



[Click here](#) for a recording of the presentation.

# Brake Hose and Tube Testing

Austin Squire

Test Engineer – Product Testing



# Presenters



**Austin Squire, presenter**  
Test Engineer  
330-762-7441  
[asquire@smithers.com](mailto:asquire@smithers.com)



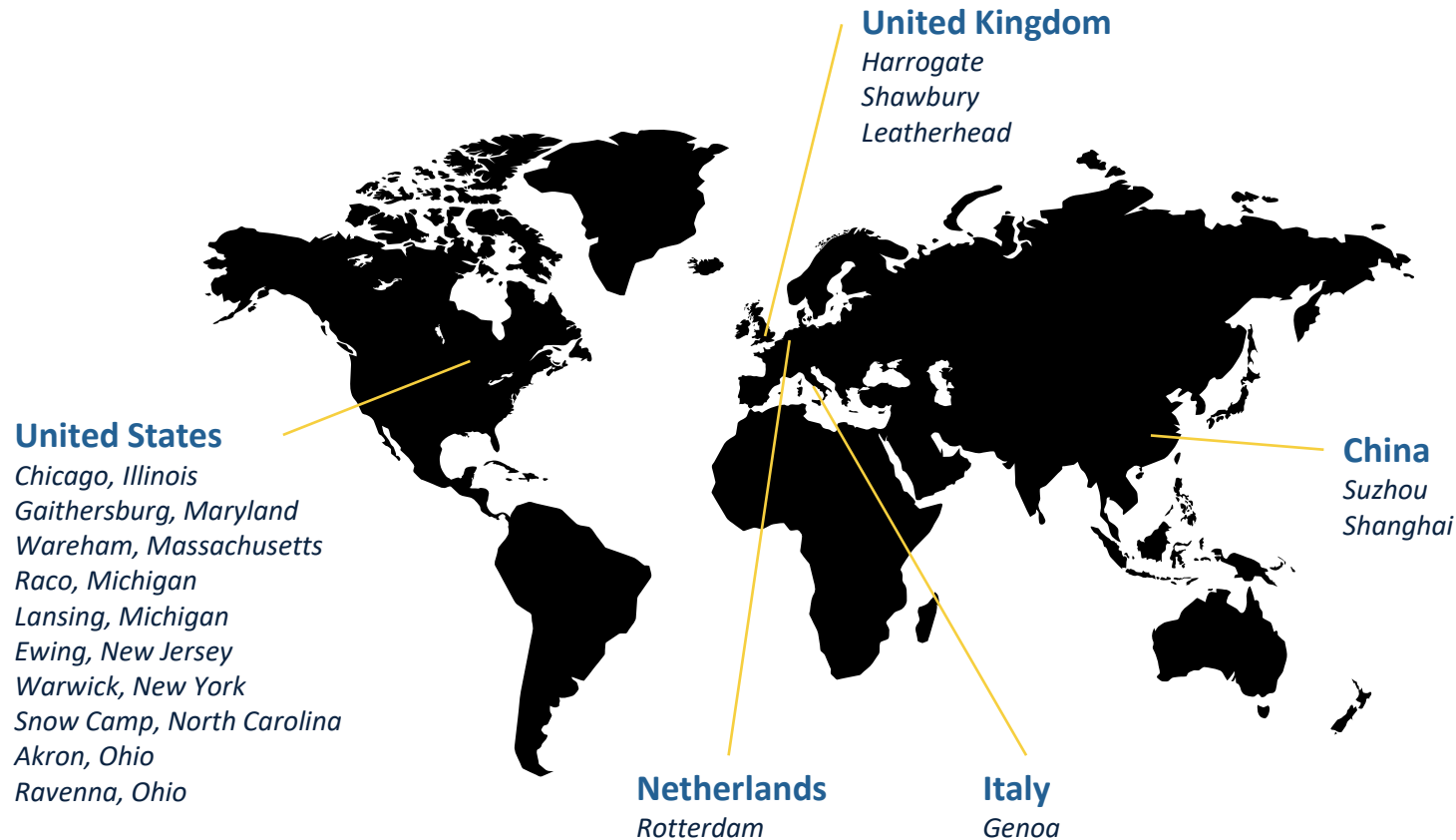
**Todd Hain, moderator**  
Director of Marketing  
330-762-7441  
[thain@smithers.com](mailto:thain@smithers.com)

# Agenda / Framework

- Smithers overview
- Brief background
- FMVSS 106 Testing Overview
  - Air Brake Hose Testing
  - Hydraulic Brake Hose Testing
  - Vacuum Brake Hose Testing
  - Air Brake Tube Testing
- Common failure modes, etc.
- Thoughts on Braking of the Future: Electronic / regenerative braking - how does this change the system (electronic feedback / sensors)
  - What testing / validation may be required? FMVSS 135
- Summary

# Smithers: Trusted Global Partner

Independent third-party **laboratory testing** and **consulting**  
Incisive **strategic consulting**, **market forecasting** and **events**



Successfully operating for  
**95 years**



**900+** employees



**World-class** facilities and  
expertise



**Continual investment**  
in scientific and engineering  
talent



Scientists and engineers who  
are **experts** in their field

# Smithers: Who We Are

Portfolio of trusted services - providing clients with the **clarity and confidence** to make the **right technical and business decisions** for over **95 years**



## DRY COMMODITIES

Surveying and Inspection Services



## INFORMATION

Strategic intelligence and events



## MATERIALS

Materials science and engineering



## ENVIRONMENTAL

Product registration and safety



## PHARMACEUTICAL

Drug development services



## QUALITY

Auditing and certification services



## MEDICAL

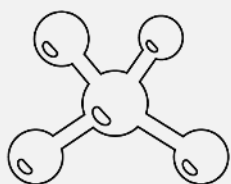
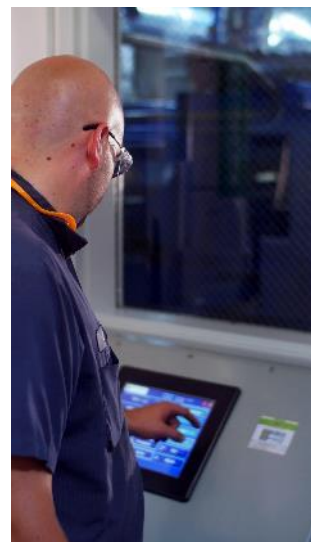
Device and pharmaceutical product testing



## CANNABIS, CBD, & HEMP

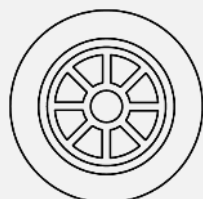
Testing Services

# Materials Science and Engineering Division



## Materials Science

Material chemistry & physical properties testing



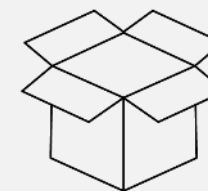
## Product Testing & Validation

Accelerated life cycle testing  
Regulatory & industry-based validation testing



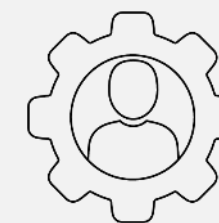
## Winter Proving Ground

Vehicle system validation  
Snow & ice traction testing  
Product launch & demo events



