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RAIL VEHICLE END OF CAR HOSE FLEXIBILITY TESTING

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ABSTRACT

This paper describes how rail vehicle end hoses, that form the connection between the brake equipment on adjacent vehicles, have been traditionally tested for flexibility and a new test method that was recently introduced in The Association of American Railroads Specification (AAR) M-601 [1].

The Railroads had expressed a need to be able to perform both initial hose assembly specification compliance and subsequent quality assurance performance tests under controlled temperature conditions. This led to the development of a new test device and a simplified test procedure, which closely simulates the actions of railroad personnel when connecting end hoses in the train yard.

This paper describes how end hoses have traditionally been tested, the evolution of a new test device, and the steps taken to qualify it for acceptance by the AAR as the test method in the recently revised Specification M-601.

INTRODUCTION

The Association of American Railroads (AAR) promulgates and publishes "The Manual of Standards and Recommended Practices (MSRP)" which establishes standards for components used by the industry on vehicles which operate in interchange service on the North American continent. Section E of this manual covers Brake Equipment, and the Brake Systems Committee (BSC) of the AAR maintains and updates this section. The BSC saw a need to upgrade hose specifications and directed the hose manufacturers and assemblers to form an industry Technical Advisory Group (Hose TAG) to review current standards and to formulate proposals for any revisions determined necessary. The BSC, after being made aware of difficulties coupling hoses during winter operations, wanted the capability to routinely test hoses from warehouse stock. A revision to the existing specification was deemed necessary since the traditional test method employed specially prepared test samples.

Flexibility tests are made at two temperature ranges to ensure that hoses will not kink in operation during warm temperatures and can be bent (kinked) when coupling hoses together at cold temperatures.

FORMER TESTING METHOD – "SUSPENSION METHOD"

The AAR Specification M-601, paragraph 4.10 [2], calls for the end hose to pass flexibility tests at 70°F ± 2° F (room temp) and at -55° F ± 2° F (low temp). The test samples must be held at 70°F ± 2°F for seven days prior to the room temperature tests and subsequently at -55° F ± 2° F for 48 hours prior to the low temperature tests. The configuration of the test hose assemblies requires AAR male pipe fittings at each end of the hose assemblies, whereas standard production end hose assemblies have a "gladhand" connection on one end, and the AAR male pipe fitting on the other end. Thus special hose assemblies have to be manufactured for the initial qualification tests. There are two disadvantages to this test method:

1. The non-standard hose assembly configuration requirement makes it impossible to audit hoses from warehouse stock for conformance to M-601.
2. Deflection results vary, depending on whether a walk-in environmental chamber (cold room) is used to perform the test, or an industrial freezer (cold box) is used. Walk-in cold rooms of suitable size are not common features at railroad test locations or hose assembly plants. Also, they are costly to install and operate and require three people to perform the tests efficiently.

TEST SETUP FOR FORMER SUSPENSION METHOD

Threaded caps with eyebolts are applied to each end of the AAR male pipe fitting to enable the hoses to be suspended horizontally on a test frame. A tape measure is attached to the test fixture for measuring the hose deflection; weights in 10 lb increments are applied to the center of the exposed hose via an S-hook formed as per M-601, Figure 4.2 [2]. The weight attachment positions are pre-marked on the center of the exposed hose for each hose sample. A zero load measurement is first taken and subsequently the deflection is measured 30 seconds after each weight is applied. Force versus Deflection values are recorded and results must conform to the values given in M-601, Fig.4.3 [2] for the hose to be acceptable.

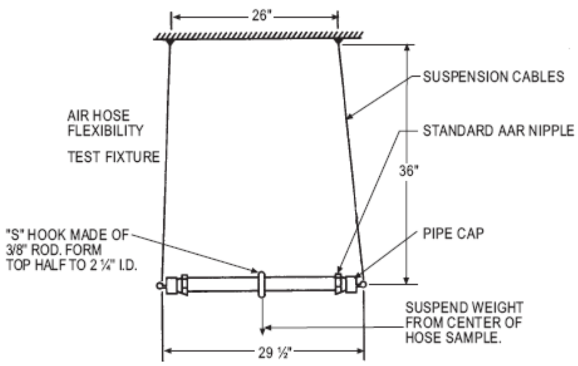

Fig. 4.2 AAR test apparatus

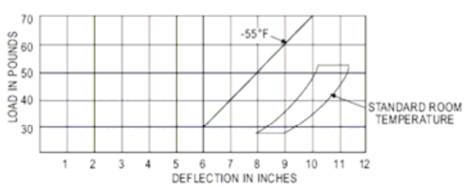

Fig. 4.3 Hose deflection (in.)

