



960 Gateway Drive,
Burlington, ON L7L 5K7
(905) 639-4050
Fax: (905) 639-6163

LOKRINGTM Test Summaries

Copyright 2003 Lokring Technology Corporation, All rights reserved
® Registered Trademark of Lokring Technology
™ Trade mark of Lokring Technology

LOKRING Type 316/316L Fittings **Summary of Test Requirements¹**

<u>Test Group</u>	<u>Requirement/Objective</u>
Gas Leak:	500 psi Nitrogen gas for 5 minutes: No leakage
Hydrostatic Burst ² :	Establish fitting pressure rating per FS-200E
Flexure Fatigue ² :	Min. 7,000 bending cycles @ $\pm$ pipe yield strength
Tensile:	Exceed pipe tensile yield strength
Torsion:	Establish torsional resistance
Thermal Cycling/Shock • High Temperature • Low Temperature	Ambient to 425° F (3 cycles) Ambient to -60° F (3 cycles)
Vibration	Per MIL-STD-167
Helium Leak • Inboard (Vacuum): • Outboard: • Fire Testing:	Exceed 2×10^{-11} scc/sec Helium leak rate Per ASTM E498-73 (1×10^{-5} Torr Internal vacuum) Per ASTM E493-73 (450 psig Internal pressure) 1,800° F for 30 minutes – Internal gas pressure No leak during fire test and/or after cool-down

Note 1: See TR-1190-01 for detailed description of procedures, requirements, and results

Note 2: Burst and Flexural testing carried out in accordance with requirements of
ASMD/ANSI B31 codes

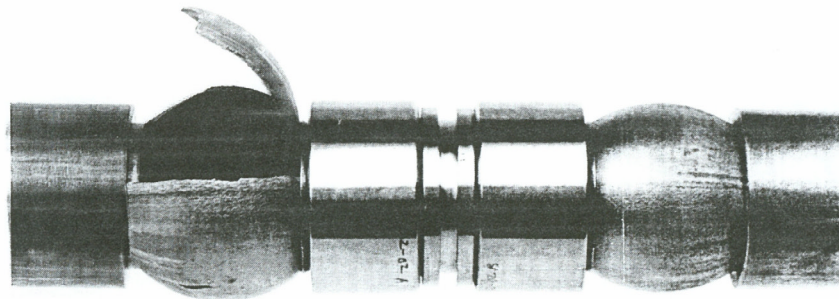
SS40 Series 316L LOKRING Fittings

Burst Test Summary

<u>NPS (PXX)</u>	<u>Fitting</u>	<u>Pipe Sch</u>	<u>Burst Pressure psi (Bar)</u>	<u>Failure Mode</u>
1/2" (P08)	Coupling	10	17,000 (1,145)	Pipe Burst
	Coupling	80	24,000 (1,620)	Fitting Failure
	Straight Tee	80	25,500 (1,720)	Tee Throat Rupture
	90° Elbow	80	27,500 (1,860)	Fitting Failure
3/4" (P12)	Coupling	10	12,500 (845)	Pipe Burst
	Coupling	80	23,500 (1,990)	Pipe Ejection
1" (P16)	Coupling	10	12,000 (827)	Pipe Burst ¹
	Coupling	40	16,500 (1,115)	Pipe Burst
	Coupling	80	18,000 (1,256)	Fitting Failure
	Straight Tee	80	19,000 (1,203)	Tee Throat Rupture
	90° Elbow	80	20,000 (1,350)	Elbow Burst
1-1/2" (P24)	Coupling	10	10,000 (675)	Pipe Burst
	Coupling	80	14,000 (945)	Fitting Failure
	Straight Tee	80	12,000 (810)	Tee Throat Rupture
	90° Elbow	80	13,500 (910)	Fitting Failure
2" (P32)	Coupling	10	8,500 (570)	See Note 2
	Coupling	40	9,000 (605)	Fitting Failure