## Distribution/Packaging

Package testing  
Transit & supply chain evaluations



## Technical Consulting

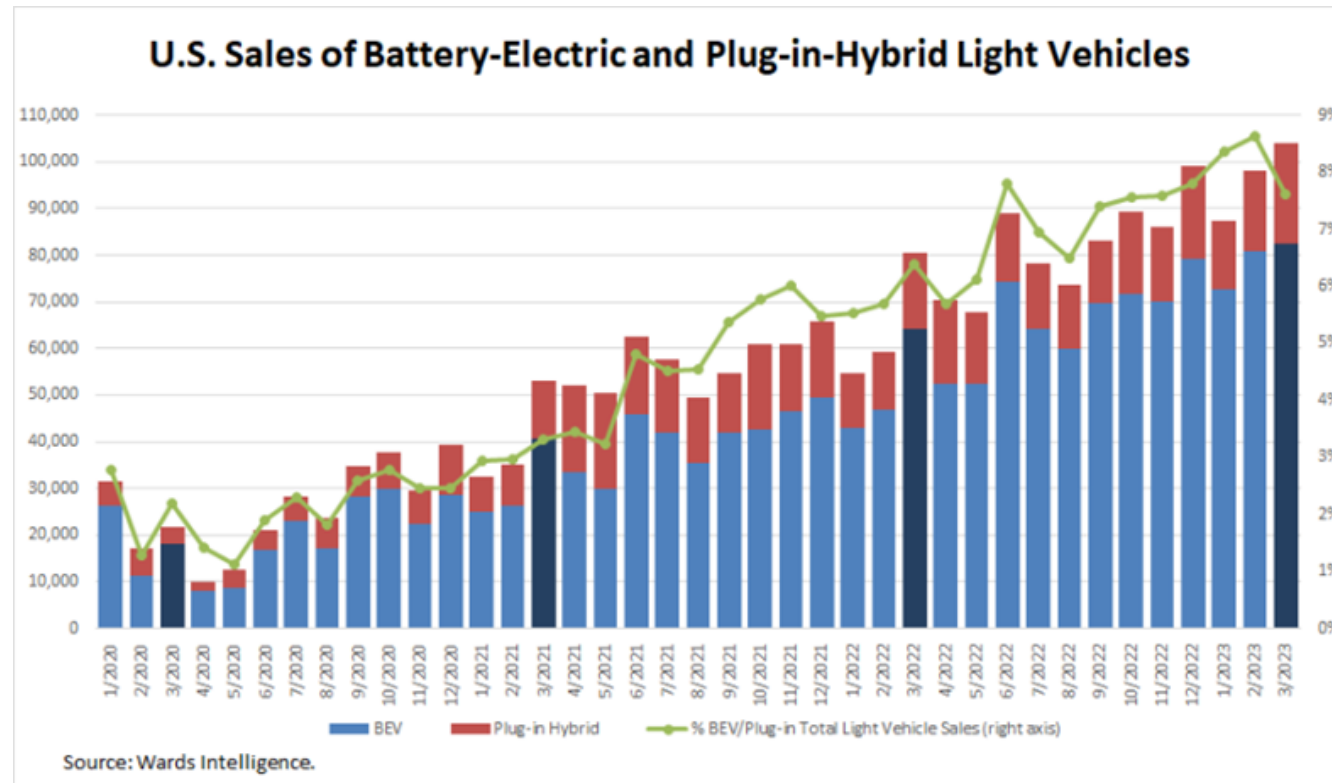
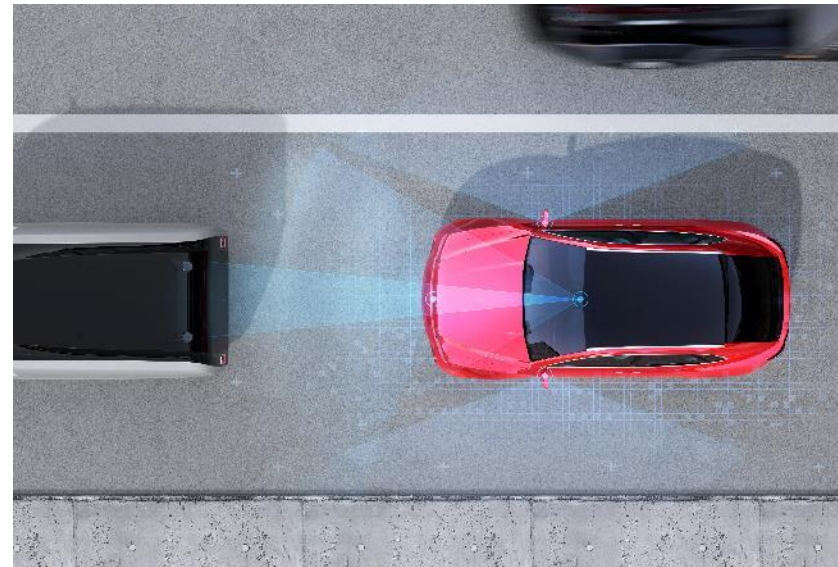
Failure analysis  
Benchmarking & performance analysis



# Overview

# Background

- Key braking systems cross multiple vehicle types
  - Passenger vehicles
  - Light trucks
  - Commercial vehicles, trucks, and trailers
- Automotive trends
  - Overall production volumes have been steadily growing since 2020, but not back to pre-pandemic levels
  - Electrification is growing quickly (now 7%+ of market)
  - ADAS improvements and rollouts integrated with brake systems
    - Requires integration points and quick reaction times driving tech development





# Standards and What's Required

- US Department of Transportation - FMVSS 106
  - Purpose: "To reduce deaths and injuries" due to failure of braking system caused by pressure or vacuum loss from hoses, tubes, connectors, etc.
  - Standard applies for any vehicle from passenger vehicles to truck and trailer.
  - Covers hydraulic/air brake hoses, tubes, and end fittings testing.

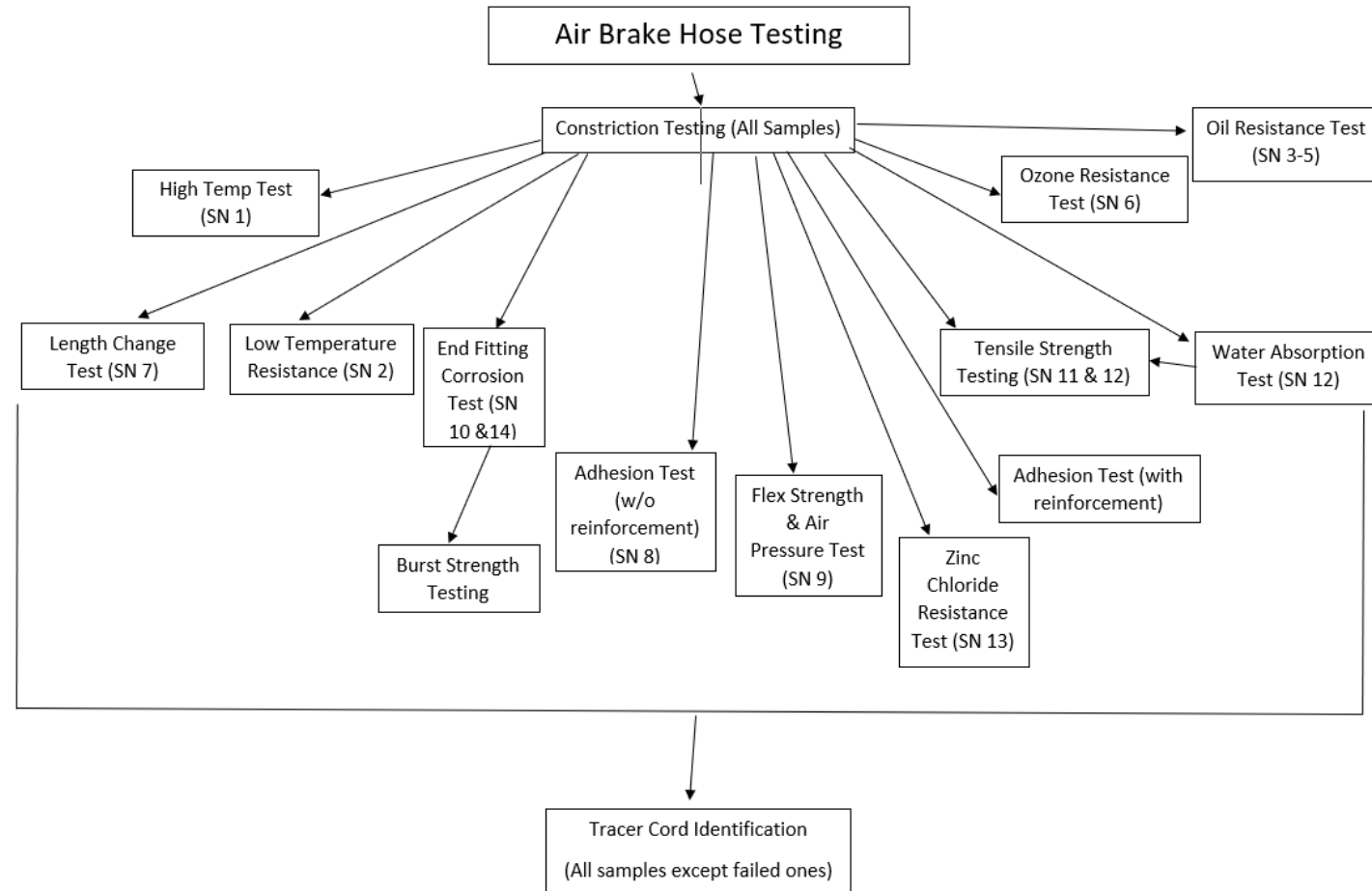




# Air Brake Hoses

# Air Brake Hose Testing

- 12.B.2. Constriction Testing (pre-test)
  - All samples are tested.
  - A ball that is 66% of the nominal diameter is dropped through the hose.
  - Gravity-induced fall
  - 1 in/s rate average.
  - Failure: Does not exit at the other end and doesn't fall at that rate.