4.10.5 Flexibility at −55 °F must be equal to or better than that shown, and stiffness at 70 °F ± 2 °F must be within the range shown.

If the tests are made using an industrial-type cold chest, the hose assemblies must be removed from the chest in order for them to be suspended and measurements taken. Accordingly, the hose assemblies rise in temperature and yield false results. After the BSC reviewed the results of tests made via a cold box by an Independent Laboratory and found them to be inconsistent, they instructed the Hose Tag to perform tests in a walk-in cold room.

TEST SETUP FOR COLD ROOM SUSPENSION TESTS

The purpose of the tests was to produce load versus deflection curves for both standard end hose assemblies, with a threaded nipple at one end and a gladhand coupling at the other end, and the currently required test hose assemblies with capped nipples at each end. This would enable the flexibility requirements of specification M-601 to be revised in order to establish the standard end hose assembly to be used for qualification testing. Acceptance values would be based on currently approved hoses with a proven performance.

Testing was performed on five manufacturers' samples in January, 2005 using 10 assemblies in each configuration from each of the suppliers. Testing was performed at the Ellcon National test facility in South Carolina. The validity of the results were subsequently questioned due to conflicting interpretations of certain aspects of M-601. After the conflicting issues were resolved, further testing was performed in August, 2005, in a cold room at the New York Air Brake (NYAB) plant in New York State. In this instance four manufacturers submitted hose assembly samples in the same configurations as previously tested.

The hose assemblies were tested in batches of four, one from each manufacturer, so that small variations in the cold room air temperature that would occur when the test crews entered and exited the chamber, would have an equal effect on each supplier's hose samples.

At -55°F a suitably attired test crew was able to remain inside the cold room for typically 30 minutes. Rest and warm up periods outside the cold room were necessary which prolonged the test time.

Although testing the currently approved manufacturers' hoses in the gladhand x male pipe configuration would have enabled the BSC to revise the M-601 specification with new acceptance curves for both Low and Room temperatures, shown in Figure 4, the economic disadvantages of using a walk-in cold room in order to perform the testing still remained.

Figure 1: Test Fixture photo, Former SUSPENSION Test Method, Male x Male, Cold Room

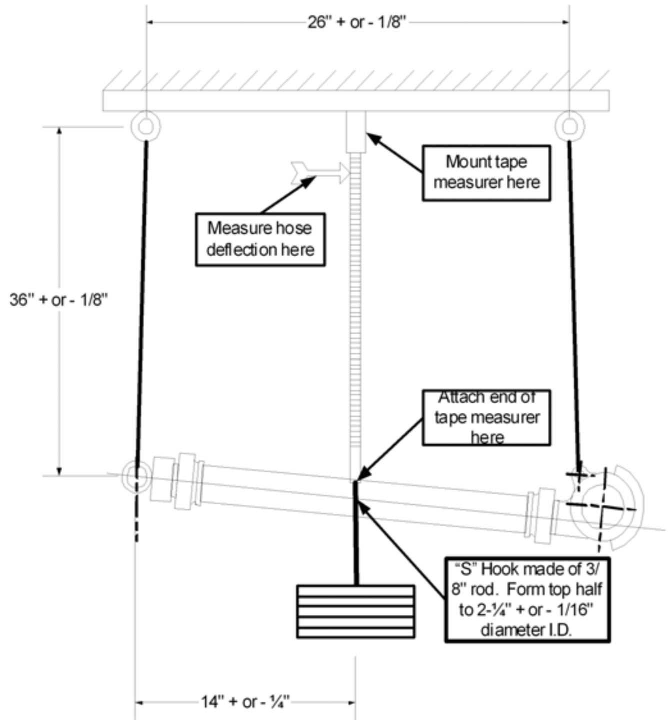

Figure 1A: Fixture dimensions, Former Proposed SUSPENSION Method, Male x Gladhand

Figure 1B: Test Fixture photo, Former Proposed SUSPENSION Method, Male x Gladhand, Cold Room

