SURFACE VEHICLE INFORMATION REPORT

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Non-Contact Hose Measurement Study 1

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 Hose Measurement Task Force conducted a round-robin study to determine the measuring capability of automotive suppliers and users to simultaneously measure the Inside Diameter (ID), Outside Diameter (OD), Wall Thickness (Wall), and Wall thickness Variation (WV) of hose using a laser-based, non-contact LOTIS QC-20 gauging device. Three (3) companies (all end users) participated in this testing with one of the three companies performing the GR&R calculations presented herein. Based upon the round-robin study this report will detail procedures, test measuring devices, results, and conclusions.

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

2. ***References***

2.1 **Applicable Publication—**The following publication forms a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATION—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 J1759—SAE Hose Measurement Study. Summary of a GR&R study completed using plug gauges, PI tapes and calipers.

2.2 **Related Publication—**The following publication is provided for information purposes only and is not a required part of this document.

2.2.1 AIAG PUBLICATION—Available from Automotive Industry Action Group, Suite 200, 262 Lahser Road, Southfield, MI 48034-7100, Tel: 248-358-3570, www.aiag.org.

(MSA) Manual-Measurement Systems Analysis Manual

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

3.1 This study attempted to duplicate the methodology and data presentation used in SAE J1759 as much as practical. Specifically this includes using identical tolerance levels as well as presenting both the detailed and average GR&R results.

3.2 Three (3) sets of hoses were measured; with 10 samples in each set. The three hose sets consisted of two straight sections (parts X & Y) and one curved (part Z). The specific hose parameters are provided in Table A1 of Appendix A within this document. All three sets of hoses were black.

3.3 One end of each hose was uniquely marked for measurement. The measurements were taken at approximately 19 mm (0.75 in) from the end.

NOTE—All measurements were made using metric units.

3.4 Three (3) people repeated each measurement three (3) times at each of the three (3) testing locations (plants). Subsequently designated plants A, B, and C.

3.5 The data were recorded on forms supplied with the samples.

3.6 Hose samples and measuring devices were brought to equilibrium for 24 h in a reasonably controlled environment of 23 degrees and a target relative humidity of 50%.

4. Attributes

4.1 **Procedure—**All of the samples were forwarded to the three participants in order. Each participant used their own QC-20 to perform the tests. The form for recording the measurements and test instructions (Appendix A) were also included. After taking the measurements, the data were sent to Plant A for analysis. The attributes were measured as follows:

4.1.1 INSIDE DIAMETER (ID)—The ID of the sample hoses were measured using a 12 mm QC-20 non-contact hose measurement system. The device makes 1600 ID radius measurements to compute the ID.

4.1.2 OUTSIDE DIAMETER (OD)—The OD of the sample hoses were measured using a 12 mm QC-20 non-contact hose measurement system. The device makes 1600 OD radius measurements to compute the OD.

4.1.3 WALL THICKNESS (WT)—The wall thickness is computed from the ID and OD results.

4.1.4 WALL THICKNESS VARIATION (WV)—The wall thickness variation is computed using the inside and outside radii results.

5. ***Results—***The gage R&R calculation is based upon the Automotive Industry Action Group Measurement Systems Analysis (MSA) manual. The results are presented in Tables 1 through 6. Two (2) separate GR&R calculations were made.

5.1 **GR&R Calculation 1—**This is done for each hose set in each plant using the data from the 3 operators at each plant. A summary of the average GR&R for all three plants and for each hose and dimension is shown in Table 1. Detailed results are provided in Tables 2 through 5. This data is presented in manner similar to SAE J1759.