# Air Brake Hose Testing

- 12.B.3. High Temp Test (Sample #1)
  - Wrap the brake hose around test cylinder specified in the table to the right.
  - Soak for 70 hours at 212 °F.
  - After the soak, remove and allow to cool then straighten.
- 12.B.4. Low Temp Resistance Test (Sample #2)
  - Same duration soak but at -40 °F in straight orientation.
  - After soak, it is then wrapped around a mandrel specified to the right while still cold.
- Acceptance criteria: No cracks shall be present on or inside the hose.

High Temperature Test Table

HOSE NOMINAL I.D. (mm)	TEST CYLINDER RADIUS
3/16" (4,5)	1" (25)
1/4" (6)	1½" (38)
5/16" (8)	1¾"
3/8" (-)	1¾"
13/32" (10)	1 7/8"
7/16", 1/2" (12)	2"
5/8"	2½"

Low Temperature Test Table

HOSE NOMINAL I.D. (mm)	TEST CYLINDER RADIUS
3/16" (4,5)	2" (51)
1/4" (6)	2½" (64)
5/16" (8)	3" (76)
3/8" (-)	3½" (89)
13/32" (10)	3½" (89)
7/16", 1/2" (12)	4" (102)
5/8"	4½" (114)

# Air Brake Hose Testing

- 12.B.5. Oil Resistance Test (Sample 3-5)
  - Section inner layer of hose:
    - Size: 2"x 3/8" with a thickness  $\leq 1/16$ "
    - Our sample prep team can cut these.
  - Measure initial weight of each specimen in water and air.
  - The specimens will then be immersed in
    - ASTM IRM 903 Oil
    - Duration: 70 hours
    - Temperature: 212 °F
  - Measure final weights and calculate percent increase in volume.

# Air Brake Hose Testing

- 12.B.6. Ozone Resistance Test (Sample #6)
  - Precondition at RT for 24 hours.
  - Wrap around specified mandrel. Then condition for 70 hours at:
    - 104 °F
    - Air/ozone mix: 100 parts of ozone per 100 million parts air.
  - Acceptance Criteria: No visible cracks.
- 12.B.7. Length Change Test (Sample #7)
  - Apply 10 psig of air to hose assembly then measure the free length.
  - Raise air pressure to 200 psig and measure free length.

HOSE NOMINAL I.D. (mm)	TEST CYLINDER RADIUS
3/16" (4,5)	2" (51)
1/4" (6)	2½" (64)
5/16" (8)	3" (76)
3/8" (-)	3½" (89)
13/32" (10)	3½" (89)
7/16", 1/2" (12)	4" (102)
5/8"	4½" (114)



# Air Brake Hose Testing

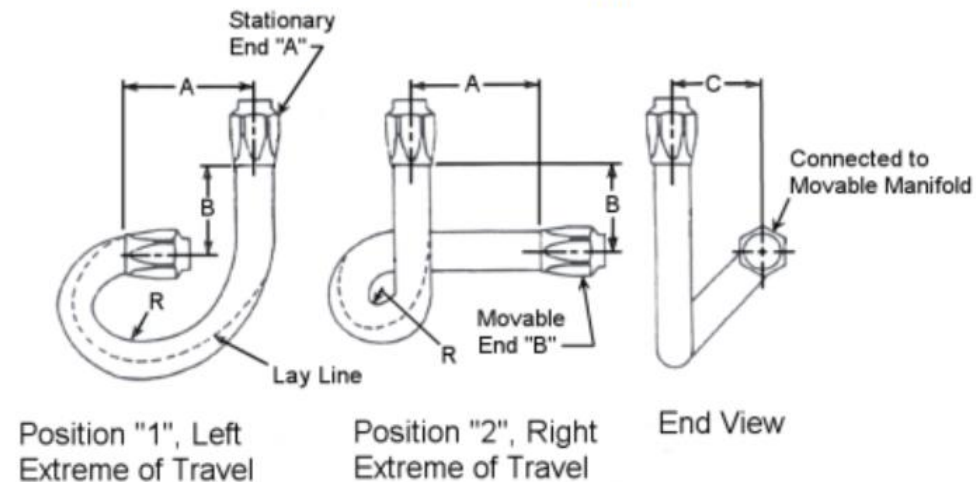
- Adhesion Test
  - 12.B.8. w/o reinforcement wire
    - Record sample length
    - Cut the layer of the hose to be tested.
    - Peel the layer to be tested to create a flap which will be pulled by a tensile tester.
    - Minimum force recorded in the initial and final 20 percent of displacement is adhesion value (lbf/in).
  - 12.B.15. With reinforcement:
    - A ball is placed in the hose.
      - Diameter is 73% of nominal ID.
    - Apply 25 inHg of vacuum.
    - Bend hose 180 degrees around specified mandrel, then bend it the other way.
    - With vacuum still applied, straighten the hose and roll the ball to the other end using gravity.

HOSE NOMINAL I.D. (mm)	TEST CYLINDER RADIUS
3/16" (4,5)	2" (51)
1/4" (6)	2½" (64)
5/16" (8)	3" (76)
3/8" (-)	3½" (89)
13/32" (10)	3½" (89)
7/16", 1/2" (12)	4" (102)
5/8"	4½" (114)

# Air Brake Hose Testing

- 12.B.9. Flex Strength & Air Pressure Test (Sample #9)
  - Sample must undergo salt spray/heat soak prior to this test.
  - Brake hose assembly is mounted in an orientation as shown in the right.
  - During flex, assembly also undergoes from 0-150 psi impulse.
    - Frequency: 0.5 cycles/minute
  - Assembly undergoes a million flex cycles.

**Figure 7. Flex Test Apparatus**



Free Hose Length	Nominal Hose Inside Diameter	Dimensions							
		Position "1"				Position "2"			
		A	B	C	R <sup>(1)</sup>	A	B	C	R <sup>(1)</sup>
10.00 (254)	3/16, 1/4	3.00 (76)	2.75 (70)	3.75 (95)	1.40 (34)	3.00 (76)	2.75 (70)	3.75 (95)	1.20 (30)
11.00 (279)	5/16, 3/8, 13/32	3.00 (76)	3.50 (89)	4.50 (114)	1.70 (43)	3.00 (76)	3.50 (89)	4.50 (114)	1.30 (33)
14.00 (355)	7/16, 1/2, 5/8	3.00 (76)	4.00 (102)	5.00 (127)	2.20 (56)	3.00 (76)	4.00 (102)	5.00 (127)	1.80 (46)

Note (1) This is an approximate average radius.



# Air Brake Hose Testing

- 12.B.10. End Fitting Corrosion Test (Sample #10 & #14)
  - 24-hour salt spray exposure (5 parts NaCl 95 parts water).
  - Chamber temperature of 95°F.
  - Acceptance criteria: No evidence of corrosion on end fitting.
- 12.B.10. Burst Strength Testing (Sample #10)
  - End fitting corrosion precedes.
  - Hydrostatic pressure rise until the hose bursts.
  - Rate ~1,000 psi/minute



# Air Brake Hose Testing

- 12.B.12. Water Absorption Test (Sample 12)
  - Hose assembly is immersed in room temperature water for 70 hours.
  - Immediately after follows tensile strength testing.
- 12.B.11. Tensile Strength Testing (Sample 11 & 12)
  - Hose assembly is pulled axially until failure occurs.
    - Pull Rate: 1 in  $\pm$  0.1 in/minute
  - Failure criteria:
    - Separation of hose from end fittings.
    - Failure of hose structure.
  - Yield Strength Criteria is shown in the table to the right.