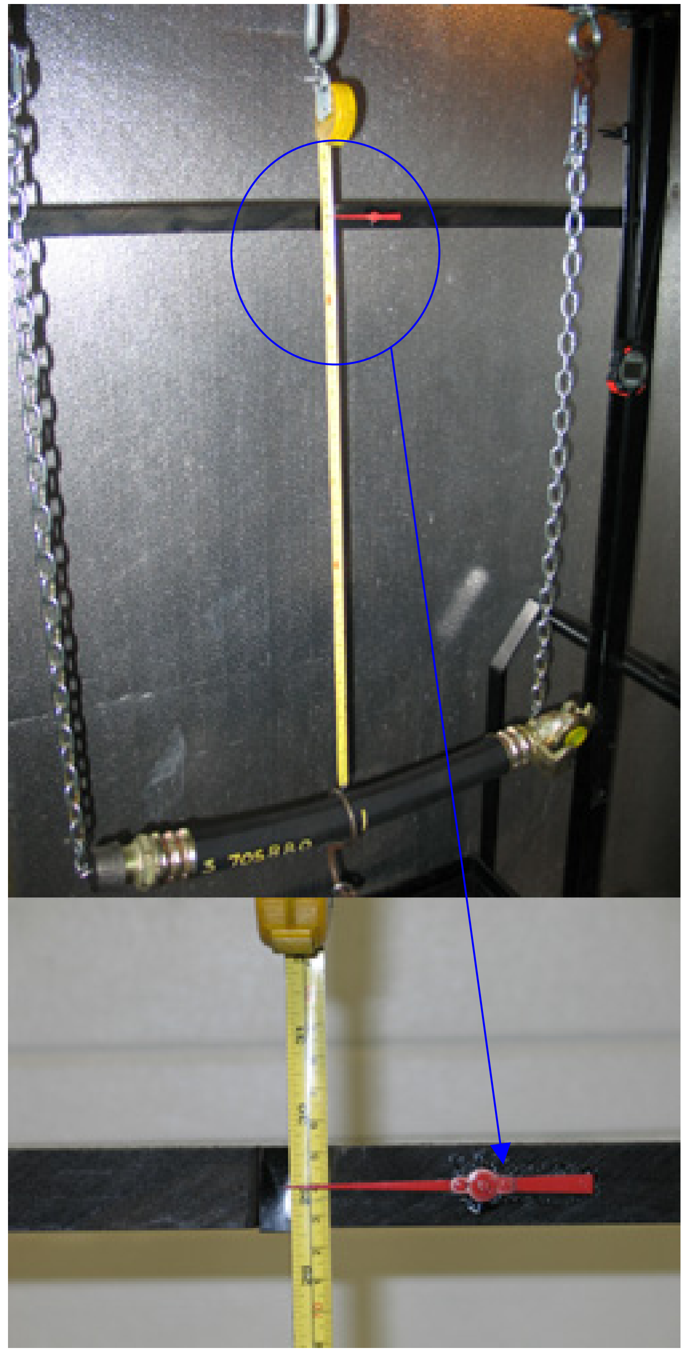

Figure 1C: Test Fixture photo, Former Proposed SUSPENSION Method, Male x Gladhand, Cold Room

THE DEVELOPMENT OF A NEW TEST METHOD

During the time that the above testing was taking place, an idea persisted that there had to a better way to test and evaluate hose flexibility by a method that was more closely related to the actions a railroad carman performs when coupling hoses during train make-up. A generally accepted method of connecting hoses is for the carman to grasp one hose at about mid-point of the flexible part, and while grasping the gladhand coupling in the other hand, pull the coupling towards him and produce a kink in the hose. The hose is held kinked while the gladhand on the other hose is brought into contact with the kinked hose gladhand. The kinked hose is then released which allows the two gladhands to rotate to the coupled position.

A prototype device, constructed of wood, was produced and demonstrated to the BSC. This device would kink a hose in much the same way as a carman does and, importantly, would allow measurement of the force required to produce the kink. The BSC gave the go ahead to proceed with the concept and Strato developed the device, shown in Figure 2, which the BSC informally dubbed the “Cobden Tester”.

In operation, weights are added to a "scale pan" conveniently located outside the cold box. Forces are transmitted via pullies and a constant-radius cam to an eye in the gladhand connection of the test hose inside the cold box.

TEST PROCEDURE - “FLEX DEVICE METHOD”

The device underwent initial testing in the NYAB cold room in August, 2005, using the same standard end hose samples that had been provided for the suspension test comparison tests described earlier. ***In this way there would be reasonable assurance of being able to directly compare the test results with the results obtained from earlier tests.***

The test begins when the end hose, in a gladhand x male pipe configuration, is inserted into the test device as shown in Figure 2. When weight is applied, the movement of the cam on the test device simulates the forearm movement of a carman when he “kinks” one hose, to fold it back, and then aligns the gladhand with the gladhand on the hose of the adjacent car to couple them.

Ten samples from each of four manufacturers were tested at room temperature (70°F) and cold temperature (-55°F). Weights, in 10 lb increments, were applied to a formed hook, attached to the test device. The applied weight rotates the cam causing the hose to flex or “kink” upward. Maximum rotation of the cam (90°) denotes that the hose fully “kinked”. The test device was equipped with a scale for measuring deflection corresponding to the applied force, Figure 5A.

