at -35 °C (1 cP = 1 mPa·s) |
| P. High Temperature, High Shear | ASTM D4683: +150 °C | 2.00 cP minimum (1 cP = 1 mPa·s) |
| Q. NOACK Evaporation | ASTM D5800 | Evaporation: 10 % maximum, 1 h at +200 °C |
| R. Elastohydrodynamic (EHD) Film Thickness | EHDPROC_11 at Imperial College;<br>+60 °C, +80 °C, +100 °C, +120 °C | Report, Committee Decision |
| S. Tapered Roller Bearing Shear-KRL | CEC L-45-99<br>3 480 000 revolutions (≈ 40 h) at +100 °C | KV100, 4.0 minimum at EOT, decrease 10 % maximum at EOT<br>EOT KV 100 ≥ 4.0<br>(BOV + EOTV)/2 > 3.5 $mm^2/s$ (cSt) at +100 °C |

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| Test | Method | Requirement |
|---|---|---|
| T. Foam Test | Appendix A<br>ASTM D892 Modified | New fluid:<br>a) Sequence I, ASTM D892; 50/0 maximum<br>b) Sequence II, ASTM D892; 50/0 maximum<br>c) Sequence III, ASTM D892; 50/0 maximum<br>d) Sequence IV, ASTM D6082; 50/0 maximum<br>After cycling test filtered fluid:<br>a) Sequence I, ASTM D892; 50/0 maximum<br>b) Sequence II, ASTM D892; 50/0 maximum<br>c) Sequence III, ASTM D892; 50/0 maximum<br>d) d) Sequence IV, ASTM D6082; 150/0 maximum<br>After thermal aging at +130 °C for 100 h<br>a) Sequence I, ASTM D892; 50/0 maximum<br>b) Sequence II, ASTM D892; 50/0 maximum<br>c) Sequence III, ASTM D892; 50/0 maximum<br>d) Sequence IV, ASTM D6082; 50/0 maximum<br>After Thermal Aging at +150 °C for 100 h<br>Report results for all four (4) sequences<br>After KRL<br>a) Sequence I, ASTM D892; 50/0 maximum<br>b) Sequence II, ASTM D892; 50/0 maximum<br>c) Sequence III, ASTM D892; 50/0 maximum<br>d) Sequence IV, ASTM D6082; 50/0 maximum |
| U. Elastomer Test | GM Aerated Seal Test (see Appendix B) | Better or equal to Reference |
| V. Plate Friction Test | Appendix C | 1) Satisfactory operation for 200 h<br>2) No unusual wear or flaking on test parts<br>3) Between 10 h and 200 h of operation:<br>a) Midpoint dynamic torque between 80 Nm and 105 Nm<br>b) Maximum Torque > 90 Nm<br>c) Delta Torque < 30 Nm<br>d) Stop Time between 0.85 s and 1.05 s<br>e) Report End Torque in Nm<br>f) Report Shift Energy in kJ |
| W. DKA Oxidation Stability Test | CEC L-48 modified<br>+180 °C for 192 h<br>Method B<br>Appendix E | 1) delta KV 100 (%), 10 % maximum<br>2) delta KV 40 (%), 8 % maximum<br>3) PAI (units), Report<br>4) delta TAN (mg KOH/g fluid), Report<br>5) Sludge rating of flask, 1.0 maximum<br>6) Blotter, report with photo |

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| Test | Method | Requirement |
|---|---|---|
| X. Cycling Test | Appendix F | 1) Satisfactory operation for 42 000 cycles<br>2) Condition of transmission parts must be equal to or better than that obtained with the Reference Fluid<br>3) TAN Increase < 2.0<br>4) Carbonyl Absorbance increase < 0.30<br>5) Used fluid viscosity at +100 °C > 3.5 $mm^2/s$ (cSt)<br>6) Used fluid viscosity at -20 °C < 2000 cP (1 cP = 1 mPa·s)<br>7) Used fluid viscosity at -40 °C < 10 000 cP (1 cP = 1 mPa·s)<br>8) 1 to 2 shift time between 0.30 s and 0.75 s<br>9) 2 to 3 shift time between 0.30 s and 0.75 s<br>10) 3 to 4 shift time, s (Report)<br>11) No expulsion of ATF from vent |
| Y. Vehicle Performance Test | Appendix G | Shift performance essentially equal to that obtained with the Reference Fluid |
| Z. ECCC Vehicle Performance Test | Appendix H | Equal to or better than Reference Fluid |
| AA. ARKL | PV 1454 | C, Report-Committee Decision |
| BB. Low-Speed Carbon Fiber Friction Test | Appendix J | New and used fluid from Cycling Test must be equal to or better than Reference Fluid |
| CC. Aeration Test RDL 3434 Reference shall be run before every candidate fluid | Appendix K | New and used fluid from Cycling Test must have the following limits:<br>< 2 % above RDL 3434 reference - Aeration % +60 °C<br>< 2 % above RDL 3434 reference – Aeration % +90 °C<br>< 2 % above RDL 3434 reference – Aeration % +120 °C<br>< 5 s above RDL 3434 reference – Dearation +60 °C<br>< 5 s above RDL 3434 reference – Dearation +90 °C<br>< 2 s above RDL 3434 reference – Dearation +120 °C<br>RDL 3434 Reference shall be run before every candidate fluid |