Vehicle Application	ALLOWABLE TENSILE STRENGTH			
	I.D. $\leq$ ¼ "	I.D. $>$ ¼ "	¼" $<$ I.D. $\leq$ ½ "	I.D. $<$ ½"
Between frame and axle	250 lbs	325 lbs	-	-
Other	50 lbs	-	150 lbs	325 lbs

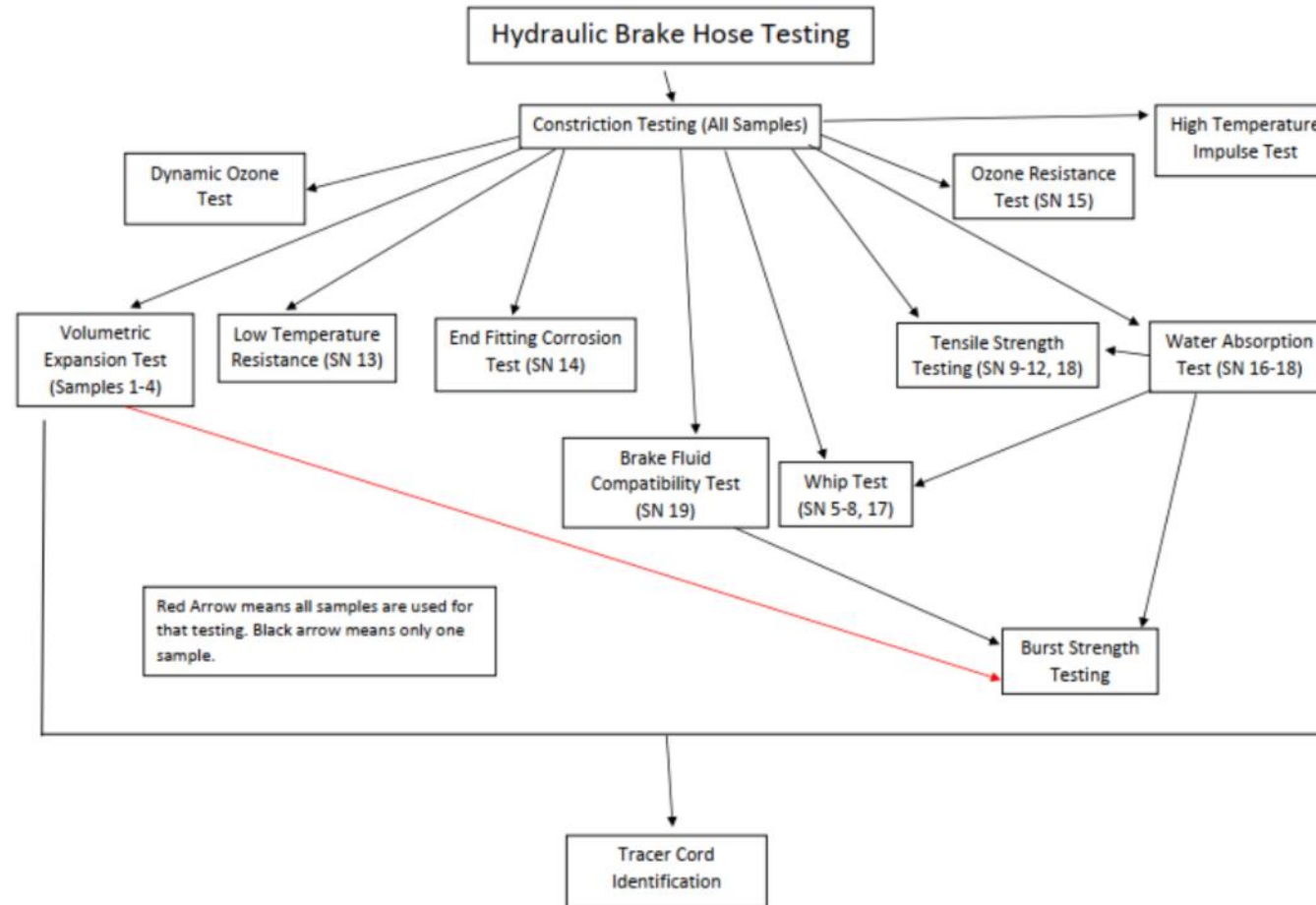
# Air Brake Hose Testing

- 12.B.13. Zinc Chloride Resistance Test (Sample 13)
  - 50-50 Zinc Chloride Water Immersion
  - 200-hour duration at room temperature
  - Followed by examination for cracks under a microscope at 7-power magnification.
- 12.B.16. Tracer Cord Identification
  - All hoses except failed samples undergo this test.
  - Remove a section of the outer cover to expose the braid to identify the color of the tracer cord.



# Hydraulic System Requirements

# Validation may Be Required



# Similar Tests Between Air/Hydraulic Brake Hose Testing

- 12.A.2. Constriction Test
  - Difference: Steel ball's diameter is 64% of nominal ID.
- 12.A.9. Ozone Resistance Test
- 12.A.8. End Fitting Corrosion Test
- 12.A.7. Low Temperature Resistance:
  - Difference:
    - Temperature: -49 °F to -54 °F
    - Mandrel Sizes: See the right
- 12.A.10. Water Absorption Test:
  - Difference:
    - Temperature: 185 °F (+0 °F -2 °F)
- 12.A.6. Tensile Strength Test:
  - Difference: Procedure is slightly different
    - Supplier chooses either slow or fast pull
      - Slow pull: 1 in/min rate with minimum UYS of 325 lb.
      - Fast Pull: 2 in/min rate with minimum UYS of 370 lb.
- 12.A.14. Tracer Cord Identification

<b>HOSE I.D.</b>	<b>MANDREL DIAMETER (+ 0.03", -0")</b>
Less than 1/8"	2.50"
1/8"	3.00"
3/16" and 1/4"	3.50"
Greater than 1/4"	4.00"

# Hydraulic Brake Hose Testing

- 12.A.4. Burst Strength Testing
  - Apply hydrostatic pressure to the hose assembly.
    - Rate: 15,000 psi/min
    - ID > 1/8" or 3 mm:
      - 4,000 psi hold for 2 minutes
      - Then increase until pressure exceeds 5,000 psi
    - ID ≤ 1/8" or 3 mm:
      - 4,000 psi hold for 2 minutes
      - Then increase until pressure exceeds 7,000 psi



# Hydraulic Brake Hose Testing

**TABLE  
MAXIMUM EXPANSION OF FREE LENGTH BRAKE HOSE (cc/ft)**

I.D.	Test Pressure					
	1,000 psi		1,500 psi		2,900 psi	
	Regular expansion hose	Low expansion hose	Regular expansion hose	Low expansion hose	Regular expansion hose	Low expansion hose
1/8 in (or 3mm) or less	0.66	0.33	0.79	0.42	1.21	0.61
>1/8in (or 3mm) to 3/16in (or 5mm)	0.86	0.55	1.02	0.72	1.67	0.91
>3/16in(or 5mm)	1.04	0.82	1.30	1.17	Not applicable	Not applicable

- 12.A.3. Volumetric Expansion
  - Mount hose in a vertical position with a ball valve and burette at the top.
  - Pressurize hose to 1,000 psig and hold for 3 seconds then open the ball valve to the burette.
    - Record hose expansion and repeat 3 times.
    - Average is the hose's expansion.
  - Repeat this for 1,500 and 2,900 psig.
- Acceptance Criteria: Expansion should be less than or equal to the values listed in the table on the right.