Using the test data of the three approved hose manufacturers with successfully proven performance in the field (one manufacturer omitted), it was possible to establish values for the force that “must not kink” the hose at room temperature and “must kink” at low temperature. The procedure evolved to a simple pass/fail test using only two weight limits as follows:

M-601 Final Procedure for Flex Device shown below:

4.10.3 The end hose assembly samples with standard AAR nipples and gladhands are stored for 7 days at 70°F $\pm$ 2°F.

4.10.4 At 70°F $\pm$ 2°F, the application of a 9-lb weight *must not* produce kinking of the hose within 30 seconds, as evidenced by maximum rotation of the cam.

4.10.5 For the cold temperature test, the hose samples must be held at –55 °F $\pm$ 2°F for 48 hours, the steady application of weights totaling 40 lb *must* produce kinking of the hose within 30 seconds, as evidenced by maximum rotation of the cam.

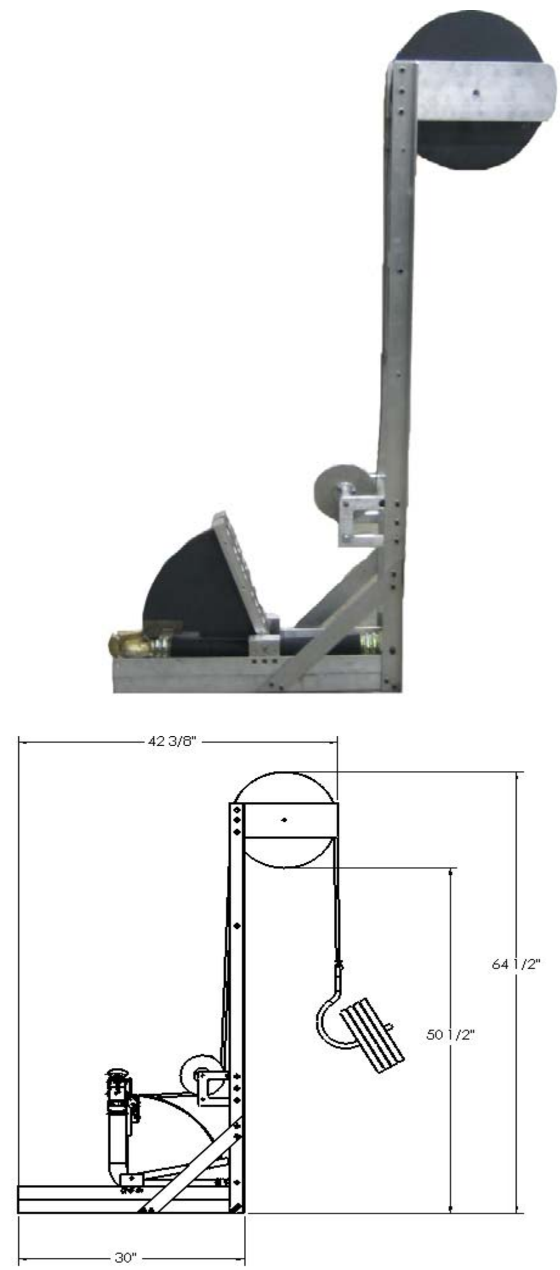

Figure 2 - Flex Test Device – New Test Method

TEST RESULTS

FORCE VS DEFLECTION – "SUSPENSION METHOD"

In the graphs below, Figure 3, the average deflection of ten samples at both temperatures for each manufacturer is plotted. Test results are shown for the male pipe x male pipe configuration.

