



# SURFACE VEHICLE RECOMMENDED PRACTICE

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SAE Hose Measurement Study

## RATIONALE

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

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**1. Scope**—The Measurement of Coolant Hose task group conducted a round-robin study to determine the measuring capability of automotive suppliers and users to measure Inside Diameter (ID), Outside Diameter (OD), Wall Thickness (Wall) and wall thickness variation of hose using traditional measuring devices and techniques. Seven companies (five suppliers and two end users) participated in this testing. Based upon the round-robin study this information report will detail procedures, test measuring devices, results and recommendations.

**1.1 Rationale**—This document has been reaffirmed to comply with the SAE 5-Year Review policy.

## **2. References**

**2.1 Applicable Publications**—The following publication forms a part of this specification to the extent specified herein.

2.1.1 AIAG PUBLICATIONS—Available from Automotive Industry Action Group, Suite 200, 26200 Lahser Road, Southfield, MI 48034-7100, Tel: 248-358-3570, [www.aiag.org](http://www.aiag.org).

(MSA) Manual-Measurement Systems Analysis Manual

**3. Procedure**—The following procedures were employed in the round-robin study:

**3.1** Two (2) sets of hoses were checked; there were 10 samples in each set.

**3.2** One end of each hose was marked for measurement. The attribute was taken from 6.4 mm (0.250 in) to 25.4 mm (1.000 in) from the end of the hose.

NOTE—All measurements were made using inch measuring units due to the lack of adequate metric equipment).

**3.3** Three (3) people repeated each measurement three (3) times at each testing location.

**3.4** The data were recorded on forms supplied with the samples.

**3.5** Hose samples and measuring devices were brought to equilibrium for 24 h in a controlled environment of 23 °C ± 2 °C and relative humidity of 50% +5%.

#### 4. **Attributes**

- 4.1 Procedure**—All of the samples and measuring devices were forwarded to the seven participants in order. The form for recording the measurements was also included. After taking the measurements, the data were sent to the chairman of the Measurement of Coolant Hose task group for analysis.

The attributes of ID, OD, Wall Thickness, and Wall thickness variation were measured as follows:

- 4.1.1 INSIDE DIAMETER**—The ID of the sample hoses was measured with step gages. Two sets of gages were provided that were centered around the target of each of the hose ID's; one set included diameter steps in increments of 0.05 mm (0.002 in) and the other 0.1 mm (0.004 in). The gages were inserted dry with a steady rotating motion and not causing more than an increase of 0.13 mm (0.005 in) in the OD when measured with a pi tape.
- 4.1.2 OUTSIDE DIAMETER**—The OD was measured by two methods:
- 4.1.2.1 Method 1**—A plug which had an OD the same as the maximum specified ID of the hose to be measured was inserted into the hose. The OD was measured by means of pi tape. (The plug was provided for this test with diameter steps graduated in 0.25 mm (0.010 in) increments).
- 4.1.2.2 Method 2**—The OD was measured by means of calipers. Find the largest OD and record; take another reading 90 degrees  $\pm$  15 degrees from the first and record. The average of the two readings was recorded and used as the OD of the hose.

(Calipers were provided for this test)

- 4.2 Wall Thickness**—The wall thickness was measured with calipers. Four (4) readings were taken, starting with the thinnest spot on the hose and rotating 90 degrees for each of the following three (3) measurements. An average of the four (4) numbers was recorded as the wall thickness.
- 4.3 Wall Thickness Variation**—The Wall Thickness Variation was calculated using the first wall thickness recorded in 4.2. A second measurement was taken at the thickest location of the wall measurement and recorded. The difference between the two readings was recorded as the Wall Thickness Variation.

- 5. Results**—The Gage R & R calculation is based upon the Automotive Industry Action Group Measurement Systems Analysis (MSA) manual.

The Results of this study were as follows in Figures 1 to 17:

- 6. Recommendations**—The results of this study have shown that traditional measuring devices and techniques are not capable of meeting the required 10% Gage R&R as suggested in the AIAG MSA automotive standards.

It is the consensus of the SAE Coolant Hose Committee that new gaging methods must be found and implemented before current hose measurement can be validated between companies. The SAE Coolant Hose Committee urges the membership jointly or individually to develop measuring devices and techniques which will conform to the AIAG MSA Automotive Gage R & R target of 10%.

