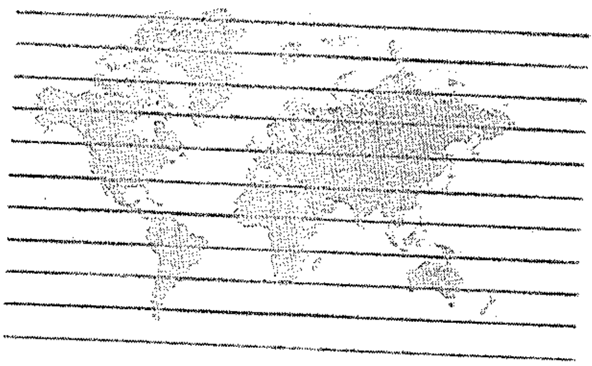
Parker Instrumentation

Cryogenic Thermal Shock Tests on A-LOK® Stainless Steel Fittings



Cryogenic Thermal Shock Tests on A-lok Stainless Steel Tube Connectors

This report is comprised of two separate cryogenic thermal shock tests.

The first test is cryogenic shock by immersion, page 1, and the second test is cryogenic shock by internal cryogenic flow, page 7.

In the appendices is the raw test data.

OVERVIEW
OF
CRYOGENIC IMMERSION TEST
ON
A-lok STAINLESS STEEL TUBE FITTINGS
By
Dennis Pape

Cryogenic immersion shock tests were performed on tube samples with A-lok stainless steel connectors. Each tube sample consisted of a tube between two fittings, a BLEN to cap the tube and a MSC to connect the tube to the pressure source (see figure 1). Five different tube O.D.'s, ($^1/_4$, $^3/_8$, $^1/_2$, $^3/_4$, and 1 inch) with two tube samples per O.D. were tested for a total of twenty (20) connections. The purpose of these tests was to determine any tube movement and leakage at the connectors, due to thermal shock induced by immersing each sample into liquid nitrogen and then warming the tube sample back to an initial temperature. Each tube sample was pressurized with helium and thermally shocked a total of thirty (30) times. Each connection was carefully measured before and after the test to determine if there was any tube movement. The pressure of each sample was measured before, during, and after the test to determine if there was any leakage.

Conclusion

Based on the measurement analysis and microscopic examination of the ferrule grip areas of each connection, there was no detectable movement of the tube in any connection. Also, based on the before test and after test pressure measurements, there was no detectable leakage in any connection.

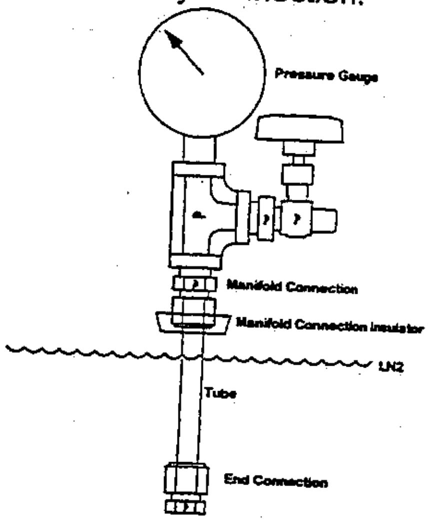


Figure 1

CRYOGENIC SHOCK
IMMERSION TEST
FOR
COMPRESSION FITTINGS

A. General Cryogenic Test Information

1. Testing will include CPI and A-lok fittings in stainless steel and brass.

2. The following matrix of tubing will be tested:

	Stainless Steel	
Sz	Wall	Press
1/4	.035"	3000psi
3/8	.035"	3000psi
1/2	.049"	3000psi
3/4	.065"	3000psi
1	.095"	3000psi

	Brass	
Sz	Wall	Press
1/8	.028"	2250psi
1/4	.030"	1100psi
1/4	.049"	2050psi
3/8	.035"	850psi
3/8	.065"	1800psi
1/2	.049"	950psi
3/4	.065"	600psi

3. Size 1/4 X .028" wall copper tubing and brass fittings will not be tested since it is not recommended in the "Instrument Tubing Selection Guide".

4. ASTM Type 304 bright annealed seamless stainless steel tubing with a max hardness of 80 Rb will be used since it has a larger contraction rate in the range of temperatures being considered.

5. ASTM B68 or B75 soft annealed seamless copper tubing will be used.

6. All tubing will be square cut and ID deburred. OD deburring will be minimal to insure no burrs and to minimize ferrule action and compression.

7. Liquid Nitrogen will be used for all tests to simulate the desired minimum temperature of -325°F (75°K) since Nitrogen boils at -320°F.

B. Cryogenic Immersion Test

1. Sections of tubing at least 10 diameters long will be assembled to fittings with a cap on one end and a gauge and valve on the other end. The valve will be used to isolate the assembly after pressurization and the gauge will be used to monitor internal pressure.