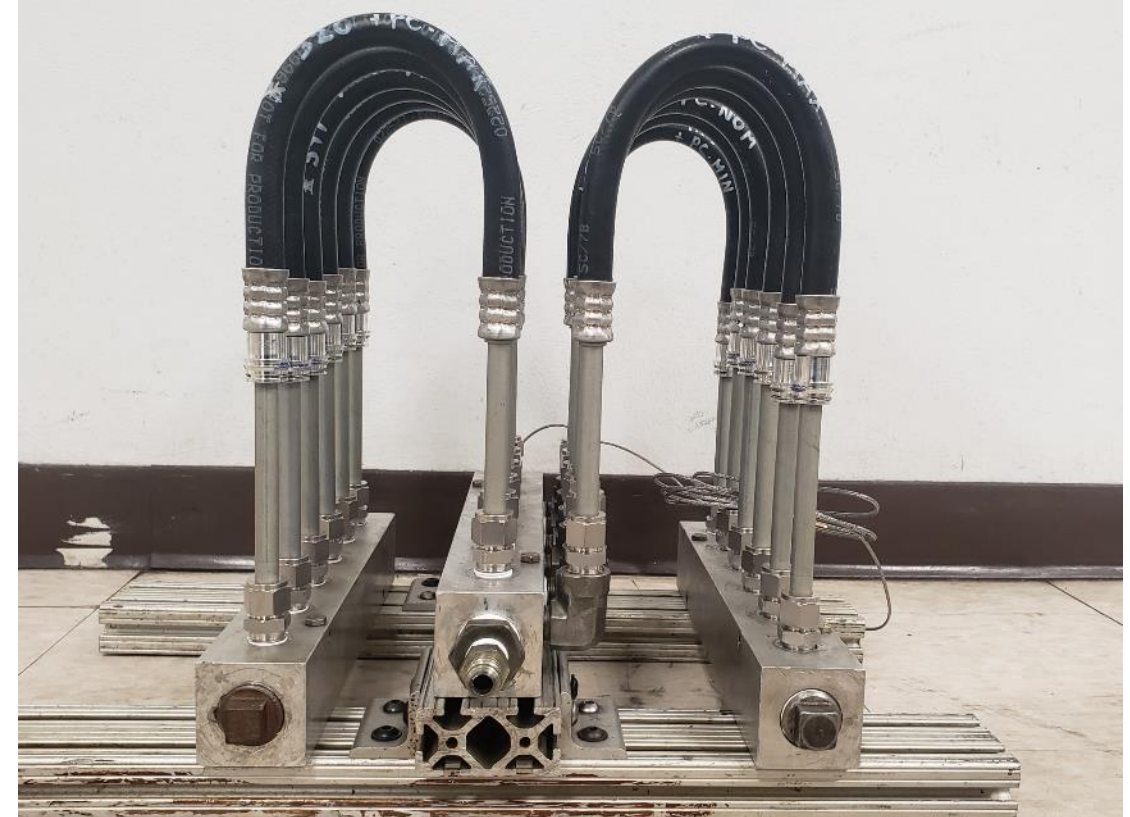
# Hydraulic Brake Hose Testing

- 12.A.11. Brake Fluid Compatibility Test
  - Fluid: 100 ml of SAE RM-66-07
  - Heat Aging to follow
    - Temperature: 248 °F
    - Duration: 70 hours
  - Then the fluid is drained, and constriction test follows.
  - Then immediately followed by 12.A.4. Burst Strength Testing.
    - Exception: After 2-minute hold raise the pressure to 5,000 psig regardless of hose size.



# Hydraulic Brake Hose Testing

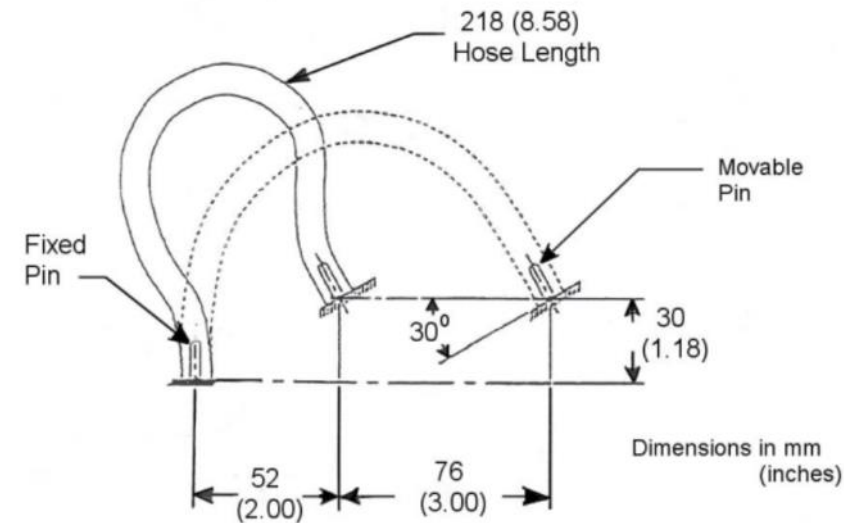
- 12.A.12. High Temperature Impulse Test:
  - Pressures: 0-1600 psig
  - Fluid: SAE RM-66-07
  - Frequency: 0.5 cycle/min
  - Chamber Temperature: 295 °F
  - Test to 150 cycles
  - Follow with Burst Strength Testing
    - Exception: After 2-minute hold increase to 5,000 psig regardless of hose size.



Not in this orientation. Samples are in a straight orientation.

# Hydraulic Brake Hose Testing

- 12.A.13. Dynamic Ozone Test:
  - Cut the hose assembly to 8.6 inches without end fittings.
  - Mount the hose to a fixture and expose it to...
    - Chamber Temperature: 104 °F
    - 100/1,000,000 ozone to air by volume.
    - 0.3 Hz Vibration Cycling
    - Duration: 48 hours
  - Examine for cracks after exposure.



# Hydraulic Brake Hose Testing

- 12.A.5. Whip Test: (Samples 5-8 & 17)
  - Prior to start of testing, free length is measured.
    - Hoses that are less than 8" or more than 24" free length do not need tested.
  - Install hose to machine with specified slack.
  - Test procedure:
    - 220-235 psig hydrostatic
    - Motor speed: 780-800 rpm
    - Duration: 35 hours

**TABLE - HOSE LENGTHS**

Free Length Between End Fittings, inches	SLACK	
	1/8" hose (3 mm) or less	More than 1/8" hose (3 mm)
8 to 15½, inclusive	1.750"	No Test
Over 15½ to 19, inclusive	1.250"	No Test
Over 19 to 24, inclusive	0.750"	No Test
10 to 15½, inclusive		1.000"

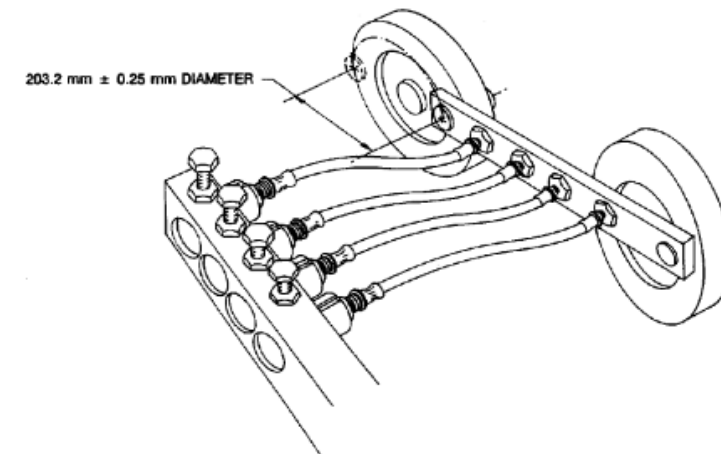
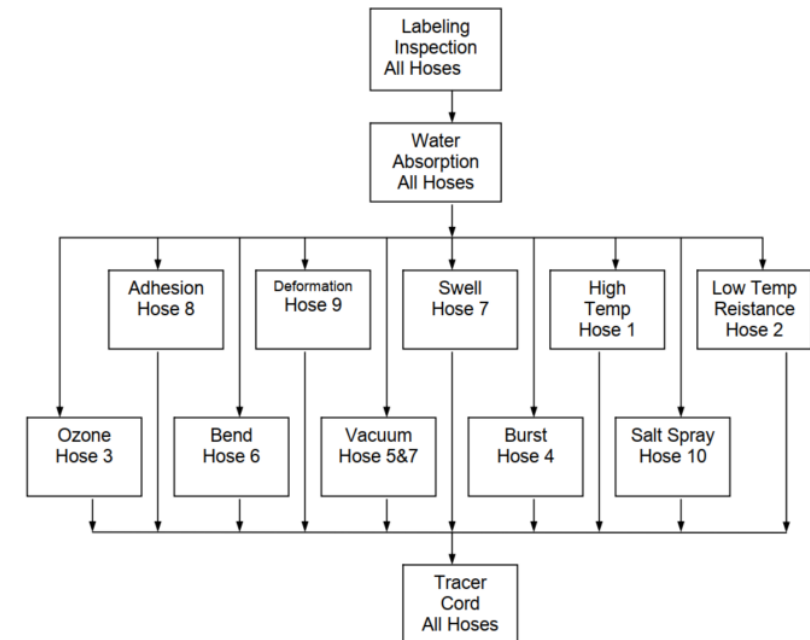