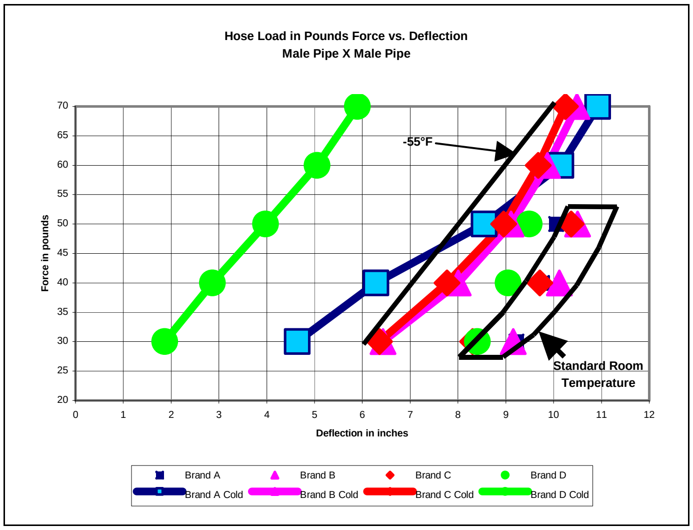

Figure 3: SUSPENSION Method, Male x Male, Test Results at Room and Cold Temp

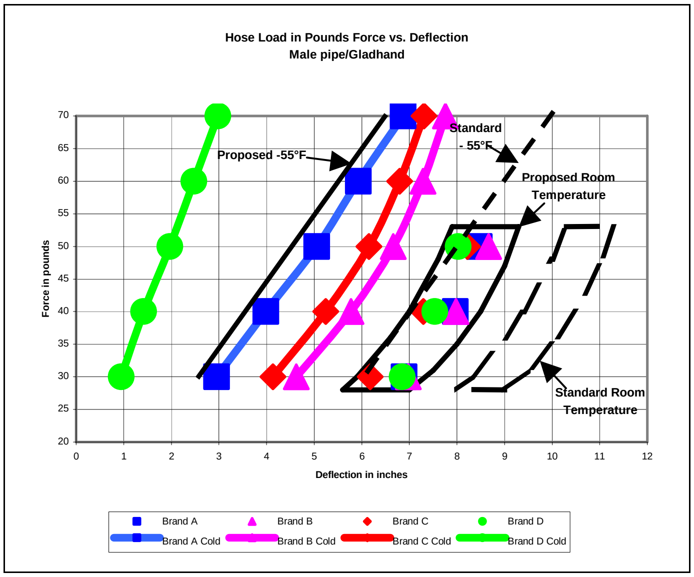

Figure 4: SUSPENSION Method, Male x Gladhand - Test Results at Room and Cold Temperatures

Using the new configuration, all deflection measurements shifted to the left on the graph, Figure 4. This is an expected result because the gladhand x male pipe hose configuration was tested with the weights applied at the center of the exposed hose, which yields results in an 'off center' loading since the fittings have different lengths. See Figure 1A, M-601- Former Proposed Suspension Method.

The former hose configuration, male pipe x male pipe, Figure 1, was tested with the weights applied at the center of the exposed hose resulting in symmetrical loading since the fittings are the same length at each end. The resulting curve, Figure 4, gives the false notion that the hoses are allowed to be "stiffer" when the proposed acceptance curves are compared to the former curves. However, the curves are comparing two different hose configurations using two different application positions of the weights.

FORCE VS DEFLECTION – "FLEX DEVICE METHOD"

The next graph, Figure 5, shows the results using the flex test device at 70°F. The hoses are tested in gladhand x male pipe configuration. The application of weights greater than 11 pounds fully "kinked" the hoses. Based on this data, the TAG determined that the application of a weight of 9 pounds would be the acceptable limit at which the hose must *not* Kink.

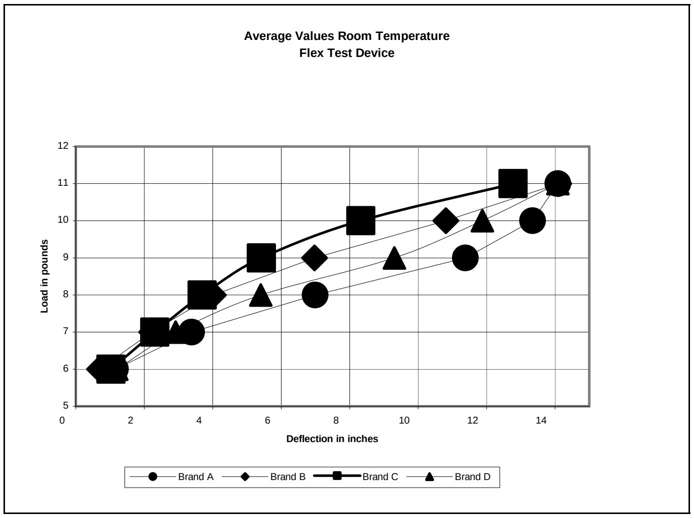

Figure 5: Room Temperature Results for Flex Test Device Method

Figure 5A: Shows scale on Flex Device for measuring deflection

Figure 6, shows the test results using the flex test device at -55°F.

