Swagelok Company
29500 Solon Road
Solon, Ohio 44139 U.S.A.

TITLE

Helium Gas Seal Test with Repeated Reassembly of 4ABT, 6ABT, 8ABT, 6MABT, 8MABT, 10MABT, and 12MABT Series Stainless Steel Swagelok® Assembly-by-Torque (AbT) Tube Fitting Assembled to Stainless Steel Tubing with Alternating Torque

PRODUCT TESTED

Fractional

Ordering Number	Description	Part Form	ABT Hardware Set	Stainless Steel Tubing Size in.	Tubing Hardness HRB
1/4 in.					
SS-400-1-4BO	Male Connector	Bar stock	SS-4ABT- NFSET	1/4 × 0.028	77
SS-400-9BO	Male Elbow	Forging			
SS-400-7-4BO	Female Connector	Bar stock	SS-4ABT- NFSET	1/4 × 0.035	78
SS-400-9BO	Male Elbow	Forging			
SS-400-6BO	Male Union	Bar stock			
SS-400-3BO	Male Tee	Forging			
SS-400-7-4BO	Female Connector	Bar stock	SS-4ABT- NFSET	1/4 × 0.049	77
SS-400-9BO	Male Elbow	Forging			
SS-400-6BO	Male Union	Bar stock			
SS-400-3BO	Male Tee	Forging			
3/8 in.					
SS-600-6BO	Union	Bar stock	SS-6ABT-NFSET	3/8 × 0.049	85
SS-600-9BO	Male Elbow	Forging			
SS-600-6BO	Union	Bar stock	SS-6ABT-NFSET	3/8 × 0.065	74
SS-600-9BO	Male Elbow	Forging			
1/2 in.					
SS-810-6BO	Union	Bar stock	SS-8ABT-NFSET	1/2 × 0.049	80
SS-810-9BO	Male Elbow	Forging			
SS-810-6BO	Union	Bar stock	SS-8ABT-NFSET	1/2 × 0.065	81
SS-810-9BO	Male Elbow	Forging			
SS-810-6BO	Union	Bar stock	SS-8ABT-NFSET	1/2 × 0.083	79
SS-810-9BO	Male Elbow	Forging			

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PRODUCT TESTED

Metric

Ordering Number	Description	Part Form	ABT Hardware Set	Stainless Steel Tubing Size mm	Tubing Hardness HRB
6mm					
SS-6M0-7-4BO	Female Connector	Bar stock	SS-6MABT-NFSET	6 × 1.0	82
SS-6M0-9BO	Male Elbow	Forging			
SS-6M0-6BO	Male Union	Bar stock			
SS-6M0-3BO	Male Tee	Forging			
8 mm					
SS-8M0-6BO	Union	Bar stock	SS-8MABT-NFSET	8 × 1.0	80
SS-8M0-9BO	Male Elbow	Forging			
SS-8M0-6BO	Union	Bar stock	SS-8MABT-NFSET	8 × 1.2	80
SS-8M0-9BO	Male Elbow	Forging			
10 mm					
SS-10M0-6BO	Union	Bar stock	SS-10MABT-NFSET	10 × 1.0	80
SS-10M0-9BO	Male Elbow	Forging			
SS-10M0-6BO	Union	Bar stock	SS-10MABT-NFSET	10 × 1.5	82
SS-10M0-9BO	Male Elbow	Forging			
12 mm					
SS-12M0-6BO	Union	Bar stock	SS-12MABT-NFSET	12 × 1.5	81
SS-12M0-9BO	Male Elbow	Forging			
SS-12M0-6BO	Union	Bar stock	SS-12MABT-NFSET	12 × 1.8	83
SS-12M0-9BO	Male Elbow	Forging			

PURPOSE

The assemblies were tested under laboratory conditions to observe the gas seal reassembly performance of the 4ABT, 6ABT, 8ABT, 6MABT, 8MABT, 10MABT, and 12MABT series stainless steel Swagelok tube fitting when assembled to stainless steel tubing using a specified torque.

TEST CONDITIONS

Original test dates: August 2016, November 2019, and October 2020.

- Each tubing assembly tested consisted of one tube length and two fittings.
- Tube assemblies were preswaged and assembled into fitting bodies according to *Assembly-by-Torque (AbT) Fittings* catalog, MS-02-466.
- The tube assemblies were reassembled alternating between the minimum and maximum reassembly torques according to *Assembly-by-Torque (AbT) Fittings* catalog, MS-02-466.
- Tests were conducted at room temperature.