**Note Key: BOV** = Base Oil Viscosity, **EOT** = End of Test, **TAN** = Total Acid Number, **ECCC** = Electronically Controlled Capacity Clutch

**Table 2: LV ATF Approved Chemistry Combinations**

| | Company | Chemistry Name | Treat Rate (% by mass) |
|---|---|---|---|
| 1 | Afton Chemical Corporation | HiTEC 3492 | 12 % |
| 2 | | | |
| 3 | | | |
| 4 | | | |

**Note:** For the most up to date list of approved chemistries, contact the ATF Committee Chairman.

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**Table 3: LV ATF Additional Test Methods and Requirements for New Chemistries**

| Test | Method | Requirement |
|---|---|---|
| 3A. Hunting Behavior | LR4 4.8L 4L60-E | No Hunting |
| 3B. FZG Pitting | FVA NO. 2/IV: PT-C/9/90 | Report, Committee Decision |
| 3C. Carbon Fiber Durability | MERCON SP Procedure 3.14 Modified:<br>1) Low Speed Carbon Fiber plates | Equal to or better than Reference Fluid |
| 3D. Fleet Test | See paragraph 3.5.4 | See paragraph 3.5.4 |

**Note:** Reference = Something of known performance characteristics, designated by the GM ATF and Gear Oil Committee.

## 4 Manufacturing Process

Not applicable.

## 5 Rules and Regulations

**5.1 Legal Regulations.** All materials must satisfy applicable laws, rules, regulations and recommendations valid in the country of usage.

**5.2 Language.** In the event of conflict between the English and domestic language, the English language shall take precedence.

**5.3 Inspection and Rejection.** Samples of components or materials released to a GM material specification shall be tested for conformity with the requirements of this material specification and approved by the responsible Engineering department prior to commencement of delivery of bulk supplies.

A new approval must be received for any changes, e.g., properties, manufacturing process, location of manufacture, etc. If not otherwise agreed, all testing and documentation normally required for initial release must be completed.

It is the responsibility of the supplier to inform the customer in a timely manner, without solicitation, and to include documentation of all modifications of materials and/or processes and to apply for a new release.

If not otherwise agreed, all release tests shall be repeated and documented by the supplier prior to commencement of delivery of non-conforming bulk supplies. In individual cases, a shorter test can be agreed to between the responsible Engineering department and the supplier.

**5.4 Material Safety Data Sheets/Safety Data Sheets (MSDS/SDS).** For new product submissions, or when a change in chemical composition of an existing product has occurred, a complete copy of the Material Safety Data Sheet/Safety Data Sheet must be submitted in compliance with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) requirements or other country-specific MSDS/SDS requirements. In addition, product MSDS/SDS submissions must be in compliance with specific country General Motors TMC003 Material Safety Data Sheet/Safety Data Sheet guidance documents where available.

**5.5** All materials supplied to this standard must comply with the requirements of GMW3059**, Restricted and Reportable Substances for Parts.**

## 6 Approved Sources

Materials supplied to this specification must be approved by General Motors.

A list of approved materials can be found in MATSPC. This GM Material File is provided to third parties to reduce redundant testing of materials. If approved material already listed is used, the part supplier can use GM Material File reference for Production Part Approval Process (PPAP) material approval. If the decision is made to use a not yet approved material, contact the responsible Engineering group for details on the approval process. The material approval process shall be completed prior to PPAP start date of the part supplied to General Motors.

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# 7 Notes

## 7.1 Glossary.

**MATSPC:** Global repository of GM approved materials for corresponding GM Engineering Standards.

$n_1$ = number of candidate fluid data points (typically, 24 for shudder and 12 for hunting)

$n_2$ = number of reference fluid data points (typically, 24 multiplied by number of reference fluids for shudder and 12 multiplied by number of reference fluids for hunting)

$\bar{x}_1$ = average response of the candidate fluid

$$\bar{x}_1 = \left(\sum_{i=1}^{n_1} x_{1i}\right) \Big/ n_1$$

$\bar{x}_2$ = average response of the reference fluid

$$\bar{x}_2 = \left(\sum_{i=1}^{n_2} x_{2i}\right) \Big/ n_2$$

$s_1$ = standard deviation of the candidate fluid

$$s_1 = \sqrt{\frac{1}{n_1 - 1}\sum_{i=1}^{n_1}(x_{1i} - \bar{x}_1)}$$

$s_2$ = standard deviation of the reference fluid

$$s_2 = \sqrt{\frac{1}{n_2 - 1}\sum_{i=1}^{n_2}(x_{2i} - \bar{x}_2)}$$

$s_1^2$ = variance of the candidate

$s_2^2$ = variance of the reference fluid

$s_p$ = pooled standard deviation (for pooling 2 groups)

$$s_p = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{(n_1 - 1) + (n_2 - 1)}}$$