Note 1: After 30,000 flexural fatigue cycles

Note 2: Weld end caps failed ending test



LOKRING Fittings

Fire Test Results

<u>Fitting Part No.</u>	<u>Matching Pipe Material Specification</u>	<u>Matching Pipe Size/Schedule</u>	<u>Avg. Fire Temp. °F</u>	<u>Hydrostatic Proof Pressure (psi)</u>
SS-3000-CPL-P24	Type 316SS to A312	1-1/2" NPS Sch 40	1,800	4,144
SS-3000-CPL-P24	Type 316SS to A312	1-1/2" NPS Sch 10	1,800	3,066
SS-3000-CPL-P24	Carbon Steel to A106B	1-1/2" NPS Sch 80	1,800	5,517
SS-3000-CPL-P24	Carbon Steel to A106B	1-1/2" NPS Sch 40	1,800	3,901
SS-3000-CPL-P04	Type 316SS to A312	1/4" NPS Sch 80	1,800	4,500
SS-3000-CPL-P04	Type 316SS to A312	1/4" NPS Sch 80	1,800	4,500
SS-3000-CPL-P04	Type 316SS to A312	1/4" NPS Sch 80	1,800	4,500

Fire Test Procedure:

- Prior to Fire Test, all specimens are leak tested with gaseous Nitrogen at 500 psi for 5 minutes
- During Fire, 1-1/2" specimens are pressurized at 300 psi Nitrogen; 1/4" specimens at 3,000 psi

Hydrostatic Proof Test Procedure:

- When specimens cool to room temperature, they are filled with water at proof pressure for 30 minutes

Requirement: No leakage before or during Fire Test, and no leakage in hydrostatic proof test

Results: ALL SPECIMENS MET THE REQUIREMENTS

SS40 Endurance Flex Test Summary

<u>NPS (PXX)</u>	<u>Pipe Sch</u>	<u>Internal Pressure (psi)¹</u>	<u>Pipe Stress (S)²</u>	<u>Cycles Tested (N)³</u>	<u>SIF (i)⁴</u>	<u>Failure Mode</u>
1/2" (P08)	10	250	30,000	141,715	<0.77	Fitting Leak
	80	250	30,000	84,140	<0.85	No Failure
	80	3,330	38,000	33,000	<0.80	No Failure
3/4" (P12)	10	250	30,000	112,000	<0.80	No Failure
	80	3,300	38,000	64,437	0.70	Fitting Leak
1" P(16)	10	250	30,000	69,570	<0.88	No Failure
	80	250	30,000	85,888	<0.84	No Failure
	10	3,300	38,000	30,045	<0.82	No Failure
	80	3,300	38,000	58,750	<0.72	No Failure
1-1/2" P(24)	10	250	30,000	135,634	<0.77	No Failure
	40	250	30,000	89,564	0.84	Fitting Leak
	80	250	30,000	33,285	1.02	Fitting Failure
2" P(32)	10	250	30,000	61,045	.90	Fitting Leak

Notes:

1. All specimens pressurized with water to given pressure during endurance flex test.
2. Total pipe stress resulting from combination of internal pressurization and bending.
3. In one complete cycle, pipe is bent in both directions around neutral axis.
4. Stress Intensification factor $i = 245,000 / (S \times N^{0.2})$.

Endurance Flex Testing **LOKRING 316L Fitting vs. Weld** **1" NPS Sch 80 Stainless Steel Pipe**

<u>Test Parameter</u>	<u>LOKRING (SS40 Series)</u>	<u>3000# Socket Weld² (ANSI B16.11)</u>
Total Pipe Stress (S)	38,000 (psi)	42,166
Cycles to Failure (N)	57,750 ¹	9,330
SIF (i) ⁴	0.72	0.93
Failure Mode	None Test Stopped	Weld Leak Thru-wall crack

Notes:

1. 3,3300 psi internal pressure during test. 1" NPS Specimen did not fail; test was stopped.
2. Full (1.09 t_n x 1.09 t_n) socket weld samples supplied by Duke Power for PVRC testing.
3. In one complete cycle, pipe is bent both directions around neutral axis.
4. Stress Intensification factor $i = 245,000 / (S \times N^{0.2})$.