The *average* results for *straight* hoses (X and Y) across all measurements (ID, OD, WT, and WV) and all plants (A, B, C) from Tables 2 through 5 are:

Repeatability (% of tolerance) 8.9%
Reproducibility (% of tolerance) 4.6%
R&R (% of tolerance) 10.6%

The *average* results for *curved* hose (Z) across all measurements (ID, OD, WT, and WV) and all plants (A, B, C) from Tables 2 through 5 are:

Repeatability (% of tolerance)..... 10.7%
Reproducibility (% of tolerance)..... 8.0%
R&R (% of tolerance) 14.6%

5.2 GR&R Calculation 2—This second calculation was performed by using the data from operator #1 from each of the 3 plants. Those results are presented in Table 6. It is important to note that when combining the results from 3 different instruments the calibration offset between instruments will result in higher GR&R numbers. The QC-20 factory calibration only ensures absolute calibration of ±0.051 mm. Hence, the maximum deviation between systems is ±0.102 mm. Ten percent (10%) of the OD, wall, and wall variation tolerance and 13% of the ID tolerance is used up as a result of this difference. This effect is demonstrated in comparing the Repeatability and Reproducibility columns in Table 6. *This calculation was not performed in SAE J1759 but provides useful information to quality control personnel using multiple gauges.*

A tolerance of 0.76 mm was used for all ID calculations. All other calculations used 1.02 mm.

6. Conclusions

a. The LOTIS QC-20 non-contact measurement gauge provides a significantly better gauge R&R as compared to the results obtained for plug gauges, pi tapes and calipers as presented in SAE J1759. In addition, the ID, OD, wall thickness and wall variation measurements are collected simultaneously without touching the surface of the hose.
b. The GR&R is sufficient to settle measurement differences between suppliers and end users.
c. The results presented in Tables 2, 3, 4, and 5 use the conventional AIAG methods for GR&R calculations.
d. This committee recommends a standard procedure be developed for gauge evaluation using this study and SAE J1759 as a basis. The new gauge evaluation procedure would be used for evaluation of any future hose gauges.

TABLE 1—SUMMARY RESULTS
3 OPERATORS/1 SYSTEM AVERAGED OVER 3 PLANTS
(METRIC UNITS)[1]

Characteristic[2]	Gage/Method	%R&R Median	Actual Median	%R&R Average	Actual Average
ID X	QC-20 12 mm	10.87	0.08	10.18	0.08
ID Y	QC-20 12 mm	14.28	0.11	13.19	0.10
ID Z	QC-20 12 mm	13.91	0.11	14.49	0.11
OD X	QC-20 12 mm	8.68	0.09	11.07	0.11
OD Y	QC-20 12 mm	9.70	0.10	13.57	0.14
OD Z	QC-20 12 mm	17.57	0.18	19.41	0.20
Wall X	QC-20 12 mm	4.49	0.05	5.00	0.05
Wall Y	QC-20 12 mm	10.82	0.11	10.52	0.11
Wall Z	QC-20 12 mm	11.09	0.11	10.06	0.10
W.V. X	QC-20 12 mm	6.24	0.06	7.68	0.05
W.V. Y	QC-20 12 mm	13.44	0.14	13.61	0.14
W.V. Z	QC-20 12 mm	14.30	0.15	14.33	0.15

1. 25.4 mm = 1 in
2. Hoses X and Y are straight sections and Hose Z is curved.

This table is an average of the GR&R results obtained from plants A, B, and C. Although it is not standard practice to provide GR&R results as averages, it is provided here to allow comparison with the results provided in Figure 1 of SAE J1759.

TABLE 2—ID RESULTS FROM EACH PLANT (A, B, AND C)
3 OPERATORS/1 SYSTEM
METRIC UNITS(1)

Co./Hose	Dim.	Gage Used	Repeat % of Tol.	Actual Tol. Used	Reprod. % of Tol.	Actual Tol. Used	Gage R&R %	Actual Tot. Tol. Used	Spec. Tol.
A/X	ID	QC-20 12 mm	4.68	0.0356	0.99	0.0075	4.79	0.0364	0.76
B/X	ID	QC-20 12 mm	6.01	0.0457	9.05	0.0688	10.87	0.0826	0.76
C/X	ID	QC-20 12 mm	12.58	0.0956	7.96	0.0605	14.88	0.1131	0.76
		Average:	**7.76**		**6.00**		**10.18**		
A/Y	ID	QC-20 12 mm	11.11	0.0844	9.01	0.0685	14.30	0.1087	0.76
B/Y	ID	QC-20 12 mm	9.09	0.0691	6.17	0.0469	11.00	0.0836	0.76
C/Y	ID	QC-20 12 mm	11.91	0.0905	7.88	0.0599	14.28	0.1085	0.76
		Average:	**10.70**		**7.69**		**13.19**		
A/Z	ID	QC-20 12 mm	10.03	0.0762	7.11	0.0540	12.30	0.0935	0.76
B/Z	ID	QC-20 12 mm	13.91	0.1057	0.00	0.0000	13.91	0.1057	0.76
C/Z	ID	QC-20 12 mm	12.04	0.0915	12.36	0.0939	17.25	0.1311	0.76
		Average:	**11.99**		**6.49**		**14.49**		

