

Request for use of ASME Code Case N-879 for Exelon Nuclear Power Plants

January 23, 2019



Exelon Generation.

Relief Request Scope/Subject Matter

- Requesting use of ASME Case N-879 for alternative material for use in Lokring Pipe Fittings for Class 2 and 3 Applications
 - This request is for the material only – not for design, fabrication, or testing
- Case N-879 has been approved and published by ASME
 - Published in ASME Nuclear Cases, 2017 Edition, Supplement 1
 - Not yet generically endorsed in Reg. Guide 1.84
- Case N-879 material has micro-alloying elements (C, Mn, V, N) to enhance yield strength.
 - Although containing extra alloying elements (Mn, V, N), meets all other requirements in ASME Section III-approved material specification SA-675.
 - N-879 material has a composition very similar to Pressure Vessel Plate Specification SA-737 Grade C (also approved for ASME Section III).
- Yield strength of 80 ksi is required, to confine installation deformation to pipe, rather than fitting.
 - Specified properties ensure no leakage or separation of joint during service

Existing ASME Code Requirements

- ASME Section XI, IWA-4220 requires compliance with Construction Code requirements (or later Codes) for materials used in repair/replacement activities.
- For older plants, B31.1 is required
 - Case N-879 material is permitted by B31.1 for these applications.
 - B31.1 Case 164 or B31.1, 123.1.2, Unlisted Materials
- For newer plants, Section III is required
 - NC/ND-2121(a) requires materials selected from Section III, Appendix I or Section II, Part D.
 - NC/ND-2121(d) permits use of other materials, such as Case N-879 material, for fittings up to NPS 1.

Applications Currently Permitted

- Lokring fittings made from stainless steel materials are already permitted without restrictions.
- Lokring fittings made from micro-alloyed carbon steel material permitted by Case N-879 are already permitted by ASME B31.1.
- Therefore permitted to be used in safety-related service with no restrictions at
 - Calvert Cliffs, Dresden, Fitzpatrick, Ginna, Nine Mile Point 1, Peach Bottom, Quad Cities, and TMI
- Lokring fittings made with Case N-879 material are already permitted in piping up to NPS 1, for all design conditions.

Relief Being Requested

- NRC acceptance of Case N-879 will permit use of micro-alloyed carbon steel material in Class 2 and 3 piping larger than NPS 1 and up to NPS 2 at
 - Braidwood, Byron, Clinton, LaSalle, Limerick, Nine Mile Point 2

Hardship Reasons for Relief Request

- Safety hazards
 - Welding and NDE in high-radiation environments
- Lokring mechanical installation – without welding or associated weld NDE – reduces radiation exposure and outage time.
- None of the carbon or low-alloy steel materials listed for Section III applications are suitable for both the service conditions and the Lokring installation conditions.
- The materials listed for Section III application do not have both of the following characteristics in combination.
 - Similar chemistry to the pipe materials on which the fittings will be applied.
 - Adequate yield strength to limit deformation to less than that of the pipe materials on which the fittings will be applied.

Responses to NRC Questions/Concerns

- Construction Code Editions and Addenda used:
 - B31.1: 1965 through 1968
 - Section III: 1971, 1974, S74, S75
 - Some later Editions and Addenda for new or modified systems, such as TMI modifications at Calvert Cliffs
- Systems include any made with carbon steel piping NPS 2 or smaller:
 - Typically, instrumentation, sampling, cooling water piping
 - Excludes borated systems (RCS, charging, chemical and volume control, etc.)
 - Design temperature: ambient to 650°F
 - Design pressure: ~100 to ~1000 psi
 - Environment: air, water, or steam, inside or outside containment