Flexure Fatigue Test Summary 1-1/2" NPS Test Specimens

<u>Specimen No.</u>	<u>Matching Pipe Size</u>	<u>Test Stress S, (psi)</u>	<u>No. of Cycles to Failure, N</u>	<u>SIF, i</u>
<u>LOKRING Couplings</u>				
1	Sch 10	43,016	14,667	0.84
2	Sch 40	43,619	2,682	1.16
3	Sch 40	45,544	2,742	1.10
4	Sch 40	28,866	20,800	1.16
5	Sch 40	32,394	7,971	1.25
<u>Butt-Weld Joints</u>				
6	Sch 10	36,052	6,146	1.19
7	Sch 40	32,394	596	2.11
8	Sch 40	32,394	12,935	1.14
9	Sch 40	32,073	7,804	1.27

Conclusions:

- LOKRING Fitting fatigue performance comparable to but-welded joint.
- LOKRING connection has less variability than but-welded joint.

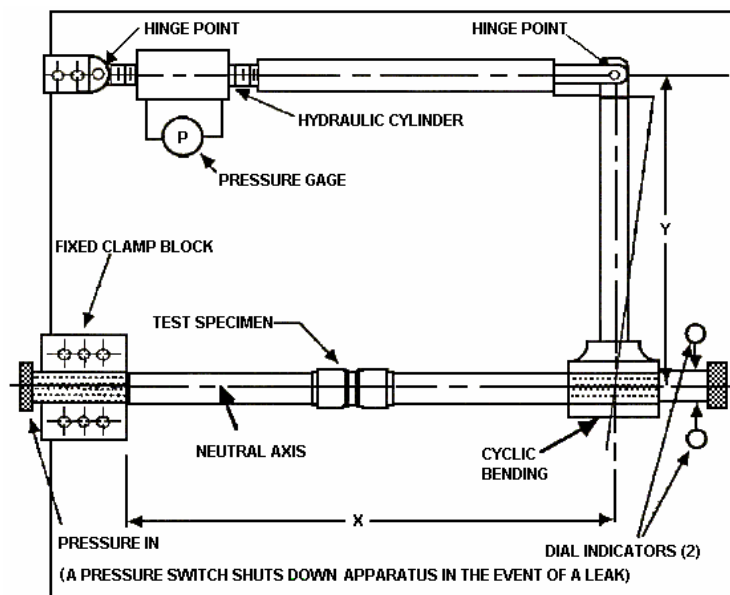


Figure: Test Setup

SS40 316L Fittings **Torsional Testing**

<u>NPS</u>	<u>Pipe</u>	<u>Break-away Torque (ft-lb)</u>	<u>Max. Applied Torque (ft-lb)</u>	<u>Leakage @ Max. Torque</u>	<u>Pipe Yields?</u>	<u>Pipe Yield Torque (ft-lb)</u>
1/2"	SS Sch 10	165	135	None	Yes	133
	SS Sch 80	No B/A	230	None	Yes	186
	CS Sch 80	No B/A	300	None	Yes	186
3/4"	SS Sch 10	250	275	Water	No	220
	SS Sch 80	No B/A	400	None	Yes	333
	CS Sch 80	500	500	Water	Yes	333
1"	SS Sch 10	400	400	None	No	449
	SS Sch 40	No B/A	500	Air	Yes	518
	SS Sch 80	No B/A	600	None	No	626
	CS Sch 80	No B/A	460	None	No	626
1-1/2"	SS Sch 10	No B/A	600	None	No	1,013
	SS Sch 40	No B/A	600	None	No	1,272
	CS Sch 80	No B/A	600	None	No	1,606
2"	SS Sch 10	No B/A	600	None	No	1,639
	SS Sch 40	No B/A	600	None	No	2,186