1. 25.4 mm = 1 in

**TABLE 3—OD RESULTS FROM EACH PLANT (A, B, AND C)
3 OPERATORS/1 SYSTEM
METRIC UNITS[1]**

Co./Hose	Dim.	Gage Used	Repeat % of Tol.	Actual Tol. Used	Reprod. % of Tol.	Actual Tol. Used	Gage R&R %	Actual Tot. Tol. Used	Spec. Tol.
A/X	OD	QC-20 12 mm	4.70	0.0478	7.30	0.0742	8.68	0.0882	1.02
B/X	OD	QC-20 12 mm	7.71	0.0783	0.00	0.0000	7.71	0.0783	1.02
C/X	OD	QC-20 12 mm	16.81	0.1708	0.44	0.0045	16.82	0.1709	1.02
		Average:	**9.74**		**2.58**		**11.07**		
A/Y	OD	QC-20 12 mm	8.00	0.0813	5.48	0.0557	9.70	0.0986	1.02
B/Y	OD	QC-20 12 mm	8.31	0.0844	2.08	0.0211	8.56	0.0870	1.02
C/Y	OD	QC-20 12 mm	20.01	0.2033	10.17	0.1033	22.45	0.2281	1.02
		Average:	**12.11**		**5.91**		**13.57**		
A/Z	OD	QC-20 12 mm	7.51	0.0763	15.89	0.1614	17.57	0.1785	1.02
B/Z	OD	QC-20 12 mm	15.21	0.1545	23.13	0.2350	27.69	0.2813	1.02
C/Z	OD	QC-20 12 mm	12.51	0.1271	3.48	0.0354	12.98	0.1319	1.02
		Average:	**11.74**		**14.17**		**19.41**		

1. 25.4 mm = 1 in

**TABLE 4—WALL RESULTS FROM EACH PLANT (A, B, AND C)
3 OPERATORS/1 SYSTEM
METRIC UNITS[1]**

Co./Hose	Dim.	Gage Used	Repeat % of Tol.	Actual Tol. Used	Reprod. % of Tol.	Actual Tol. Used	Gage R&R %	Actual Tot. Tol. Used	Spec. Tol.
A/X	Wall	QC-20 12 mm	1.51	0.0153	4.06	0.0413	4.33	0.0440	1.02
B/X	Wall	QC-20 12 mm	2.10	0.0213	3.97	0.0403	4.49	0.0456	1.02
C/X	Wall	QC-20 12 mm	5.91	0.0600	1.83	0.0186	6.18	0.0628	1.02
		Average:	**3.17**		**3.29**		**5.00**		
A/Y	Wall	QC-20 12 mm	3.60	0.0366	6.16	0.0626	7.15	0.0726	1.02
B/Y	Wall	QC-20 12 mm	8.31	0.0844	2.08	0.0211	10.82	0.1099	1.02
C/Y	Wall	QC-20 12 mm	11.21	0.1139	7.71	0.0783	13.60	0.1382	1.02
		Average:	**7.71**		**5.31**		**10.52**		
A/Z	Wall	QC-20 12 mm	4.80	0.0488	10.24	0.1040	11.31	0.1149	1.02
B/Z	Wall	QC-20 12 mm	6.90	0.0701	8.68	0.0882	11.09	0.1127	1.02
C/Z	Wall	QC-20 12 mm	4.50	0.0457	6.33	0.0643	7.77	0.0789	1.02
		Average:	**5.40**		**8.42**		**10.06**		