Responses to NRC Questions/Concerns

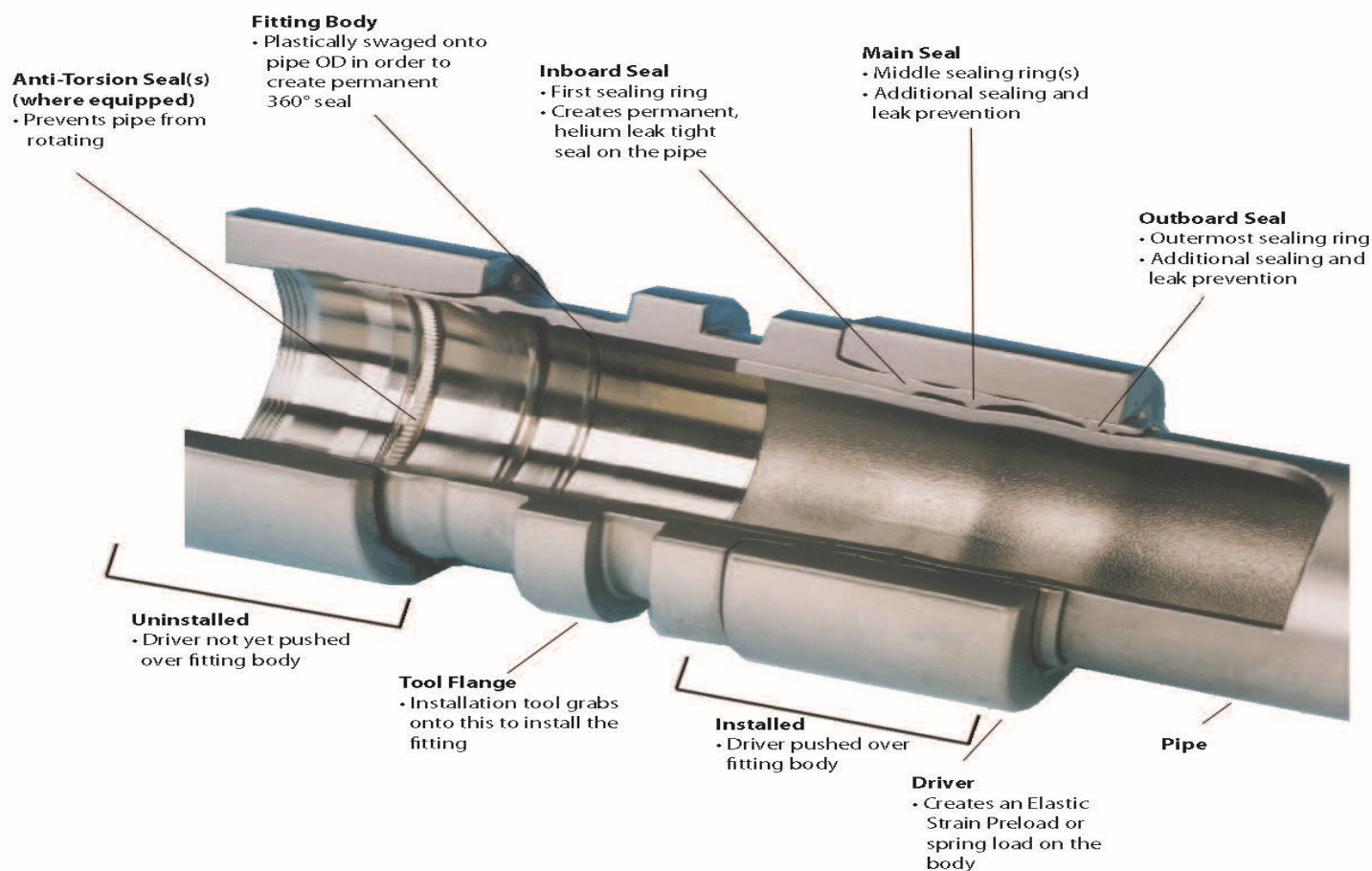
Lokring Technology is a manufacturer of pipe and tube fittings developed and qualified for use in ASME B31 pressure piping systems

- Fitting materials: Stainless Steel, Carbon Steel, Copper Nickel
- Pipe Schedules 10, 40, 80, 160
- Sizes 1/4" OD to NPS 4"