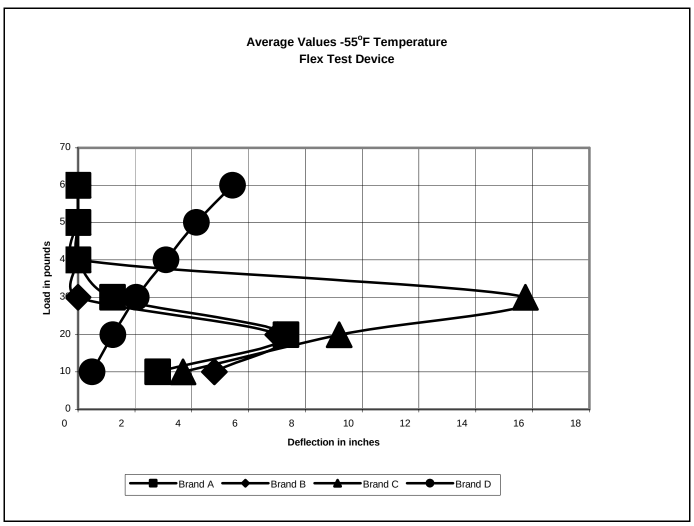

Figure 6: Test Results, Flex Test Device, –55°F

All hoses, except the Brand D hose, deflected to a certain position and then "kinked". The common method used to couple a hose is to "kink" the hose nearest you and then pull the other hose to you and couple the gladhands. The ability to "kink" a hose in extreme cold weather is very necessary for the carmen. The Brand D hose never kinked, and remained extremely stiff. The load at which the hoses "kinked" on hose Brands A thru C was at weights exceeding 30 pounds; any deflection measurement after the hose fully "kinked" was recorded as Zero. As a result of this test, the failure criteria for the cold flex test was simplified to a applied load of 40 pounds, and the hose *must* then kink**.**

DISCUSSION OF RESULTS

The test data from the suspension method (male pipe x male pipe) compares favorably with the current acceptance curves for 70°F and –55°F, see Figure 3, with the exception of Brand A and Brand D. Brand A's curve displayed a different slope than Brands B to D. This can be attributable to the variations in compound and hose construction among the hose manufacturers.

Referring to the gladhand x male pipe configuration, Figure 1A to Figure 1C, tested at 70°F, all hose Brands performed similarly, see Figure 4. However, for the –55°F test, hose Brand D did not perform as well as Brands A to C. Based on the former acceptance curve, the ideal hose would deflect from 2.5 inches min. at 30 lbs up to 6.5 inches min. at 70 lbs and exhibit an average total deflection of 4 inches. The origin of the former curve derivation is unknown.

Brand D remained very stiff during the deflection test, did not meet the minimum deflection at 30 lbs on up to 70 lbs, and exhibited an average total deflection of 2.03 inches. Brands A to C all met the minimum deflection points at each corresponding weight. Brand A's total deflection was 3.92 inches, Brand B's total deflection was 3.13 inches, and Brand C's total deflection was 3.18 inches.

The test data from the flex device test method (gladhand x male pipe), performed at 70°F is plotted and shown in Figure 5. At the lighter loads (6 to 11 lbs), all hose Brands performed similarly. The plotted curves have similar shapes. However, for the –55°F test, Figure 6, hose Brand D did not perform as well as Brands A to C.

Hose Brand D remained very stiff throughout the test and did not "kink" as the others did. These results agree with the results obtained via the suspension method at –55°F for both hose configurations (male/male & gladhand/male).

CONCLUSION

The carman's ability to bend or "kink" hoses, as he moves down the train coupling hoses together, is seen to be the limiting factor in determining acceptability of the hose. If this is so, then it would follow that if an acceptable force is determined for bending or "kinking" hoses at a given temperature, then a much simpler hose qualification test could be devised that would not require the use of a walk-in cold room. This would satisfy the BSC request for a revised specification for end hoses that would allow for compliance testing on the standard product rather than specially prepared test samples as required by the former specification.

The new test method utilizing the flex test device provides a means to accomplish the BSC request, without the expense of a walk-in cold chamber and a test crew. These benefits more than offset the cost to manufacture the new test device. Strato has granted usage rights to the AAR and provided manufacturing drawings for the new device that can be obtained by contacting the AAR directly.

Following the successful completion of the tests, the BSC accepted the Hose Tag recommendation to amend Spec. M-601 to include the new hose flex device method of determining acceptable flexibility.