1. 25.4 mm = 1 in

TABLE 5—WALL VARIATION RESULTS FROM EACH PLANT (A, B, AND C)
3 OPERATORS/1 SYSTEM
METRIC UNITS[1]

Co./Hose	Dim.	Gage Used	Repeat % of Tol.	Actual Tol. Used	Reprod. % of Tol.	Actual Tol. Used	Gage R&R %	Actual Tot. Tol. Used	Spec. Tol.
A/X	Wall Var.	QC-20 12 mm	6.00	0.0610	1.71	0.0174	6.24	0.0634	1.02
B/X	Wall Var.	QC-20 12 mm	7.01	0.0712	1.70	0.0173	7.20	0.0732	1.02
C/X	Wall Var.	QC-20 12 mm	9.61	0.0976	0.00	0.0000	9.61	0.0976	1.02
		Average:	**7.54**		**1.14**		**7.68**		
A/Y	Wall Var.	QC-20 12 mm	11.11	0.1129	4.13	0.0420	11.85	0.1204	1.02
B/Y	Wall Var.	QC-20 12 mm	11.60	0.1179	6.76	0.0687	13.44	0.1365	1.02
C/Y	Wall Var.	QC-20 12 mm	15.21	0.1545	3.22	0.0327	15.55	0.1580	1.02
		Average:	**12.64**		**4.70**		**13.61**		
A/Z	Wall Var.	QC-20 12 mm	12.61	0.1281	4.50	0.0457	13.39	0.1360	1.02
B/Z	Wall Var.	QC-20 12 mm	13.51	0.1373	4.70	0.0478	14.30	0.1453	1.02
C/Z	Wall Var.	QC-20 12 mm	15.31	0.1556	0.00	0.0000	15.31	0.1556	1.02
		Average:	**13.81**		**3.07**		**14.33**		

1. 25.4 mm = 1 in

TABLE 6—SUMMARY RESULTS BY HOSE X, Y, AND Z
3 OPERATORS/3 SYSTEMS
METRIC UNITS[1]

Hose[2]	Dim.	Gage Used	Repeat % of Tol.	Actual Tol. Used	Reprod. % of Tol.	Actual Tol. Used	Gage R&R %	Actual Tot. Tol. Used	Spec. Tol.
X	ID	QC-20 12mm	4.93	0.0376	19.93	0.1519	20.54	0.1565	0.76
Y	ID	QC-20 12mm	9.07	0.0691	20.49	0.1561	22.40	0.1707	0.76
Z	ID	QC-20 12mm	9.34	0.0712	14.42	0.1099	17.19	0.1310	0.76
X	OD	QC-20 12mm	4.20	0.0427	4.09	0.0416	5.87	0.0596	1.02
Y	OD	QC-20 12mm	9.80	0.0996	7.86	0.0799	12.57	0.1277	1.02
Z	OD	QC-20 12mm	8.60	0.0874	2.03	0.0206	8.84	0.0898	1.02
X	Wall	QC-20 12mm	1.90	0.0193	5.93	0.0602	6.22	0.0632	1.02
Y	Wall	QC-20 12mm	7.51	0.0763	3.45	0.0351	8.27	0.0840	1.02
Z	Wall	QC-20 12mm	3.80	0.0386	5.90	0.0599	7.02	0.0713	1.02
X	W.V.	QC-20 12mm	8.00	0.0813	5.75	0.0584	9.86	0.1002	1.02
Y	W.V.	QC-20 12mm	12.30	0.1250	10.85	0.1102	16.41	0.1667	1.02
Z	W.V.	QC-20 12mm	13.91	0.1413	11.51	0.1169	18.05	0.1834	1.02

1. 25.4 mm = 1 in
2. Hoses X and Y are straight sections and Hose Z is curved.

These results utilize a combination of data from all three plants that participated in the study. Each plant used their own QC-20. This is NOT the traditional method of performing GR&R calculations but is provided here as an additional measure of gauge capability.

PREPARED BY THE SAE NON-HYDRAULIC HOSE COMMITTEE