5/13/92

**MEDIAN VS AVERAGE TOLERANCE  
FOR GAGE ERROR**

| CHARACTERISTIC | GAGE/METHOD     | R&R<br>MEDIAN | ACTUAL<br>MEDIAN | R&R<br>AVERAGE | ACTUAL<br>AVERAGE |
|----------------|-----------------|---------------|------------------|----------------|-------------------|
| I.D.           | .002 W/1.75     | 41.860        | .013             | 67.730         | .020              |
| I.D.           | .004 W/1.75     | 33.880        | .010             | 44.457         | .013              |
| I.D.           | .002 W/.725     | 16.190        | .005             | 20.650         | .006              |
| I.D.           | .004 W/.725     | 21.170        | .006             | 26.375         | .008              |
| O.D.           | PI TAPE W/1.75  | 62.310        | .025             | 73.354         | .029              |
| O.D.           | CALIPERS W/1.75 | 38.865        | .016             | 43.437         | .017              |
| O.D.           | PI TAPE W/.725  | 56.760        | .023             | 66.834         | .027              |
| O.D.           | CALIPERS W/.725 | 66.465        | .027             | 67.470         | .027              |
| WALL           | CALIPERS W/1.75 | 28.465        | .011             | 42.418         | .017              |
| WALL           | CALIPERS W/.725 | 44.440        | .018             | 49.538         | .020              |
| CONCENTRICITY  | CALIPERS W/1.75 | 61.200        | .024             | 61.050         | .024              |
| CONCENTRICITY  | CALIPERS W/.725 | 78.985        | .032             | 75.088         | .030              |

The characteristic "concentricity" is the wall variation

NOTE—1 in = 25.4 mm  
 1 lb/ft = 1.49 kg/m  
 1 psi = 6.9 kPa

FIGURE 1—MEDIAN VERSUS AVERAGE TOLERANCE FOR GAGE ERROR USING  
 PLUG GAGE FOR ID, PI TAPE AND CALIPERS FOR OD AND CALIPERS  
 FOR WALL THICKNESS AND WALL VARIATION