$\alpha$ = level of significance for hypothesis tests (0.01 for this procedure)

$R_{sv}$ = ratio of the shudder variances

$R_{sa}$ = ratio of the shudder averages

**DoF** = degrees of freedom

**Reference:** Something of known performance characteristics, designated by the GM ATF and Gear Oil Committee.

**VTi:** An electronically controlled Continuously Variable Transaxle (CVT)

**VWR**: VWR is the name of a laboratory supply company

## 7.2 Acronyms, Abbreviations, and Symbols.

| | |
|---|---|
| **ARKL** | Achsial-Rillen-Kugal-Lager |
| **AAM** | American Axle and Manufacturing |
| **ATC** | Air-To-Close |
| **ATF** | Automatic Transmission Fluids |
| **BOV** | Base Oil Viscosity |
| **CCA** | Customer Care and Aftersales |

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| | |
|---|---|
| **CEC** | Coordinating European Council |
| **CVT** | Continuously Variable Transmission |
| **DC** | Direct Current |
| **ECCC** | Electronically Controlled Capacity Clutch |
| **ECM** | Electronic Control Module |
| **EOT** | End of Test |
| **FFT** | Fast Fourier Transform |
| **FVC** | Frequency to Voltage Converter |
| **FZG** | Forschungstelle für Zahnräder und Getriebebau |
| **GHS** | Globally Harmonized System of Classification and Labeling of Chemicals |
| **GMPT** | GM Powertrain |
| **GSSLT** | Global Subsystem Leadership Team |
| **HP** | Horse Power |
| **ID** | Inside Diameter |
| **LDTHL** | Long Duration Test High Load |
| **MATSPC** | GM Materials File |
| **MSDS** | Material Safety Data Sheet |
| **MY** | Model Year |
| **NEC** | North-East Corner |
| **NPT** | National Pipe Tapered Thread |
| **OD** | Outside Diameter |
| **PCM** | Powertrain Control Module |
| **ppm** | Parts per Million |
| **PPAP** | Production Part Approval Process |
| **PTFE** | polytetrafluoroethylene |
| **SAE** | Society of Automotive Engineers |
| **SDS** | Safety Data Sheet |
| **SCOWT** | Sprag Clutch Overrunning Wear Test |
| **SI** | International System of Units |
| **SOT** | Start of Test |
| **Std. Dev.** | Standard Deviation |
| **TAN** | Total Acid Number |
| **TCC** | Torque Converter Clutch |
| **TCM** | Transmission Control Module |
| **TEI** | Test Engineering, Incorporated |
| **TPS** | Throttle Position Sensor |
| **VTi** | The VTi is an electronically controlled Continuously Variable Transaxle |
| **VWR** | VWR is the name of a laboratory supply company |
| **WOT** | Wide Open Throttle |

## 8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Material per GMW16954

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## 9 Release and Revisions

This standard was originated in April 2013. It was first approved by Fuels, Fluids and Lubricants GSSLT in August 2013. It was first published in August 2013.

| Issue | Publication Date | Description (Organization) |
|---|---|---|
| 1 | AUG 2013 | Initial publication. |

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# Appendix A

## A1 Foam Test

**A1.1 Objective.**

**A1.1.1** To determine the foaming characteristics of new and used automatic transmission fluid.

**A1.2 Test Equipment.**

**A1.2.1 Standardized Foam Test Equipment.**

**A.1.2.1.1 ASTM D892 Equipment.**

**A1.2.1.2 Automated Oven.** Lawler, Model Number 323-4.

**A1.2.1.3 Mott Diffuser.**

**A1.2.2 Used Cycling Test Fluid Filtration.**

**A1.2.2.1 Filtering Flask. Erlenmeyer style, Borosilicate glass, 4 l capacity.**

**A1.2.2.2 Buchner Funnel.** Coors Ceramics U.S.A. Model Number 60248, 253 mm diameter, or equivalent.

**A1.2.2.3 Filter Paper.** VWR (VWR is the name of a laboratory supply Company) VWR Grade 417, 25.0 cm diameter, Part Number 28313 160.

**A1.2.2.4 Rubber Stopper Adaptor.** Rubber stopper with hole to adapt Buchner funnel to filter flask.

**A1.3 Procedure.**

**A1.3.1** ASTM D892 shall be followed exactly as written, with the following points included.

**A1.3.1.1** As indicated in Note 4 ASTM D892, only liquid baths (i.e., silicone oil) shall be used for Sequences I, II, and III.

**A1.3.2** Run ASTM D6082.

**A1.3.3** Repeat paragraphs A1.3.1 thru A1.3.2 for ATF taken from the end of the Cycling Test. This step should be performed within 24 h of completion of the GM Aeration Test. The fluid is to be filtered through the filtration system described in paragraph A1.2.2 before testing commences.