FIGURE 4—WHIP TEST MACHINE

# Vacuum Brake Hose Testing

- Similarities with other types:
  - 12.C.2. Constriction
    - Difference: Ball Diameter
  - 12.C.4. Low Temperature Resistance Test (12.B.4.)
    - Difference: Conduct pressure test afterwards per 12.C.3. section E.
  - 12.C.5. Ozone Test (12.A.9.)
  - 12.C.6. Burst Test (12.A.4.)
    - Difference: Allowable Burst Strength: 350 psig
  - 12.C.12. Salt Spray Test (12.A.8.)
  - 12.C.13. Tracer Cord Identification (12.A.14.)

Hose Inside Dia. (I.D.)	High Temperature Resistance		High Temperature Resistance		Bend		Deformation-Collapsed Inside Dia. (Dimen. D)
	Hose Length	Dia. of Cylinder (+.03,-0)	Hose Length	Dia. of Cylinder (+.03,-0)	Hose Length	Max. Collapse of Outside Dia. (O.D.)	
7/32"	8"	3"	17.5"	6"	7"	11/64"	3/64"
1/4"	9"	3"	17.5"	6"	8"	3/32"	1/16"
9/32"	9"	3.5"	19"	7"	9"	12/64"	4/64"
11/32"	9"	3.5"	19"	7"	11"	13/64"	5/64"
3/8"	10"	3.5"	19"	7"	12"	5/32"	3/32"
15/32"	11"	4"	20.5"	8"	14"	17/64"	5/64"
1/2"	11"	4"	20.5"	8"	16"	7/32"	1/8"
5/8"	12"	4.5"	22"	9"	22"	7/32"	5/32"
3/4"	14"	5"	24"	10"	28"	7/32"	3/16"
1"	16"	6.5"	28.5"	13"	36"	9/32"	1/4"



# Vacuum Brake Hose Testing

- 12.C.3. High Temperature Resistance Test
  - Apply 26 in Hg vacuum to the hose and condition at...
    - 257 °F for 96 hours.
  - Remove to room temp and relieve vacuum.
  - Measure minimum OD within 5 minutes.
  - Cool for 5 hours at RT.
  - Bend the hose around a mandrel 5 times initial OD. Examine for cracks or degradation.
  - Then apply 175 psi of water pressure to the hose and hold for 1 minute and check for leaks.

# Vacuum Brake Hose Testing

- 12.C.7 Vacuum Test
  - Record OD before
  - Apply 25-26 inHg vacuum for 5 minutes.
  - Measure minimum OD with vacuum still applied.
  
- 12.C.8 Bend Test
  - Record OD at point A before and after the test.
  - Bend brake hose around specified cylinder then relieve it.
  - The difference is the collapse
  - Acceptance criteria: Collapse < Collapse Max

Fig. 6 - Bend Test of Vacuum Brake Hose.

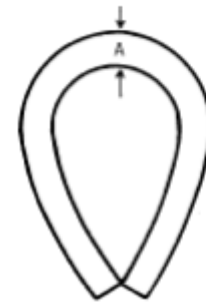
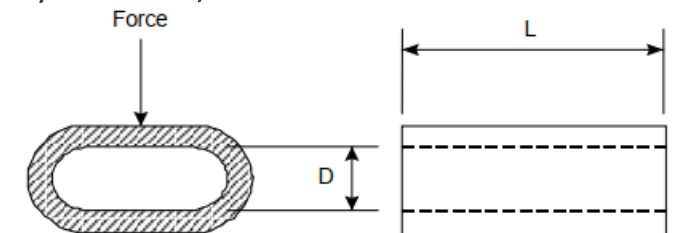


TABLE II - VACUUM BRAKE HOSE TEST REQUIREMENTS							
Hose Inside Dia. (I.D.)	High Temperature Resistance		High Temperature Resistance		Bend		Deformation-Collapsed Inside Dia. (Dimen. D)
	Hose Length	Dia. of Cylinder (+.03,-0)	Hose Length	Dia. of Cylinder (+.03,-0)	Hose Length	Max. Collapse of Outside Dia. (O.D.)	
7/32"	8"	3"	17.5"	6"	7"	11/64"	3/64"
1/4"	9"	3"	17.5"	6"	8"	3/32"	1/16"
9/32"	9"	3.5"	19"	7"	9"	12/64"	4/64"
11/32"	9"	3.5"	19"	7"	11"	13/64"	5/64"
3/8"	10"	3.5"	19"	7"	12"	5/32"	3/32"
15/32"	11"	4"	20.5"	8"	14"	17/64"	5/64"
1/2"	11"	4"	20.5"	8"	16"	7/32"	1/8"
5/8"	12"	4.5"	22"	9"	22"	7/32"	5/32"
3/4"	14"	5"	24"	10"	28"	7/32"	3/16"
1"	16"	6.5"	28.5"	13"	36"	9/32"	1/4"