FIRE TEST JUNE 93

<u>Fitting</u>	<u>NPS/Schedule</u>	<u>Specimen Temperature (F)</u>	<u>Internal Pressure (psi)</u>	<u>Leakage During Fire</u>	<u>Post Fire Leakage</u>
MAS-3000-CPL-P32B	2" Schedule 40	1200-1290	30	None	See Chart Below

Post Fire Hydro test

<u>Pressure (psig)</u>	<u>Hold time (min)</u>	<u>Leakage Rate (mL/min)</u>
30	5	1.2 drops/min
100	5	0.4
200	5	0.8
300	5	1.1
400	5	1.3
500	5	1.6
600	5	1.8
800	5	2.1
1000	3	2.1
1500	3	0.4
2000	2.93	1.0 drops/min
2500	3	0.3 drops/min
3000	3	0

Note:

- Testing conducted at Southwest Research Laboratories
- Test technique per API 607, 4th edition
- Leakage volumes for leakage rates given in drops per min were too small for measurement

MAS COUPLING BURST TEST RESULTS

<u>Schedule 40</u>			<u>Schedule 80</u>	
<u>Size</u>	<u>Burst pressure (psi)</u>	<u>Failure Mode</u>	<u>Burst pressure (psi)</u>	<u>Failure Mode</u>
(P08)	22,500	Pipe Burst	31,000	Pipe Burst
(P12)	19,000	Pipe Burst	28,500	Pipe Burst
(P16)	20,000	Pipe Burst	24,500	Fitting Failure
(P24)	14,000	Pipe Burst	18,500	Pipe Ejection
(P32)	13,500	Pipe Burst	17,500	Fitting Failure
Constrained Pipe (NTS Tests)				
(P08)	25,000	Pipe Burst	33,500	Fitting Failure
(P32)	12,750	Pipe Burst	15,600	Fitting Failure

*ASTM A106B Pipe

FLEX TEST RESULTS

Lokring MAS Couplings

<u>Size</u>	<u>Schedule 40</u>			<u>Schedule 80</u>		
	<u>Bending Stress (ksi)</u>	<u>Cycles to failure</u>	<u>SIF</u>	<u>Bending Stress (ksi)</u>	<u>Cycles to failure</u>	<u>SIF</u>
1/2"	33.3	55,010*	.83	31.7	56,800*	.86
	55.6	10,476	.69	54.6	8,828	.73
	58.8	7,829	.69	60.5	5,742	.72
	62.1	4,968	.72	65.9	4,268	.70
1-1/2"	32.7	9,790	1.19	35.0	26,735*	.91
	33.5	7,826	1.22	36.6	29,660	.85
	45.9	2,963	1.08	43.6	10,461	.88
	50.8	1,039	1.20	50.0	7,338	.83

*No Failure occurred

MAS FLEX TEST COMPARISON

Lokring Couplings

<u>Size</u>	<u>Schedule 40</u>			<u>Schedule 80</u>		
	<u>Bending Stress (ksi)</u>	<u>Cycles to failure</u>	<u>SIF</u>	<u>Bending Stress (ksi)</u>	<u>Cycles to failure</u>	<u>SIF</u>
1/2"	35.0	57,000*	.86	35.0	55,010	.83
	60.0	5,742	.72	65.0	6,000	.69
3/4"	35.0	25,000*	.92	35.0	22,634*	.94
1"	35.0	80,000*	.74	35.0	43,429	.83
1-1/2"	35.0	23,000	.90	35.0	10,000	1.20
	50.0	7,338	.83	50.0	1,039	1.20
2"	35.0	38,734	.85	35.0	7,212	1.18