-55F, gladhand/male
Average Deflection, inches, based on 10 samples

		30 lb	40 lb	50 lb	60 lb	70 lb	Total Deflection
Brand A	Avg	2.95	3.99	5.06	5.93	6.87	3.92
	Std Dvn	0.42	0.52	0.63	0.76	0.88	
	Min	2.31	3.19	3.94	4.88	5.56	
	Max	3.63	4.88	5.94	7	8.19	
	AAR M601	2.5	3.5	4.5	5.5	6.5	4
Brand B	Avg	4.63	5.76	6.66	7.29	7.76	3.13
	Std Dvn	0.79	0.84	0.83	0.86	0.88	
	Min	3.440	4.500	5.440	6.000	6.38	
	Max	5.440	6.690	7.500	8.130	8.63	
	AAR M601	2.5	3.5	4.5	5.5	6.5	4
Brand C	Avg	4.13	5.24	6.15	6.79	7.31	3.18
	Std Dvn	0.390	0.380	0.410	0.370	0.37	
	Min	3.500	4.690	5.500	6.250	6.81	
	Max	4.690	5.880	6.810	7.375	7.94	
	AAR M601	2.5	3.5	4.5	5.5	6.5	4
Brand D	Avg	0.95	1.42	1.97	2.48	2.98	2.03
	Std Dvn	0.220	0.310	0.390	0.500	0.61	
	Min	0.440	0.810	1.380	1.630	2	
	Max	1.250	1.880	2.380	3.060	3.69	
	AAR M601	2.5	3.5	4.5	5.5	6.5	4

70F, gladhand/male
Average Deflection, inches, based on 10 samples

		30 lb	40 lb	50 lb
Brand A	Avg	6.894	7.969	8.469
	Std Dvn	0.2	0.21	0.21
	Min	6.69	7.38	7.88
	Max	7.06	7.75	8.25
	AAR M601	5.8 - 7.25	7.0 - 8.5	7.75 - 9.25
Brand B	Avg	6.975	7.981	8.663
	Std Dvn	0.52	0.47	0.33
	Min	6.060	7.130	8.060
	Max	7.810	8.560	9.060
	AAR M601	5.8 - 7.25	7.0 - 8.5	7.75 - 9.25
Brand C	Avg	6.175	7.293	8.225
	Std Dvn	0.190	0.330	0.290
	Min	5.750	6.880	7.880
	Max	6.440	8.060	8.630
	AAR M601	5.8 - 7.25	7.0 - 8.5	7.75 - 9.25
Brand D	Avg	6.85	7.538	8.025
	Std Dvn	0.130	0.140	0.140
	Min	6.690	7.380	7.880
	Max	7.060	7.760	8.260
	AAR M601	5.8 - 7.25	7.0 - 8.5	7.75 - 9.25

Test Data used for plotting the deflection curves are shown below.

SUSPENSION METHOD
Test Data for Figures 3-4

-55F, male/male
Average Deflection, inches, based on 10 samples

		30 lb	40 lb	50 lb	60 lb	70 lb	Total Deflection
Brand A	Avg	4.638	6.288	8.544	10.15	10.925	6.287
	Std Dvn	0.57	0.69	1.25	0.65	0.54	
	Min	3.563	4.875	6.375	9.375	10.375	
	Max	5.25	7	10.438	11.063	12.313	
	AAR M601	6	7	8	9	10	4
Brand B	Avg	6.431	8.006	9.106	9.875	10.488	4.057
	Std Dvn	0.56	0.42	0.36	0.32	0.29	
	Min	5.750	7.375	8.500	9.250	10.125	
	Max	7.313	8.625	9.625	10.250	10.875	
	AAR M601	6	7	8	9	10	4
Brand C	Avg	6.356	7.769	8.956	9.875	10.244	3.888
	Std Dvn	0.600	0.510	0.640	0.640	0.53	
	Min	5.250	6.938	8.250	8.625	9.688	
	Max	7.250	8.625	10.500	10.813	11.375	
	AAR M601	6	7	8	9	10	4
Brand D	Avg	1.869	2.863	3.975	5.05	5.894	4.025
	Std Dvn	0.320	0.440	0.610	0.810	0.65	
	Min	1.375	2.125	2.938	3.813	4.75	
	Max	2.313	3.500	4.688	5.875	6.625	
	AAR M601	6	7	8	9	10	4

70F, male/male
Average Deflection, inches, based on 10 samples

		30 lb	40 lb	50 lb
Brand A	Avg	9.225	9.756	10.05
	Std Dvn	0.56	0.43	0.36
	Min	8.125	8.813	9.25
	Max	9.875	10.188	10.375
	AAR M601	8.25 - 9.25	9.4 - 10.5	10.125 -11.25
Brand B	Avg	9.156	10.118	10.5
	Std Dvn	0.61	0.40	0.28
	Min	8.125	9.313	10.000
	Max	10.000	10.563	10.813
	AAR M601	8.25 - 9.25	9.4 - 10.5	10.125 -11.25
Brand C	Avg	8.306	9.713	10.369
	Std Dvn	0.380	0.350	0.120
	Min	7.938	9.250	10.125
	Max	9.313	10.188	10.563
	AAR M601	8.25 - 9.25	9.4 - 10.5	10.125 -11.25
Brand D	Avg	8.406	9.05	9.488
	Std Dvn	0.260	0.210	0.210
	Min	8.063	8.813	9.250
	Max	9.000	9.563	10.000
	AAR M601	8.25 - 9.25	9.4 - 10.5	10.125 -11.25