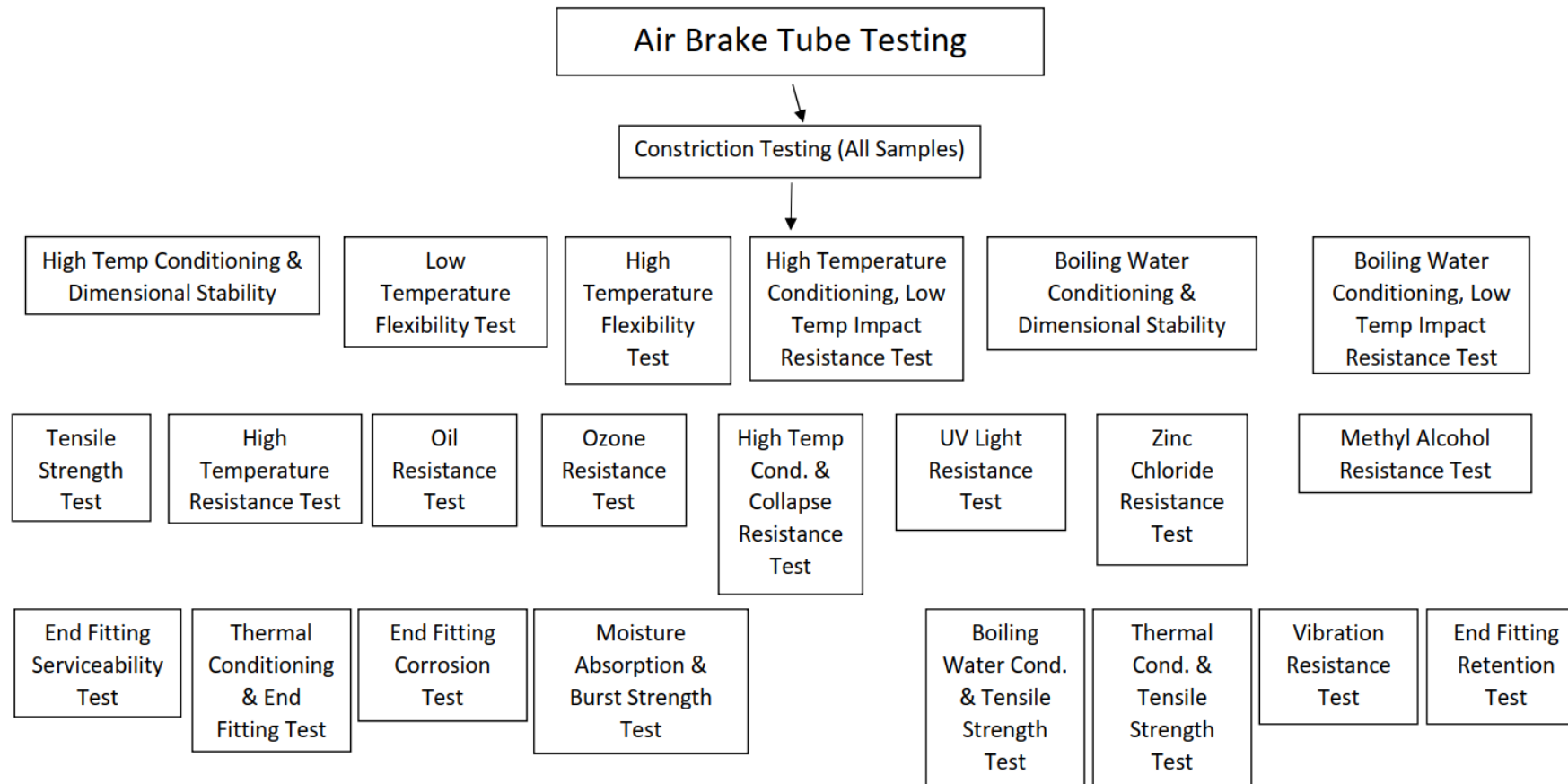
# Vacuum Brake Hose Testing

- 12.C.9 Swell & Adhesion Test
  - Fill 12" long hose with oil and condition...
    - Duration 48 hours
    - At standard atmospheric conditions
    - Fluid: ASTM Reference Fuel B (ASTM D471-98e)
  - Remove fuel and conduct constriction test
  - Apply 26 inHg vacuum for 10 minutes.
  - For vacuum hoses with 2 or more layers conduct adhesion test without wire.
- 12.C.11. Deformation Test
  - Gradually apply force to the hose until D is obtained.
  - After 5 seconds release and record the peak load and repeat 4 times.
  - Acceptance Criteria:
    - Hose returns to 90% of the original OD.
    - First application should not be higher than 50 lbs (Heavy Duty 70 lbs).
    - Fifth application should be at least 20 lbs (Heavy Duty 40 lbs)





# Air Brake Tube Testing



# Similarities between other types

- 12.D.2. Constriction Test
  - 66% of nominal ID size ball.
- 12.D.5. Burst Strength Test (12.B.10.)
  - Difference: Rate is 3,000 psi/min until specified burst pressure in the table.
- 12.D.13. Zinc Chloride Resistance Test (12.B.13.)
  - Exceptions: Bend tube 180 deg around cylinder and hold for immersion.
- 12.D.14. Methyl Alcohol Resistance Test (12.D.13.)
  - Exceptions: Bath is 95 percent methyl alcohol solution.
- 12.D.16. Ozone Resistance Test (12.B.6.)
- 12.D.17. Oil Resistance Test (12.B.5.)
  - Exceptions: The temperature is 200 F. Followed by 12.D.5.
- 12.D.18. Tensile Strength Test (12.A.6.)
- 12.D.25. End Fitting Corrosion Test (12.A.8.)

TABLE III - PLASTIC AIR BRAKE TUBING MECHANICAL PROPERTIES

Nominal Tubing OD	Burst Strength Pressure		Supported Bend Radius <sup>1</sup>		Unsupported Bend Radius <sup>2</sup>		Conditioned Tensile Load	
	kPa	Psi	mm	inches	mm	inches	N	lbf
1/8 inch	6900	1000	9.4	0.37	9.4	0.37	156	35
5/32 inch	8300	1200	12.7	0.50	12.7	0.50	178	40
3/16 inch	8300	1200	19.1	0.75	19.1	0.75	222	50
1/4 inch	8300	1200	25.4	1.00	25.4	1.00	222	50
5/16 inch	6900	1000	31.8	1.25	38.1	1.50	334	75
3/8 inch	9700	1400	38.1	1.50	38.1	1.50	667	150
1/2 inch	6600	950	50.8	2.00	63.5	2.50	890	200
5/8 inch	6200	900	63.5	2.50	76.2	3.00	1446	325
3/4 inch	5500	800	76.2	3.00	88.9	3.50	1557	350
6 mm	7600	1100	20.0	0.75	25.4	1.00	222	50
8 mm	6200	900	31.8	1.25	38.1	1.50	334	75
10 mm	8200	1200	38.1	1.50	38.1	1.50	667	150
12 mm	6900	1000	44.5	1.75	63.5	2.50	890	200
16 mm	6000	875	69.9	2.75	76.2	3.00	1446	325

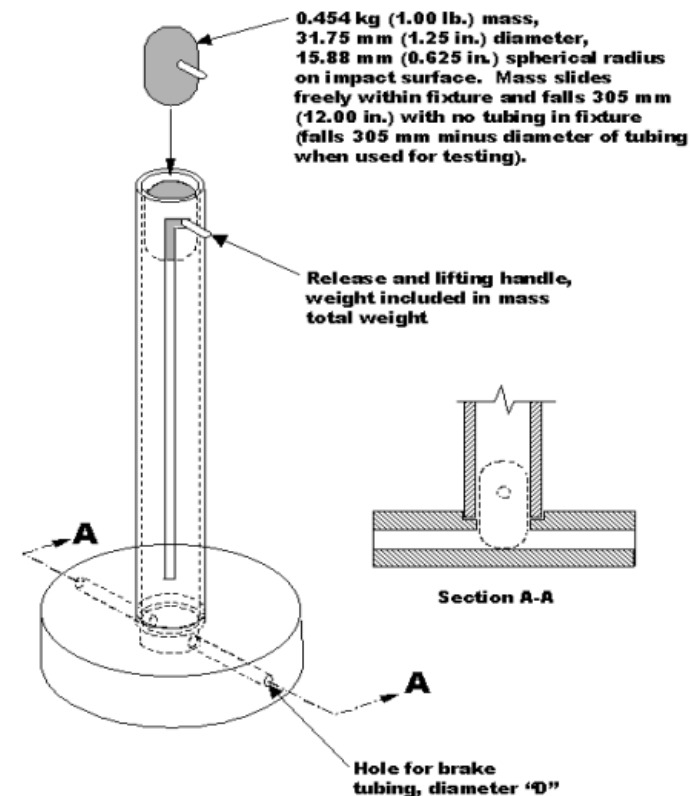
# Air Brake Tube Testing

- 12.D.3. High Temperature Conditioning
  - Temperature: 230 °F
  - Duration: 4 hours
  - Dimensional Stability to follow cooling.
- 12.D.4. Boiling Water Conditioning
  - Place tubing in boiling water for 2 hours.
  - Cool then Dimensional Stability follows.
- Dimensional Stability:
  - Measure tubing ID, OD, and wall thickness.

# Air Brake Tube Testing

- 12.D.6. Moisture Absorption & Burst Strength Test
  - Condition at 230 °F for 24 hours then weigh sample.
  - Then condition at 100 percent humidity for 100 hours at 75 °F
  - Remove moisture and weigh the sample.
  - Calculate percentage of moisture absorption
  - Followed by Burst Testing per 12.D.5.
    - Except go to 80% of rated burst strength.
- 12.D.7. UV Light Resistance Test
  - Tubing is subjected to UV irradiance of 0.85 W/m<sup>2</sup> at 340 nanometers.
    - At atmospheric humidity and a temperature of 113 °F for 300 hours.
  - Impact Testing follows

- Impact Testing
  - Place tube in apparatus and drop mass on it.
  - 12.D.5. Burst to follow with exception.