5/13/92

## SUMMARY SAE HOSES I.D.

| COMPANY  | DIM. | GAGE USED      | REPEAT.<br>% OF TOL. | ACTUAL<br>TOL. USED | REPROD.<br>% OF TOL. | ACTUAL<br>TOL. USED | GAGE R & R | ACTUAL TOTAL<br>TOL. USED | SPEC. TOL. |
|----------|------|----------------|----------------------|---------------------|----------------------|---------------------|------------|---------------------------|------------|
| A-1      | I.D. | .002 S/P 1.750 | 10.27                | .003                | 22.35                | .007                | 32.62      | .010                      | .030       |
| B-1      | I.D. | .002 S/P 1.750 | 7.68                 | .002                | 7.62                 | .002                | 15.30      | .005                      | .030       |
| C-1      | I.D. | .002 S/P 1.750 | 7.39                 | .002                | 97.17                | .029                | 104.56     | .031                      | .030       |
| D-1      | I.D. | .002 S/P 1.750 | 4.39                 | .001                | 37.47                | .011                | 41.86      | .013                      | .030       |
| E-1      | I.D. | .002 S/P 1.750 | 16.14                | .005                | 1.64                 | .000                | 17.78      | .005                      | .030       |
| F-1      | I.D. | .002 S/P 1.750 | .29                  | .000                | 130.06               | .039                | 130.34     | .039                      | .030       |
| G-1      | I.D. | .002 S/P 1.750 | .50                  | .000                | 131.15               | .039                | 131.65     | .039                      | .030       |
| AVERAGE: |      |                | 6.666                |                     | 61.066               |                     | 67.730     |                           |            |
| A-2      | I.D. | .004 S/P 1.750 | 11.70                | .004                | 1.02                 | .000                | 12.72      | .004                      | .030       |
| B-2      | I.D. | .004 S/P 1.750 | 5.60                 | .002                | 15.42                | .005                | 21.01      | .006                      | .030       |
| C-2      | I.D. | .004 S/P 1.750 | 19.20                | .006                | 50.57                | .015                | 69.77      | .021                      | .030       |
| D-2      | I.D. | .004 S/P 1.750 | 11.40                | .003                | 22.48                | .007                | 33.88      | .010                      | .030       |
| E-2      | I.D. | .004 S/P 1.750 | 8.47                 | .003                | 2.17                 | .001                | 10.63      | .003                      | .030       |
| F-2      | I.D. | .004 S/P 1.750 | .88                  | .000                | 101.56               | .030                | 102.44     | .031                      | .030       |
| G-2      | I.D. | .004 S/P 1.750 | 1.48                 | .000                | 59.26                | .018                | 60.75      | .018                      | .030       |
| AVERAGE: |      |                | 8.390                |                     | 36.069               |                     | 44.457     |                           |            |
| A-1      | I.D. | .002 S/P .725  | 6.38                 | .002                | 9.81                 | .003                | 16.19      | .005                      | .030       |
| B-1      | I.D. | .002 S/P .725  | 5.76                 | .002                | 2.21                 | .001                | 7.97       | .002                      | .030       |
| C-1      | I.D. | .002 S/P .725  | 10.28                | .003                | 4.20                 | .001                | 14.48      | .004                      | .030       |
| D-1      | I.D. | .002 S/P .725  | 5.02                 | .002                | 2.38                 | .001                | 7.41       | .002                      | .030       |
| E-1      | I.D. | .002 S/P .725  | 14.38                | .004                | 4.80                 | .001                | 19.18      | .006                      | .030       |
| F-1      | I.D. | .002 S/P .725  | .51                  | .000                | 43.55                | .013                | 46.06      | .014                      | .030       |
| G-1      | I.D. | .002 S/P .725  | 3.99                 | .001                | 29.27                | .009                | 33.26      | .010                      | .030       |
| AVERAGE: |      |                | 6.617                |                     | 13.746               |                     | 20.650     |                           |            |
| A-2      | I.D. | .004 S/P .725  | 13.43                | .004                | 3.13                 | .001                | 16.56      | .005                      | .030       |
| B-2      | I.D. | .004 S/P .725  | 0.00                 | 0.000               | 14.40                | .004                | 14.40      | .004                      | .030       |
| C-2      | I.D. | .004 S/P .725  | 19.54                | .006                | 7.63                 | .002                | 21.17      | .006                      | .030       |
| D-2      | I.D. | .004 S/P .725  | 7.44                 | .002                | 1.46                 | .000                | 8.89       | .003                      | .030       |
| E-2      | I.D. | .004 S/P .725  | 14.54                | .004                | 17.81                | .005                | 32.35      | .010                      | .030       |
| F-2      | I.D. | .004 S/P .725  | 1.89                 | .001                | 45.87                | .014                | 47.75      | .014                      | .030       |
| G-2      | I.D. | .004 S/P .725  | 2.71                 | .001                | 40.67                | .012                | 43.38      | .013                      | .030       |
| AVERAGE: |      |                | 8.507                |                     | 18.710               |                     | 26.357     |                           |            |