**A1.4 Test Results.**

**A1.4.1** Report the foaming tendency (in ml) at the end of the 5 minute blowing period.

**A1.4.2** Report the foam stability (in ml) at the end of the 10 minute settling period.

**A1.5 Test Criteria**

**A1.5.1 New Fluid.**

**A1.5.1.1** Candidate fluid results for new fluid shall meet the test limits in Table A1.

**A1.5.2 Used Fluid.**

**A1.5.2.1** Candidate fluid results for the fluid after the GM Cycling Test and filtration shall meet the limits in Table A2.

**Table A1: New Fluid Limits**

| Test | Tendency in ml | Stability in ml |
|---|---|---|
| ASTM D892, Sequence I | 50 | 0 |
| ASTM D892, Sequence II | 50 | 0 |
| ASTM D892, Sequence III | 50 | 0 |
| ASTM D6082, Sequence IV | 50 | 0 |

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**Table A2: Used Fluid Limits**

| Test | Tendency in ml | Stability in ml |
|---|---|---|
| ASTM D892, Sequence I | 50 | 0 |
| ASTM D892, Sequence II | 50 | 0 |
| ASTM D892, Sequence III | 50 | 0 |
| ASTM D6082, Sequence IV | 150 | 0 |

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## Appendix B

## B1 Aerated Seal Test

**B1.1 Objective.**

**B1.1.1** To determine the compatibility of ATF with elastomeric seal materials.

**B1.2 Test Equipment.**

**B1.2.1 ASTM D2240 Equipment.**

**B1.2.1.1 Shore Durometer A.** As described in ASTM D2240, available from The Shore Instrument and Manufacturing Company, Model CV.

**B1.2.1.2 Conveloader.** Preloaded to 822 g, mounted on a Durometer stand, available from The Shore Instrument and Manufacturing Company, Model CV.

**B1.2.2 ASTM D412 Equipment.**

**B1.2.3 Heating Device.** Aluminum heating block or oil bath. Each heating device must be approved by the General Motors ATF Committee.

**B1.2.4 Heat-Resistant Test Tubes.** Per Figure B1, with air inlet, condenser connection, condenser and elastomer hanger insert. Dimensions to match those specified in ASTM D6594, section 6.1 and 6.2.1.

**B1.2.5 Analytical Balance.** Sartorius, Model Number 2402, or equivalent.

**B1.2.6 Suspension Wire.** Stainless steel, ≈ 0.25 mm diameter.

**B1.2.7 Reagent Water.** Conforming to ASTM D1193, Type IV.

**B1.2.8 Reference Fluids.** LV ATF.

**B1.2.9 Elastomeric Compounds.** ASTM standard slabs of SREs can be ordered from Akron Rubber Development Laboratory Inc. (ARDL), the only SAE approved organization for SAE SREs.

**Table B1: Standard Reference Elastomers (SREs)**

| Compound Description | | | | | |
|---|---|---|---|---|---|
| GM No. | SAE J2643 | | ASTM D-1418 | | Compounds |
| ES-1 | FKM-2 | FKM | Type 1 | Bisphenol AF 66% | **DuPont**, A401C, Tg -16°C |
| ES-2 | FKM-3 | | Type 2 | PO 68% | **DuPont**, GBL 600S, Tg -17°C |
| | | | Type 3 | | |
| ES-4 | FKM-5 | | | Low temp, Tg at -30°C | **Solvay**, PL855 64% F |
| ES-7 | AEM-2 | AEM | G | **DuPont**, with 10 phr TP759, EM08A49-2 | |
| ES-8 | AEM-3 | | GLS | **DuPont**, with 10 phr TP759, EM08A49-4 | |
| ES-10 | ACM-1 | ACM | Traditional | ACM-1, SAE J2643, **Zeon** | |
| ES-11 | ACM-2 | | AR 12 | ACM-2, New cure technology, **Zeon** | |
| ES-14 | HNBR | HNBR | | HNBR-1, SAE J2643, **Zeon** | |

**B1.2.10 Wetting-Agent Solution.** An ≈ 0.5 % by mass dioctyl sodium sulfosuccinate, made by dilution of concentrated solution with reagent water. (Concentrated solutions, such as Aerosol OT, are available from laboratory supply companies.) Preparation of the wetting solution from the solid reagent is not recommended.

**B1.2.11** Prepare test specimens using ASTM D471, longitudinally with the grain, and punch a nominal 3 mm hole in specimen for hanging on stainless steel support bracket in test tube. All specimens are cut with Die Number 2 (ISO 37). A total of eight specimens are prepared for aging in each fluid. An additional eight specimens are prepared for initial tensile strength and elongation measurements to be done side by side with post-test measurement.

**B1.2.12** Maintain heating device so that fluid temperature in test tubes is controlled at (+150 ± 1) °C.

**B1.2.13** Air flow with dry house air, ultra high purity (UHP) air or the equivalent, into test tube at 5 l/h.

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**B1.3 Qualification of Elastomeric Compounds.**

**B1.3.1** Each batch of elastomeric compound shall meet the percent volume change and Durometer A hardness change limits with LV ATF oils as shown in Table B2. Each batch of seal materials will be tested at both independent laboratories using a minimum of five coupons from five different slabs of material in the two oils mentioned above, as well as the Reference Fluid.