FLEX TEST DEVICE METHOD
Test Data for Figures 5- 6

70F, gladhand/male
Average Deflection, inches, based on 10 samples

		6 lb	7 lb	8 lb	9 lb	10 lb	11 lb
Brand A	Avg	1.163	3.388	6.994	11.379	13.343	14.08
	Std Dvn	0.65	1.22	2.62	2.92	2.14	0.62
	Min	0.438	2.063	4.5	7.188	8.875	12.75
	Max	2.75	6.375	14	14.3	14.7	14.7
	AAR M601	HOSE MUST NOT KINK AT 9 LBS					
Brand B	Avg	0.694	2.213	4.019	6.969	10.809	14.11
	Std Dvn	0.40	0.43	0.71	2.84	3.68	0.95
	Min	0.125	1.625	3.000	4.500	6.5	11.5
	Max	1.438	2.813	5.125	14.000	14.5	14.8
	AAR M601	HOSE MUST NOT KINK AT 9 LBS					
Brand C	Avg	1.031	2.306	3.694	5.419	8.331	12.773
	Std Dvn	0.240	0.370	0.540	0.850	2.43	2.57
	Min	0.688	1.750	3.063	4.250	5.875	7.438
	Max	1.438	2.750	4.375	6.438	14	14.6
	AAR M601	HOSE MUST NOT KINK AT 9 LBS					
Brand D	Avg	1.2	2.913	5.4	9.308	11.875	14.08
	Std Dvn	0.560	0.750	1.160	2.750	2.04	0.7
	Min	0.438	1.875	3.750	7.000	8.938	12.25
	Max	2.313	4.500	7.750	14.200	14.3	14.7
	AAR M601	HOSE MUST NOT KINK AT 9 LBS					

-55F, gladhand/male
Average Deflection, inches, based on 10 samples

		10 lb	20 lb	30 lb	40 lb	50 lb	60 lb
Brand A	Avg	2.806	7.325	1.213	0	0	0
	Std Dvn	0.64	1.63	3.83	0	0	0
	Min	2.063	5.25	0	0	0	0
	Max	4	10.5	12.125	0	0	0
	AAR M601	HOSE MUST KINK AT 40 LBS - MAX CAM ROTATION					
Brand B	Avg	4.794	7.025	0	0	0	0
	Std Dvn	1.14	6.26	0	0	0	0
	Min	3.750	0	0	0	0	0
	Max	7	14.750	0	0	0	0
	AAR M601	HOSE MUST KINK AT 40 LBS - MAX CAM ROTATION					
Brand C	Avg	3.7	9.19	1.58	0	0	0
	Std Dvn	0.490	1.340	4.98	0	0	0
	Min	3.125	7.375	0	0	0	0
	Max	4.500	11.750	15.750	0	0	0
	AAR M601	HOSE MUST KINK AT 40 LBS - MAX CAM ROTATION					
Brand D	Avg	0.494	1.225	2.05	3.094	4.163	5.438
	Std Dvn	0.440	0.700	0.920	1.050	1.2	1.47
	Min	0.063	0.500	1.125	2.063	3	3.75
	Max	1.250	2.250	3.500	5	6.125	7.75
	AAR M601	HOSE MUST KINK AT 40 LBS - MAX CAM ROTATION					

Note: Value "0" denotes hose fully Kinked.

ACKNOWLEDGMENTS

Ellcon National - Provided use of walk-in cold chamber and testing participation.
Hose TAG – Group review of proposed and final testing procedures.
NYAB - Provided use of walk-in cold chamber and testing participation.
Premtec - Testing participation.
Strato, Inc. - Conception, design and development of the “Cobden Flex Test Device”, and testing participation.
TTCI - Test witnessing and test participation.

REFERENCES

[1] *AAR Manual of Standards and Recommended Practices, Section E, Standard M-601*, Adopted: 1903, Revised: 2006, pp. E-10 – E-11.

[2] *AAR Manual of Standards and Recommended Practices, Section E, Former Standard M-601*, Adopted: 1903, Revised: 2002, pp. E-10