NOTE—1 in = 25.4 mm  
 1 lb/ft = 1.49 kg/m  
 1 psi = 6.9 kPa

FIGURE 2—MEASUREMENT OF HOSE ID USING 0.05 mm (0.002 in)  
 AND 0.1 mm (0.004 in) STEPPED PLUG GAGES

5/13/92

## SUMMARY SAE HOSES O.D.

| COMPANY  | DIM. | GAGE USED      | REPEAT.<br>% OF TOL. | ACTUAL<br>TOL. USED | REPROD.<br>% OF TOL. | ACTUAL<br>TOL. USED | GAGE R & R | ACTUAL TOTAL<br>TOL. USED | SPEC. TOL. |
|----------|------|----------------|----------------------|---------------------|----------------------|---------------------|------------|---------------------------|------------|
| A-1      | O.D. | PI TAPE 1.750  | 23.60                | .009                | 37.99                | .015                | 61.59      | .025                      | .040       |
| B-1      | O.D. | PI TAPE 1.750  | 7.61                 | .003                | 77.28                | .031                | 84.89      | .034                      | .040       |
| C-1      | O.D. | PI TAPE 1.750  | 35.95                | .014                | 22.26                | .009                | 58.22      | .023                      | .040       |
| D-1      | O.D. | PI TAPE 1.750  | 31.75                | .013                | 8.12                 | .003                | 39.88      | .016                      | .040       |
| E-1      | O.D. | PI TAPE 1.750  | 37.43                | .015                | 24.88                | .010                | 62.31      | .025                      | .040       |
| F-1      | O.D. | PI TAPE 1.750  | 2.36                 | .001                | 131.57               | .053                | 133.94     | .054                      | .040       |
| G-1      | O.D. | PI TAPE 1.750  | 69.71                | .028                | 2.94                 | .001                | 72.65      | .029                      | .040       |
| AVERAGE: |      |                | 29.773               |                     | 43.577               |                     | 73.354     |                           |            |
| A-2      | O.D. | CALIPERS 1.750 | 22.60                | .009                | 21.13                | .008                | 43.73      | .017                      | .040       |
| B-2      | O.D. | CALIPERS 1.750 | 31.99                | .013                | 1.88                 | .001                | 33.87      | .014                      | .040       |
| C-2      | O.D. | CALIPERS 1.750 | 34.74                | .014                | 23.41                | .009                | 58.16      | .023                      | .040       |
| D-2      | O.D. | CALIPERS 1.750 | 17.94                | .007                | 6.87                 | .003                | 24.81      | .010                      | .040       |
| E-2      | O.D. | CALIPERS 1.750 | 33.61                | .013                | .38                  | .000                | 34.00      | .014                      | .040       |
| F-2      | O.D. | CALIPERS 1.750 |                      |                     |                      |                     |            |                           |            |
| G-2      | O.D. | CALIPERS 1.750 | 62.12                | .025                | 3.93                 | .002                | 66.05      | .026                      | .040       |
| AVERAGE: |      |                | 33.833               |                     | 9.600                |                     | 43.437     |                           |            |
| A-1      | O.D. | PI TAPE .725   | 10.06                | .004                | 9.38                 | .004                | 19.43      | .008                      | .040       |
| B-1      | O.D. | PI TAPE .725   | 5.82                 | .002                | 105.13               | .042                | 110.95     | .044                      | .040       |
| C-1      | O.D. | PI TAPE .725   | 24.24                | .010                | 28.01                | .011                | 52.25      | .021                      | .040       |
| D-1      | O.D. | PI TAPE .725   | 87.15                | .035                | 19.88                | .008                | 107.30     | .043                      | .040       |
| E-1      | O.D. | PI TAPE .725   | 52.46                | .021                | 30.79                | .012                | 83.25      | .033                      | .040       |
| F-1      | O.D. | PI TAPE .725   | 24.54                | .010                | 13.36                | .005                | 37.90      | .015                      | .040       |
| G-1      | O.D. | PI TAPE .725   | 30.99                | .012                | 25.78                | .010                | 56.76      | .023                      | .040       |
| AVERAGE: |      |                | 33.609               |                     | 33.190               |                     | 66.834     |                           |            |
| A-2      | O.D. | CALIPERS .725  | 34.33                | .014                | 53.97                | .022                | 88.29      | .035                      | .040       |
| B-2      | O.D. | CALIPERS .725  | 22.99                | .009                | 29.91                | .012                | 52.90      | .021                      | .040       |
| C-2      | O.D. | CALIPERS .725  | 57.56                | .023                | 11.18                | .004                | 68.74      | .027                      | .040       |
| D-2      | O.D. | CALIPERS .725  | 43.75                | .018                | 20.44                | .008                | 64.19      | .026                      | .040       |
| E-2      | O.D. | CALIPERS .725  | 38.22                | .015                | 6.64                 | .003                | 44.86      | .018                      | .040       |
| F-2      | O.D. | CALIPERS .725  |                      |                     |                      |                     |            |                           |            |
| G-2      | O.D. | CALIPERS .725  | 33.18                | .013                | 52.66                | .021                | 85.84      | .034                      | .040       |
| AVERAGE: |      |                | 38.338               |                     | 29.133               |                     | 67.470     |                           |            |

NOTE—1 in = 25.4 mm  
 1 lb/ft = 1.49 kg/m  
 1 psi = 6.9 kPa

FIGURE 3—MEASUREMENT OF HOSE OD USING PI TAPE AND CALIPERS