2. Each tube end will be marked prior to assembly and the tube/fitting (T/F) relationship will be measured using the mark and recorded after makeup. The T/F relationship will be measured after the test to indicate tube movement.

3. The fitting on the valve end will be assembled in a block with a mass at least 25 times the mass of the tubing to simulate heat retention of a large manifold. This maximizes the cooling differential between the tubing and the fitting body.

4. The internal volume of each assembly up to the valve will be estimated by calculation and/or volume of liquid contained and the value recorded.

5. Maintaining the liquid nitrogen level close to the end of the fitting is important to insure maximum differential cooling. The liquid nitrogen level should not drop more than one tube diameter in distance during each cycle. Adjustments in fitting position and adding liquid nitrogen can be used to maintain the level during and between cycles. A liquid nitrogen reservoir with at least 20 times the mass of the tube and immersed fitting is suggested.

6. One assembly will be tested for each pressure increment and will include pressures of 1/3, 2/3 and full pressure as listed in A-2.

7. Each assembly will be pressurized with helium and blocked. The pressure will be recorded after immersing the fittings and block in room temperature water for 5 minutes and the temperature of the water will also be recorded.

8. Each assembly will be cycled 10 times from room temperature to the base temperature and back. The base temperature is achieved by immersing the assembly in liquid nitrogen for a minimum of 10 seconds to within one tube diameter of the nut of the fitting screwed into the block. (Shielding of the nut with styrofoam or a similar material to reduce cooling of the body is desirable.) The assembly is brought back to room temperature by blowing warm air over the assembly and immersing in water for a minimum of 30 seconds.

9. The lowest internal pressure during each cycle will be recorded along with the cycle location. If the internal pressure drops more than 20% below the test pressure at any time during the cycle, a larger contained volume of helium should be used. If the initial pressure of a subsequent cycle drops more than 10% below the test pressure after warming, an estimate of leakage will be calculated using the temperature and pressure values along with the "Leakage" equation in item #11. The assembly will be repressurized to the test pressure and so noted.

10. On the final warming cycle the entire assembly will be brought back to room temperature by immersing in water for 5 minutes. The internal pressure will be measured and recorded along with the temperature of the water bath.

11. An estimate of the total leakage will be calculated using the following formula:

$$\text{Leakage} = (V_t/14.7)(P_i - P_f(T_i/T_f))$$

Where: V_t = Total Internal Volume in^3 (Item 4)

P_i = Initial Pressure psia (Item 6)

P_f = Final Pressure psia (Item 8)

T_i = Initial Temperature °R (Item 6)

T_f = Final Temperature °R (Item 8)

Note: psia = psig + 14.7 °R = °F + 460

Note: This calculated leakage will be added to any leakages calculated in item #9 and recorded as total for the test.

12. Each assembly that completes the test will be disassembled and ferrules removed for a bite and grip evaluation. Signs of ferrule movement during cycling will be noted.

Immersion Results

To determine the minimum measurable T/F movement, the standard deviation of the negative T/F measurements was used. The negative T/F measurements indicate the T/F actually decreased which is highly improbable, so these measurements should be a good estimation of measurement accuracy. The minimum measurable T/F movement was determined to be .001".

The minimum detectable leak was determined by using the formula for leakage shown in the cryogenic immersion test instructions, assuming constant temperature and using the 20 PSI precision of the pressure gauge as the pressure differential. The following table shows the test results of those samples meeting the minimum measurable criteria.

T/F MEASUREMENT RESULTS

The T/F results indicate no detectable T/F movement. To confirm this, all fittings were disassembled, and the ferrules removed from the tubing to gain access to the ferrule grip areas. Microscopic examination of the ferrule grip areas on the tubing revealed no signs of T/F movement.

LEAK RESULTS

SAMPLE NO.	SIZE	MINIMUM DETECTABLE LEAK (cu. in.)	CALCULATED LEAK (cu. in)
3	6	2.28	7.99
4	6	2.28	2.28
29	16	9.21	9.21

The leak results for samples 3 and 4 are misleading because these samples did not return to the initial temperature at the end of the five minute soak. Samples 3 and 4 were at the beginning of the test, and the procedure to bring these samples back to the initial temperature after thermal cycling involved soaking only the tube and the end connection in the water bath for five minutes. After evaluating the situation, a decision was made to soak the tube sample along with the manifold, up to the gauge, in the five minute water soak to bring the temperature back to the initial temperature. After implementing this procedure, those configurations that the procedure was suspect were re-tested and the results showed no detectable leakage.

Sample 29 has a calculated leak rate equal to the minimum measurable leak criteria. No leakage was visually detectable on these samples and upon disassembly, no cause for leakage was found.