TEST METHOD

1. All nuts and ferrules were preswaged onto the tubing before assembling into the fitting bodies.
2. The test assemblies were attached to a gas test stand, submerged in water, pressurized with helium to the test pressure for 10 minutes, and then monitored for leakage.
   - The test pressure was at least 1.5 × working pressure for the 4ABT and 6MABT series.
   - The test pressure was at least 1.25 × working pressure for the 6ABT, 8ABT, 8MABT, 10MABT, and 12MABT series.
3. The acceptance criteria was as follows:
   - The acceptance criteria for the 4ABT and 6MABT series was leakage less than a maximum leak rate of 15 cm^3/h (4.2 × 10–3 std cm^3/s), based on the UNECE Regulation No. 110 requirement. If leakage exceeded the maximum leak rate, the leak was noted, and the following steps were performed:
     i. The test end was re-tightened to the specified torque plus 13 in.·lb (1.5 N·m) to confirm maximum torque, and retested for 10 minutes at 1.5 times working pressure. If the end still exceeded the maximum leak rate, the end failed the test criteria.
     ii. If, after retesting, the end met the leak requirements of UNECE R110, the end passed the test criteria.
   - The acceptance criteria for the 6ABT, 8ABT, 8MABT, 10MABT, and 12MABT series. was leakage less than 1 bubble per minute at the applied pressure. If leakage exceeded the maximum leak rate, the leak was noted, and the following steps were performed:
     i. The test assembly was disassembled, examined for any contamination, and reassembled to the same torque. The assembly was retested for 10 minutes at 1.25 times working pressure. If the leak persisted, the next step was employed.
     ii. The end was depressurized and tightened slightly, to ensure minimal additional advancement. If the end still exceeded the maximum leak rate, the end failed the test criteria.
     iii. If, after retesting, the end met the leak requirement, the end passed the test criteria.
4. After monitoring, pressure was reduced to zero and the fittings were disassembled.
5. The tube assemblies were reassembled alternating between the minimum and maximum reassembly torques.
6. The fittings were disassembled and reassembled according to steps 4 and 5 a total of 25 times.
   i. 4ABT and 6MABT series samples were leak tested at the reassembly intervals of 1, 2, 3, 5, 6, 9, 10, 13, 16, 20, and 25.
   ii. 6ABT, 8ABT, 8MABT, 10MABT, and 12MABT series samples were leak tested at each reassembly.

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TEST RESULTS
Fractional

Stainless Steel	Tubing Size in.	Ordering Number	End Tested	Working Pressure psig (bar)	Test Pressure psig (bar)	Results
1/4 in.						
316/316L	1/4 × 0.028	SS-400-1-4BO	16	4000 (275)	6000 (413)	Pass
		SS-400-9BO	16			Pass
316/316L	1/4 × 0.035	SS-400-7-4BO	8	5100 (351)	7650 (526)	Pass
		SS-400-9BO	8			Pass
		SS-400-6BO	8			Pass
		SS-400-3BO	8			Pass
316/316L	1/4 × 0.049	SS-400-7-4BO	6	7500 (516)	11 250 (774)	Pass
		SS-400-9BO	6			Pass
		SS-400-6BO	6			Pass
		SS-400-3BO	6			Pass
3/8 in.						
316/316L	3/8 × 0.049	SS-600-6BO	18	4800 (330)	6000 (413)	Pass
		SS-600-9BO	18			Pass
	3/8 × 0.065	SS-600-6BO	12	6500 (447)	8125 (559)	Pass
		SS-600-9BO	12			Pass
1/2 in.						
316/316L	1/2 × 0.049	SS-810-6BO	12	3700 (254)	4625 (318)	Pass
		SS-810-9BO	12			Pass
	1/2 × 0.065	SS-810-6BO	6	5100 (351)	6375 (439)	Pass
		SS-810-9BO	6			Pass
	1/2 × 0.083	SS-810-6BO	12	6700 (461)	8375 (576)	Pass
		SS-810-9BO	12			Pass

TEST RESULTS

Metric

Stainless Steel	Tubing Size mm	Ordering Number	End Tested	Working Pressure psig (bar)	Test Pressure psig (bar)	Results
6mm						
316/316L	6 × 1.0	SS-6M0-7-4BO	8	6092 (419)	9138 (629)	Pass
		SS-6M0-9BO	8			Pass
		SS-6M0-6BO	8			Pass
		SS-6M0-3BO	8			Pass
8 mm						
316/316L	8 × 1.0	SS-8M0-6BO	12	4500 (310)	5625 (388)	Pass
		SS-8M0-9BO	12			Pass
316/316L	8 × 1.2	SS-8M0-6BO	12	5100 (351)	6375 (439)	Pass
		SS-8M0-9BO	12			Pass
10 mm						
316/316L	10 × 1.0	SS-10M0-6BO	12	3480 (239)	4350 (300)	Pass
		SS-10M0-9BO	12			Pass
316/316L	10 × 1.5	SS-10M0-6BO	32	5100 (351)	6375 (439)	Pass
		SS-10M0-9BO	32			Pass
12 mm						
316/316L	12 × 1.5	SS-12M0-6BO	12	4790 (330)	5987 (413)	Pass
		SS-12M0-9BO	12			Pass
316/316L	12 × 1.8	SS-12M0-6BO	32	5100 (351)	6375 (439)	Pass
		SS-12M0-9BO	32			Pass

The stainless steel tube fitting demonstrated both initial assembly gas seal and repeated gas seal through 25 reassemblies at 1.25 times the working pressure, under laboratory conditions.

The tests were conducted beyond the product's recommended operating parameters and do not modify the product ratings.

These tests were performed to consider a specific set of conditions and should not be considered valid outside those conditions. Swagelok Company makes no representation or warranties regarding these selected conditions or the results attained. Laboratory tests cannot duplicate the variety of actual operating conditions. Test results are not offered as statistically significant. See the product catalog for technical data.

SAFE PRODUCT SELECTION

When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Referenced Document

UNECE, *Addenda to the 1958 Agreement (Regulation No. 110), CNG and LNG vehicles,* United Nations Economic Commission for Europe – UNECE, Avenue de la Paix 8-14, 1211 Geneva, Switzerland, unece.org.