**B1.3.2** No elastomeric compound shall be used after one year from the date of manufacture.

**B1.3.3** Elastomeric compounds shall be stored in a sealed, non-reactive container, < +25 °C.

**B1.3.4** ADRL (Akron Rubber Development Lab) is the only approved source for mixing SRE and ES compounds.

**B1.3.5** Test specimens shall be cut in the grain direction.

**B1.4 Test Procedure.**

**B1.4.1** Determine the original volume measurement, tensile strength, elongation, and Durometer readings of each specimen per ASTM D4289. Durometer reading shall be taken instantaneously, (1.0 ± 0.1) s. Dip each specimen in the wetting-agent solution before weighing specimen in water. Dislodge bubbles.

**B1.4.2** Hang the 8 specimens in the tubes as shown in Figure B1 making sure the specimens do not touch each other or the tube walls. They should be completely suspended and surrounded by the fluid. Add 300 ml of test fluid to each tube. Assemble the tube as shown with air tube extending through the bottom of the support hanger.

**B1.4.3** Age the seals for 504 h at (+150 ± 1) °C fluid temperature.

**B1.4.4** Remove the specimens from the test tubes and immediately place them on a clean absorbent pad or laboratory grade paper towels and cover with the same material. Cool to room temperature 30 minutes minimum before working with the elastomers. Final measurements must be taken within 120 minutes of the end of paragraph B1.4.3.

**B1.4.5** Wipe specimens dry with a clean, lint-free, laboratory grade paper towel or equivalent.

**B1.4.6** Determine the final volume, tensile strength, elongation, and Durometer readings of each specimen as described in paragraph B1.4.1.

**B1.5 Test Results.**

**B1.5.1** Report the percent volume change, percent tensile change, percent elongation, and points Durometer A hardness change for each test specimen.

**B1.5.2** Report the average values and standard deviation for the test specimens in the candidate fluid and reference fluid.

**B1.6 Test Criteria.**

**B1.6.1** Reference oils percent volume change, tensile change, elongation change, and points Durometer A hardness change must meet the limits shown in Table B2, for each batch of seal material.

**B1.6.2** Candidate fluid percent volume change, tensile change, elongation change, and points Durometer A hardness change must meet the limits shown in Table B3 for the candidate fluid to pass.

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**Figure B1: Specimen Setup**

**Full View**

**Close-Up**

**Note:** A spreadsheet is available from the GM ATF Committee that contains all report formats.

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**Table B2: Elastomer Batch Certification Values**

| GM No / SAE J2643 | Reference Fluid | Volume Change Limits in % | Durometer A Change limits | Tensile MPa | Elongation in % |
|---|---|---|---|---|---|
| ES-1 / FKM-2 | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |
| ES-2 / FKM-3 | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |
| ES-4 / FKM-5 | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |
| ES-7 / AEM-2 | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |
| ES-8 / AEM-3 | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |
| ES-10 / ACM-1 | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |
| ES-11 / ACM-2 | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |
| ES-14 / HNBR | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |

**Table B3: Elastomers Test Specification Limits**

| GM No / SAE J2643 | Reference Fluid | Volume Change Limits in % | Durometer A Change limits | Tensile MPa | Elongation in % |
|---|---|---|---|---|---|
| ES-1/ FKM-2 | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |
| ES-2 / FKM-3 | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |
| ES-4 / FKM-5 | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |
| ES-7 / AEM-2 | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |
| ES-8 / AEM-3 | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |
| ES-10 / ACM-1 | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |
| ES-11 / ACM-2 | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |
| ES-14 / HNBR | LV ATF | Better or equal to Ref. | Better or equal to Ref | Report | Report |

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## Appendix C

## C1 Plate Friction Test

**C1.1 Objective.**

**C1.1.1** To determine the friction characteristics and durability of an automatic transmission fluid in a plate friction test.

**C1.2 Test Equipment.**

**C1.2.1 SAE Number 2 Friction Test Machine.**

**C1.2.1.1 Clutch Plate Head Assembly.** Greening Associates, Inc., or equivalent.

**C1.2.1.2 Drive Motor.** Delco 22 kW, 3600 $min^{-1}$ (3600 rpm), 3-Phase, 326-UZ Frame, or equivalent.

**C1.2.1.3 Flywheel Assembly.** Flywheel, to provide (15.7 ± 0.3) kJ total energy, attached to motor shaft with taper-lock adaptor.

**C1.2.1.4 Lubricant Reservoir.** A 1 l, stainless steel lubricant reservoir with cover, vented to the atmosphere, mounted above the housing and connected to the housing at the 12 o'clock position (as viewed from cover end of machine) with a 9.5 mm Outside Diameter (OD) x 8.0 mm Inside Diameter (ID) x 100 mm long Teflon tube (with stainless steel fittings).