CONCLUSION

From the test results and observations it is concluded there was no detectable tube movement or leakage from any configuration in this test.

OVERVIEW
OF
INTERNAL CRYOGENIC SHOCK TEST
ON
A-lok STAINLESS STEEL TUBE FITTINGS
by
Dennis Pape

Internal flow cryogenic shock testing at 3000 psi was performed by WYLE laboratories for Parker Hannifin on A-lok stainless steel tube fittings and 304-SS smls tubing. Each test sample (tree) was typically made of four sections of tubing and eight A-lok tube connections, with a simulated manifold mass between two straight connections (see fig. 2). Five trees were tested, one each for the five different sizes, ranging from 1/4 inch to 1 inch for a total of forty (40) connections.

Procedure

The procedure used for this test was to flow a sufficient amount of liquid nitrogen through each sample at 3000 psi to lower the temperature of the tubing to cryogenic temperatures in the shortest amount of time possible and then warm the sample back to ambient temperature, and record any anomalies such as leaks or blowouts. Each tree was subjected to ten (10) cryogenic shock cycles. Before, and after the test, the tube/fitting (T/F) relationship was measured and recorded.

Conclusion

Based on the T/F measurement analysis using a minimum detectable movement criteria of .001" as determined in previous tests, and microscopic examination of the ferrule grip areas of each connection, there was no detectable tube movement in any connection. Also, based on the report from WYLE labs, there was no detectable leakage in any connection.

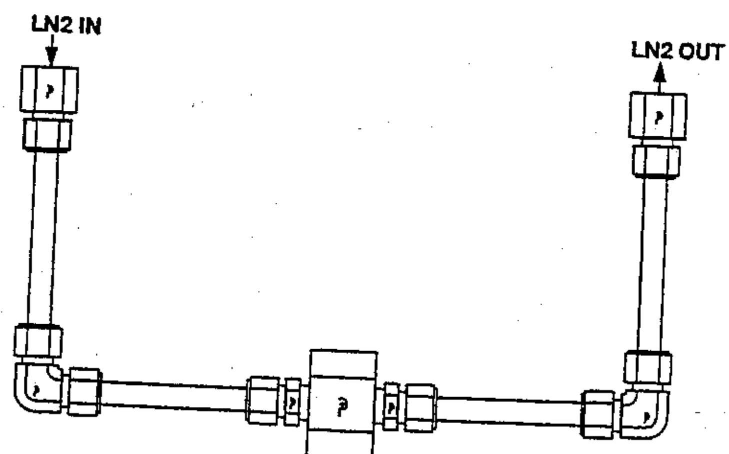


Figure 2

CRYOGENIC SHOCK
INTERNAL FLOW TEST
FOR
COMPRESSION FITTINGS

This test was performed by WYLE laboratories for Parker Hannifin Instrumentation Connectors Division.

The following parts were used for each tree.

FITTING	QUANTITY
MSC / FSC	4
EE	2

The tubing used is as follows:

TUBE O.D.	WALL THICKNESS
1/4	.035
3/8	.035
1/2	.049
3/4	.065
1	.095

PROCEDURE

Before and after testing, the tube/fitting (T/F) relationship was measured and recorded.

The test procedure used is as follows:

1. Pressurize and maintain each tree at 3000 psi not to vary more than 10%.

2. Flow sufficient quantity of liquid nitrogen through the tree (minimum 10 seconds) to bring tubing to approximate cryogenic temperature in shortest possible time.

3. After achieving thermal shock, stop the liquid nitrogen flow and bring the tree back to ambient temperature.

4. Upon reaching ambient temperature, repeat steps 2 and 3 for a total of 10 cycles.

5. Record average liquid nitrogen flow rate for the 10 cycles.

6. Record lowest pressure during the 10 cycles.

7. Record any observations (i.e. blowout, cycle number of blowout, visual leakage).

T/F MEASUREMENT RESULTS

SIZE	FITTING CONFIGURATION	MEASURED T/F DIFFERENCE (in.)
4	MSC	.0011
6	EE	.0012
12	EE	.0012
12	MSC	.0018
12	EE	.0018
16	EE	.0015
16	EE	.0016

The T/F results are at the low end of our measuring capabilities and therefore are questionable. To answer these questions, all fittings were disassembled, and the ferrules removed from the tubing to gain access to the ferrule grip areas. Microscopic examination of the ferrule grip areas on the tubing revealed no signs of T/F movement.

LEAK RESULTS

Based on the report supplied by WYLE labs, there was no detectable leakage from any sample in this test.

CONCLUSION

From the test results and observation, it is concluded that there was no detectable T/F movement or leakage from any sample in this test.