*No Failure occurred

1" Sch 80 Carbon Steel Socket Weld Flex Tests		
<u>Bending Stress (ksi)</u>	<u>Cycles to failure</u>	<u>SIF</u>
73.0	1,128	0.95
57.7	1,751	0.82
40.4	16,150	0.87

ELEVATED TEMPERATURE SOAK

<u>Fitting</u>	<u>NPS/Schedule</u>	<u>Soak Temperature (F)</u>	<u>Soak Time (hr.)</u>	<u>Burst Pressure (psi)</u>	<u>Failure Mode</u>
MAS-3000-CPL-P32	2" Schedule 40	1,000	168	13,000	Pipe Burst

Note:

- Burst testing was conducted at room temperature after completion of the elevated temperature soak.
- Evaluation of coupling body microstructure before and after the test showed no appreciable change in grain size,

COLD TEMPERATURE INSTALLATION

<u>Fitting</u>	<u>NPS/Schedule</u>	<u>Installation Temperature (F)</u>	<u>Burst Pressure (psi)</u>	<u>Failure Mode</u>
MAS-3000-CPL-P32	2" Schedule 80	-50	16,500	Pipe Burst
MAS-3000-CPL-P08	1/2" Schedule 80	-20	N/A	N/A

Note:

- Couplings and pipe were stabilized at low temperature for one hour before installation
- Sectioned specimens showed not unusual features
- Burst testing was conducted at room temperature

CHARPY IMPACT TESTING-MAS

<u>Material</u>	<u>Temperature (F)</u>	<u>Energy Absorbed (ft-lb)</u>	<u>Lateral Expansion (mils)</u>
15V24 MAS	-20	8.0	5.3
4130 CDSR Pipe	-20	4.8	2.0
A106B Pipe	-20	5.0	3.7

Note:

- Testing Conducted at Anamet Laboratories, Hayward, CA
- All tests were conducted on standard V-notch 10 mm X 10 mm specimens per ASTM E23 type A
- Results are the average of 3 specimens tested for each material

TORSION TESTING

<u>Fitting</u>	<u>NPS/Schedule</u>	<u>Break Away Torque (ft-lb)</u>	<u>Gas Leak</u>	<u>Hydrostatic Leak</u>
MAS-3000-CPL-P32	2" Schedule 40	>600	No Leakage	No Leakage
MAS-3000-CPL-P32	2" Schedule 80	>600	No Leakage	No Leakage
MAS-3000-CPL-P08	1/2" Schedule 40	115	No Leakage	No Leakage
MAS-3000-CPL-P08	1/2" Schedule 80	120	No Leakage	No Leakage

Note: Both gas leak and hydrostatic leak carried out at 500 psig following application of torque

LOKRING CARBON STEEL FITTING STEAM CYCLE TESTING

Test Parameters

- Spirax Sarco – Allentown, PA
- Started February 24 1993
- Ended March 31 1993
- Steam Pressure
- Number of cycles
- Results
- Post test observations

Comments

Steam rack located outside
 Samples exposed to cold temperatures

275 psi/saturated steam
 10,000 @ 0 to 275 psi
 No steam leaks observed
 Nitrogen leak test / No leakage

CORROSION TESTING (TO ASTM B117 5% SALT SPRAY)

<u>Fitting</u>	<u>NPS/Schedule</u>	<u>Time in Chamber (hr.)</u>	<u>Burst Pressure (psi)</u>	<u>Mode of Failure</u>
MAS-3000-CPL-P16	1" Schedule 40	240	19,500	Pipe Rupture
MAS-3000-CPL-P16	1" Schedule 40	480	19,500	Pipe Rupture
MAS-3000-CPL-P16	1" Schedule 40	720	19,500	Pipe Rupture
MAS-3000-CPL-P16	1" Schedule 40	960	19,500	Pipe Rupture

Note: No deterioration in the burst performance of the fitting/matching pipe assembly