**C1.2.2 Test Hardware.**

**C1.2.2.1 Friction Clutch Plate.** Standard SAE Number 2 size plates and BorgWarner 4329 material. All parts must be ordered from GM Racing under the part number GMPT-0506.

**C1.2.3 Instrumentation and Recording Equipment.**

**C1.2.3.1 Torque Transducer.** Lebow Load Cell, Model Number 3397, or equivalent.

**C1.2.3.2 Pressure Transducer.** Sensotech, Model Number TJU708-12, or equivalent.

**C1.2.3.3 Speed Transducer.** Electro Corporation, Model Number 3010AN, or equivalent.

**C1.2.3.4 Data Acquisition System with the Capability of Recording Speed, Torque, and Pressure.** Data shall be recorded at 1000 Hz without filtering.

**C1.2.3.5 Temperature Measurement.** Thermosensor, Iron-Constantan thermocouple, Type 22J34-E-4-TGFS36, or equivalent. Leeds and Northrup Speedmax 165, Model Number 168-10-001-0010-6-C0000-000, chart J68-F, or equivalent. If using a digital recording device, data will be collected at 1 Hz.

**C1.2.4 Control Equipment.** For installation information contact Southwest Research Institute or PerkinElmer Automotive Research.

**C2.4.1 Temperature Control.** Precision Products and Control Research Control Valve (pneumatic-activated water-temperature control), Type 755, Diaphragm 3-15, Trim J, Action Air-To-Close (ATC), or equivalent.

**C1.2.4.2 Timer.** Texas Instruments, Model Number 510, or equivalent.

**C1.2.4.3 Cycle Counter.** General Controls, Model Number CE600 BS 602, or equivalent.

**C1.2.4.4 Controller.** Allen-Bradley, Model Number 712 DAB 26-43, K-Series, or equivalent.

**C1.2.4.5** Four-Way Solenoid Valve. Automatic Switch Company, Number 83441, 115 V, 60 Hz, 10.5 W or equivalent.

**C1.2.4.6 Regulator Controls.** C. A. Norgen Company, Number 11-042-003, or equivalent, for engaging clutch plates. C. A. Norgen Company, Number 11-009-041, or equivalent, for disengaging clutch plates.

**C1.2.4.7** Quick Release Valve. Bendix-Westinghouse, Number 224417, or equivalent.

**C1.2.4.8** Pressure Gauges. Ashcroft gauges, (0 to 400) kPa for apply pressure, (0 to 100) kPa for release pressure, or equivalent.

**C1.2.4.9** Calibrated Rotameter. Aalborg Instrument Company, Model Number FM032-15, or equivalent. To be calibrated before each test.

**C1.2.4.10** Micrometering Valve. Nupro Company, or equivalent.

**C1.2.4.11** Air Source. Supply of hydrocarbon-free, dry (minimum -59 °C dew point) compressed air with regulator controls.

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**C1.2.5 Connections.**

**C1.2.5.1 Imperial-Eastman Poly-Flo Tubing.** A 44-P-1/4, 6.4 OD x 4.8 mm ID, or equivalent, to connect air cylinder to metering valve near flow meter.

**C1.2.5.2 Tygon Tubing.** A 6.4 ID x 125 mm length, to connect micrometering valve to the flow meter.

**C1.2.5.3 Tygon Tubing.** A 6.4 ID x 250 mm length to connect flow meter to Swagelok fitting at the housing.

**C1.2.5.4 Stainless Steel Orifice.** A 0.90 mm ID, as shown in Figure C1. To be fitted to test head in the 7 o'clock position. Connected to flow meter output with 6.4 mm ID Tygon Tubing. Tubing should be long enough to create a low point so that any test fluid that leaks into the tubing does not go back into the flow meter.

**C1.3 Test Procedure.**

**C1.3.1 Cleaning Procedure.**

**C1.3.1.1** Remove the front cover, spacer, retainer ring, and hub to clean.

**C1.3.1.2** Clean fixture with Stoddard solvent prior to each test. Flush the inside of the test housing, attached ports and thermocouple connections with solvent. Thoroughly clean all crevices and ports in the housing where fluid is likely to be trapped.

**C1.3.1.3** Air blow dry the cleaned parts and test housing.

**C1.3.1.4** Install new Tygon tubing to the flow meter before each test.

**C1.3.2 Assembly Procedure.**

**C1.3.2.1** Inspect rotating shaft seal and lip seal for deterioration and replace if necessary.

**C1.3.2.2** Install clutch plate hub, snap ring, and clutch plate retainer.

**C1.3.2.3** Mark clutch plates so that their order of installation is known. Mark plates in an area unaffected by the friction contact, e.g., on the steel plate tangs and composition plate splines.

**C1.3.2.4** Presoak clutch plates in test fluid for 5 minutes and then install clutch plates in the clutch plate retainer (Figure C2).

**C1.3.2.5** Install Spacer.

**C1.3.2.6** Check clutch plate pack free movement. Clearance is (1.02 ± 0.13) mm. This measurement, conveniently made with a depth micrometer, is with the clutch pack and spacer installed and compressed at the sites of measurements.