# Air Brake Tube Testing

- 12.D.8. Low Temperature Flexibility Test
  - Condition at..
    - 230 °F for 24 hours
    - Then -40 °F for 4 hours
      - Both tubing and cylinder
  - Afterwards bend the tubing 180 degrees around the cylinder.
- 12.D.9. High Temperature Flexibility Test
  - Bend tube around cylinder (table) and hold.
  - Condition tubing for 72 hours at 230 °F
    - Cool then straighten tube and re-bend around in opposite direction.
  - Conduct 12.D.5. Burst Strength Testing
    - Exception: 80% of burst strength



# Air Brake Tube Testing

- 12.D.10. High Temperature Resistance Test
  - Condition tube at 230 °F for 72 hours followed by 12.D.5. Burst Strength Testing.
    - Exception: 80% of rated burst strength.
- 12.D.11. High Temperature Cond.
  - Follow 12.D.10. conditioning but no burst.
  - Cool then follows Low Temperature Impact Resistance Testing.
- 12.D.12. Boiling Water Conditioning
  - Follow 12.D.4. conditioning then follows Low Temperature Impact Testing.
- Low Temperature Impact Test
  - Condition impact tester from 12.D.7. and tube at -40 °F for 4 hours.
  - Drop ball on tube at cold temp.
  - Warm for 1 hour and burst test per 12.D.5.

# Air Brake Tube Testing

- 12.D.15. High Temperature Conditioning & Collapse Resistance Test
  - Cut tubes to length from formula:
$$l = 3.14r_{unsupported} + 10D_{outer\ nom} + 2\ inches$$
  - Measure OD and make a reference mark.
  - Install tubing to apparatus and condition for 24 hours at 230 °F.
  - Allow to cool and measure final OD.
  - Calculate the percentage collapse of the hose.

# Air Brake Tube Testing

- 12.D.19. Boiling Water Conditioning and Tensile Strength Test
  - At lower attachment point of tensile tester is an open top container capable of heating.
  - Fill container with water and heat to boil.
  - Attach tubing to the apparatus and allow to boil for 5 minutes.
  - Then begin pulling the tube at a 1 inch/min until...
    - Table III condition tensile load is met
    - Or free length of tube reaches 9 inches (3 inches of total stretch)
- 12.D.20. Thermal Conditioning and Tensile Strength Test
  - Similar criteria to 12.D.19.
  - Except temperature cycling and conditioning prior to pull.
  - 4 cycles are to be completed of the following:
    - -40 °F for 30 minutes then warm for 30 minutes
    - Immerse in boiling water for 15 minutes then cool for 30 minutes.





# Air Brake Tube Testing

- 12.D.21. Vibration Resistance Test
  - Tubes are to be 18 inches in free length.
  - Install tubing to a shaker in straight orientation with close to ½ inch of slack.
  - Apply 120 psi of compressed air for duration of test.
  - Vibrate tubes at 10 Hz between +/- ¼".
  - Temperature cycling as follows:
    - 220 °F from 0-250,000 cycles
    - -40 °F from 250,000-500,000 cycles
    - 220 °F from 500,000-750,000 cycles
    - -40 °F from 750,000-1,000,000 cycles
  - Prior to the end record leak rates during cold.
  - Record leak rates at room temperature
  - Criteria: No leakage passed 50 ccm at cold and 25 ccm at room temperature. Also, retention nut shall not lose less than 20% original torque.

# Air Brake Tube Testing

- 12.D.22. End Fitting Retention Test
  - This is a leak test using water.
  - Increase pressure at...
    - Rate of 3,000 psi/min
    - Raise to 50% of rated burst strength (Table III). Hold for 30 seconds.
    - Then raise to rated burst.
- 12.D.23. Thermal Conditioning and End Fitting Retention Test
  - Plug one end and fill with ASTM IRM 903 oil.
  - Temperature cycle as follows:
    - 200 °F for 24 hours
      - At the end, pressurize to 450 psi and hold for 5 minutes. Then relieve the pressure.
    - Then set to 75 °F for 1 hour.
    - Next set chamber to -40 °F for 24 hours.
      - At the end, 450 psi and hold for 5 minutes. Then relieve the pressure.

TABLE III - PLASTIC AIR BRAKE TUBING MECHANICAL PROPERTIES

Nominal Tubing OD	Burst Strength Pressure		Supported Bend Radius <sup>1</sup>		Unsupported Bend Radius <sup>2</sup>		Conditioned Tensile Load	
	kPa	Psi	mm	inches	mm	inches	N	lbf
1/8 inch	6900	1000	9.4	0.37	9.4	0.37	156	35
5/32 inch	8300	1200	12.7	0.50	12.7	0.50	178	40
3/16 inch	8300	1200	19.1	0.75	19.1	0.75	222	50
1/4 inch	8300	1200	25.4	1.00	25.4	1.00	222	50
5/16 inch	6900	1000	31.8	1.25	38.1	1.50	334	75
3/8 inch	9700	1400	38.1	1.50	38.1	1.50	667	150
1/2 inch	6600	950	50.8	2.00	63.5	2.50	890	200
5/8 inch	6200	900	63.5	2.50	76.2	3.00	1446	325
3/4 inch	5500	800	76.2	3.00	88.9	3.50	1557	350
6 mm	7600	1100	20.0	0.75	25.4	1.00	222	50
8 mm	6200	900	31.8	1.25	38.1	1.50	334	75
10 mm	8200	1200	38.1	1.50	38.1	1.50	667	150
12 mm	6900	1000	44.5	1.75	63.5	2.50	890	200
16 mm	6000	875	69.9	2.75	76.2	3.00	1446	325

# Air Brake Tube Testing

- 12.D.24. End Fitting Serviceability Test
  - Assemble the retention nut on the other end and disassemble this. This will be repeated 3 times then a leak test is to follow.
  - Pressurize with 120 psi of air, check for leaks. If there is one record the leak rate.

# Common Failure Modes

- Leaks at the end fittings/crimps during and post temperature/vibration cycling.
- Collapse of hoses during temperature cycling or fluid compatibility tests.
- Breakdown of reinforcement material causing leaks.
- Kinking that results in compromised liners and covers
- Deterioration from environmental effects and aging (Ozone/UV)



# Electronic / Regenerative Braking

# Electronic/Regenerative Braking

- Brake lines and other components essential for this type of braking as well.
- Electronic/regenerative braking is gaining market share as it used in electric/hybrid vehicles to convert braking energy to charge batteries.
- Concepts like using a gear box when the gas is let off to make the electric motors rotate in the opposite direction to act as a generator.
- This is only partial braking; this can decrease wear on braking components.

# Summary

- FMVSS 106 covers multiple types of brake hose/tubing and their end fitting connections.
- Testing by this standard is good for when you need to validate any material deviations you may have or run quality audits on production samples.
- There are other standards out there for brake hose/tube testing (i.e. SAE and OEM specs)
- It is best to run as many samples as you can per test, good rule of thumb is triplicate testing.
  - From a statistical standpoint more samples equal better results to get a running average to exclude anomalies and determine root cause failures.
- Many of the different types of brake hoses/tubing have similar tests in their standards.

# Questions? Get in touch:



**Jeremy Jackson**  
Supervisor of Product Testing  
330-762-7441  
jjackson@smithers.com



**Jeff Andrasik**  
General Manager of Product Testing  
330-762-7441  
jandrasik@smithers.com



# Contact us

## Materials Science and Engineering Division

### EUROPE

Shawbury, Shrewsbury  
Shropshire  
SY4 4NR  
United Kingdom  
+44 (0) 1939 250383

Cleeve Road  
Leatherhead  
Surrey, KT22 7RU  
United Kingdom  
+44 (0) 1372 802000

### NORTH AMERICA

425 West Market Street  
Akron, OH 44303  
+1 (330) 762-7441

526 South Main Street  
Suite 820  
Akron, Ohio 44311  
+1-(330) 762-7441

1150 North Freedom St.  
Ravenna, Ohio 44266  
+1 (330) 762-7441

6539 Westland Way, Suite 24  
Lansing, MI 48917  
+1 (517) 322-2400

21105 W. M-28  
Brimley, MI 49715-9122  
Winter Season Telephone: (906)  
248-5557

### CHINA

Building F, Phase II Plainvim Industry Park  
45 Chunxing Road  
Xiangcheng Economic and Technical Development Zone  
Jiangsu, China 215143  
+86 512.6253.0073





**SMITHERS**

INNOVATE WITH CONFIDENCE