**C1.3.2.7** Install thermocouple at 4 o'clock position, relative to cover, to within 1 mm of steel clutch plate annulus OD.

**C1.3.2.8** Install new O-rings on cover.

**C1.3.2.9** Attach cover and fasten with Ring-Bearing Support and Cover Retainer.

**C1.3.2.10** Connect compressed air cylinder to micrometering valve with Poly-Flo tubing. Connect micrometering valve to flow meter with Tygon tubing with paragraph C2.5.2 and from the flow meter to the Swagelok fitting on the housing at the 7 o'clock port with paragraph C2.5.4. At the housing, insert 25 mm length of stainless steel capillary tubing (0.90 mm ID) into the Swagelok fitting.

**C1.3.2.11** Fill test head with 650 ml of test fluid. Release trapped air from head.

**C1.3.3 Test Startup.**

**C1.3.3.1** Check and calibrate torque, pressure, motor-speed, and thermocouple signals.

**C1.3.3.2** Set apply air pressure at 345 kPa.

**C1.3.3.3** Set release air pressure at 70 kPa.

**C1.3.3.4** Open cooling water valve.

**C1.3.3.5** Set timer to provide test-cycle sequence shown in Table C1.

**C1.3.3.6** Start temperature recorder (chart speed at 50 mm per hour or collect data at 1 Hz).

**C1.3.3.7** Meter cylinder air into the housing at a rate of 50 ml/minute. Adjust air flow while motor is not running.

**C1.3.3.8** Set apply air pressure at 345 kPa. Set apply rate to go from 30 kPa to 345 kPa in (0.15 ± 0.02) s. Pressure should increase linearly from 50 kPa to 250 kPa in (70 ± 5) ms.

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**C1.3.3.9** Start test cycle.

**C1.3.3.10** Check for air, fluid and water leaks, operation of transducers and cycling event times.

**C1.3.4 Test Operation.**

**C1.3.4.1** Continue to repeat test-cycle sequence until failure or for 200 h, without any scheduled shutdowns.

**C1.3.4.2** Maintain average test fluid temperature during operation at (+140 ± 3) °C. Within each cycle, the temperature may vary by ± 6 °C.

**C1.3.5 Test Startup After Unscheduled Shutdown.**

**C1.3.5.1** Ascertain and correct cause of shutdown. Record test duration at shutdown, duration of shutdown, and whether or not aeration was continued during shutdown.

**C1.3.5.2** Repeat Test Startup according to paragraph C1.3.3.

**C1.3.5.3** Resume recording test time when fluid reaches test temperature.

**C1.3.6 Required Recordings.**

**C1.3.6.1** Record fluid temperature continuously.

**C1.3.6.2** Record torque, apply pressure, and motor speed during test-cycle sequence Event 2 of Table C1 at 10 cycles to confirm proper test operation.

**C1.3.6.3** Record torque, apply pressure, and motor speed during test-cycle sequence Event 2 of Table C1 at test hours 1, 2, 3, 4, 5, and every 5 h thereafter until the end of the test at 200 test hours.

**C1.4 Test Results**

**C1.4.1** Report required recordings according to paragraph C1.3.6.

**C1.4.2** Lockup is the time when the speed reaches zero.

**C1.4.2.1** If a Direct Current (DC) tachometer is used for speed, then there should be no delay between the zero speed and zero voltage from the DC tachometer.

**C1.4.2.2** When a magnetic pickup and Frequency to Voltage Converter (FVC) are used for speed, there will be delays and non-linear response near zero. The following steps will reduce these errors. As an example for a 200 pulse per revolution speed signal, use the average (± 5 scans) speeds at 300 $min^{-1}$ (300 rpm) and 300 $min^{-1}$ (300 rpm) plus 10 scans to find a delta speed for projecting the speed through zero. Lockup scan will be the closest point to zero speed adjusted for the delay factor caused by the FVC. This delay is typically 8 scans, but shall be determined for each specific FVC unit.

**C1.4.2.3** Project the Frequency to Voltage Converter (FVC) speed from 1000 $min^{-1}$ (1000 rpm) to zero at the adjusted lockup scan found in paragraph C1.4.2.2. All speed data from lockup scan to end of data should be set to a value of zero.

**C1.4.3** End Torque is determined by the North-East Corner (NEC) method. Starting at the lockup scan, point search forward and find the first negative torque value. Calling this point N, back up 41 scans and calculate the product of $TORQUE_{(N\ minus\ 41)} \times 1$, $TORQUE_{(N\ minus\ 40)} \times 2$, etc., up to $TORQUE_{(N\ minus\ 1)} \times 40$. The NEC point will be the scan, which has the largest product from the above calculations.

**C1.4.4** Stop Time is the elapsed time in ms (milliseconds) between the start of engagement (when applied pressure reaches 30 kPa) and the lockup scan.

**C1.4.5** Midpoint Torque is a 48-point average centered about a point in time halfway between the start of engagement and the lockup scan.

**C1.4.6** Maximum Torque is the largest torque value found between 500 $min^{-1}$ (500 rpm) and the lockup scan.

**C1.4.7** Delta Torque equals Maximum Torque minus Midpoint Torque.

**C1.4.8** Energy is integrated power in W/s (Watt per second) from the start of engagement to the lockup scan.

**C1.4.9** Apply pressure is recorded at the Midpoint scan.

**C1.4.10** Report test results in Table C2. Sample analysis of test results is shown in Figure C2. Report all required torque values as three-point running averages.

**C1.5 Test Criteria.**

**C1.5.1** Between 10 h and 200 h of operation:

**C1.5.1.1** Midpoint Torque shall be (80 to 105) Nm.

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**C1.5.1.2** Report End Torque.

**C1.5.1.3** Delta Torque shall be < 30 Nm.

**C1.5.1.4** Stop Time shall be (0.85 to 1.05) s.

**C1.5.1.5** Maximum Torque shall be > 90 Nm.

**C1.5.2** Steel clutch plate and composition plate condition shall be equal to or better than that obtained with the Reference Fluid.

**C1.5.3** Submit the following parts: Direct clutch fiber plates, Direct clutch steel plates.

**Table C1: Test-Cycle Sequence**

| Event | Duration in s | Cumulative Time in s | Operation |
|---|---|---|---|
| 1 | 10 | 0 to 10 | Motor On, Clutch Plates Disengaged |
| 2 | 5 | 10 to 15 | Motor Off, Clutch Plates Engaged |
| 3 | 5 | 15 to 20 | Motor Off, Clutch Plates Disengaged |

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## Table C2: Sample Record of Test Results

### DEXRON®-VI Plate Friction - 200 HOURS

| | | | | | |
|---|---|---|---|---|---|
| **Program Code:** | | **Start Date:** | | **Fiber Plates:** | |
| **Status:** | | **EOT Date:** | | **Steel Plates:** | |
| **Test Cycles:** | | **Run Number:** | | **Delta Travel [mm]:** | |
| **Test Performance:** | | **EOT Parts Condition:** | | | |

| Test Time [h] | Cycles | Stop Time [s] 0.85 | 1.05 | Midpoint Torque [N·m] 80 | 105 | End Torque [N·m] Report | Maximum Torque [N·m] > 90 | | Max - Mid Torque [N·m] < 30 | | Shift Energy [kJ] 15.4 - 16.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.1 | 10 | | | | | | | | | | |
| 1 | 180 | | | | | | | | | | |
| 2 | 360 | | | | | | | | | | |
| 3 | 540 | | Three | | Three | | | Three | | Three | |
| 4 | 720 | | Point | | Point | | | Point | | Point | |
| 5 | 900 | | Average | | Average | | | Average | | Average | |
| 10 | 1,800 | | | | | | | | | | |
| 15 | 2,700 | | | | | | | | | | |
| 20 | 3,600 | | | | | | | | | | |
| 25 | 4,500 | | | | | | | | | | |
| 30 | 5,400 | | | | | | | | | | |
| 35 | 6,300 | | | | | | | | | | |
| 40 | 7,200 | | | | | | | | | | |
| 45 | 8,100 | | | | | | | | | | |
| 50 | 9,000 | | | | | | | | | | |
| 55 | 9,900 | | | | | | | | | | |
| 60 | 10,800 | | | | | | | | | | |
| 65 | 11,700 | | | | | | | | | | |
| 70 | 12,600 | | | | | | | | | | |
| 75 | 13,500 | | | | | | | | | | |
| 80 | 14,400 | | | | | | | | | | |
| 85 | 15,300 | | | | | | | | | | |
| 90 | 16,200 | | | | | | | | | | |
| 95 | 17,100 | | | | | | | | | | |
| 100 | 18,000 | | | | | | | | | | |
| 105 | 18,900 | | | | | | | | | | |
| 110 | 19,800 | | | | | | | | | | |
| 115 | 20,700 | | | | | | | | | | |
| 120 | 21,600 | | | | | | | | | | |
| 125 | 22,500 | | | | | | | | | | |
| 130 | 23,400 | | | | | | | | | | |
| 135 | 24,300 | | | | | | | | | | |
| 140 | 25,200 | | | | | | | | | | |
| 145 | 26,100 | | | | | | | | | | |
| 150 | 27,000 | | | | | | | | | | |
| 155 | 27,900 | | | | | | | | | | |
| 160 | 28,800 | | | | | | | | | | |
| 165 | 29,700 | | | | | | | | | | |
| 170 | 30,600 | | | | | | | | | | |
| 175 | 31,500 | | | | | | | | | | |
| 180 | 32,400 | | | | | | | | | | |
| 185 | 33,300 | | | | | | | | | | |
| 190 | 34,200 | | | | | | | | | | |
| 195 | 35,100 | | | | | | | | | | |
| 200 | 36,000 | | | | | | | | | | |

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