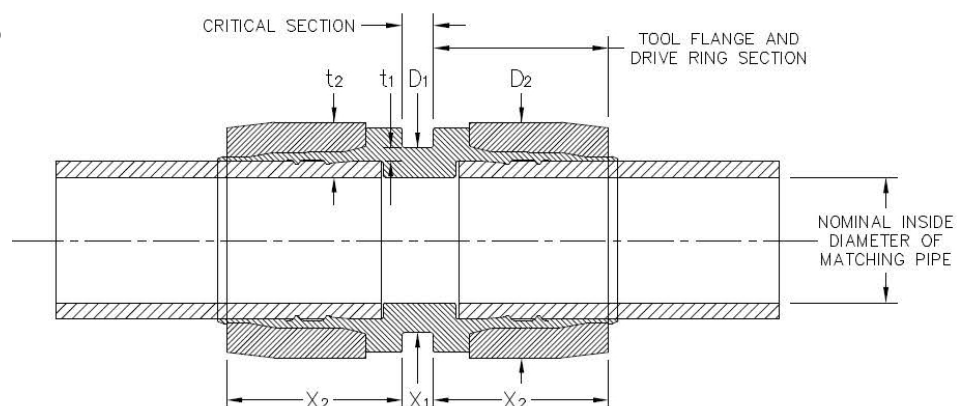
Responses to NRC Questions/Concerns

- Description and drawing



Responses to NRC Questions/Concerns

- Dimensions



Fitting Size	Tool Flange + Drive Ring Outside Diameter		Tool Flange + Drive Ring Length		Tool Groove Outside Diameter		Tool Groove Section Wall Thickness		Tool Groove Length	
NPS (DN)	D ₂		X ₂		D ₁		t ₁		t ₁	
	in	(mm)	in	(mm)	in	(mm)	in	(mm)	in	(mm)
1/4 (8)	1.050	(26.7)	0.909	(23.1)	0.764	(19.4)	0.100	(2.5)	0.203	(5.2)
3/8 (10)	1.240	(31.5)	1.012	(25.7)	0.830	(21.1)	0.068	(1.7)	0.203	(5.2)
1/2 (15)	1.460	(37.1)	1.080	(27.4)	1.004	(25.5)	0.068	(1.7)	0.203	(5.2)
3/4 (20)	1.600	(40.6)	1.212	(30.8)	1.235	(31.4)	0.079	(2.0)	0.278	(7.1)
1 (25)	1.954	(49.6)	1.500	(38.1)	1.524	(38.7)	0.091	(2.3)	0.263	(6.7)
1-1/4 (32)	2.285	(58.0)	1.633	(41.5)	1.813	(46.1)	0.062	(1.6)	0.273	(6.9)
1-1/2 (40)	2.610	(66.3)	1.795	(45.6)	2.064	(52.4)	0.068	(1.7)	0.283	(7.2)
2 (50)	3.250	(82.6)	2.203	(56.0)	2.574	(65.4)	0.075	(1.9)	0.303	(7.7)

Partial Application List – Exelon Installations – 2016 - 2018

Site	Services in which Lokring Fittings are Installed	# of Lokring Fittings Installed
Braidwood	• Circulating water system small bore piping (1-inch) • 4-inch vent line in diesel oil storage tank system • Service Building Chiller rerouting water lines above the chiller heads • Aux Boiler modification for diesel line • Line replacement on WE in RH pump room	202
Byron	• Diesel Oil Storage Tank loop seal modification. Used to prevent the need for welding on diesel piping	20
LaSalle	• 3-inch repair to exciter cooler service water piping • SPE modification / line replacement • Generic EC for up to 2-inch non-safety pipe	187
Quad Cities	• Upgrade drain line and vent lines for waste collector filter dome piping • Replace fuel pool filter demin dome drain valve • Replace sight glass on line for HPCI draing going to RBEDT • Replace piping associated with turbine bearing lift pump discharge bearing 5 RV & 7 RV • Reroute vent lines so travelling screen could be removed (TMod) • Reroute U-1 and U-2 reactor building sink outlets • Offgas piping • Gland water supply to circ pump	117
Dresden	• EHC modification to install vertical pumps • "A" Concentrator replacement • 3A RFP casing replacement • 3A IAC Replacement • Feedwater Heater Drain Valves	347
Clinton	• Scheduled to use on 2FP52A Fuel Line Replacement	187
Nine Mile Point	• Feedwater and condensate system; used in three different applications • EHC system isolation valves installed at turbine valves (1600 psi)	377
Oyster Creek	• Reactor Water clean up and Boiler system	27

Partial Application List – Non-Nuclear Applications

Industry	Year	Work Description	Product (Pipe and Fitting Material and Size)	Pressure	Temperature
Steel Manufacturing	2005	6 Temper Mill Hydraulics	CS, NPS 1/2 – NPS 3, Sch. 40	250-1000 psi	Ambient
Steel Manufacturing	1999	Hydraulics	CS, Sch. 40/80	1500 psi	Ambient
Steel Manufacturing	2009	3000 - 5000 psi Hydraulics; high vibration	NPS 2, Sch. 160	3000-5000 psi	
Steel Manufacturing	2009	Hydraulics	CS & SS, NPS 1/2 through 2	1000 psi	
Refining	1999	Condensate Lines	NPS 1, NPS 1-1/2, Sch. 80	2250 psi	Ambient
Petrochem	1999	Propylene	NPS 1-1/2, Sch. 80	2068 kPa	100°C
Offshore/Onshore	2007	Class 900 and Class 1500 RTJ flanges and couplings		1435 psi	
Pulp & Paper	1991	Hydraulic Fluid	NPS 1-1/4, NPS 1-1/2, Sch. 40	1000 psi	200°F
Chemical	1993	Lube Oil	NPS 1-1/2, Sch. 80	1200-3500 psi	Ambient
Chemical	1991	Hydraulics	NPS 3/4, Sch.40	1500 psi	Ambient
Chemical	2009	Natural Gas	CS, NPS 1/2	3800 psi	Ambient
Petrochem	1997 - 2009	Paraxylene Unit and Ethylene Unit; 1/2" fittings installed in high vibration service in Ethylene Unit Product Compressors.	NPS 1/2 – NPS 3	1450 psi	
Automotive	1998	Sealer	CS, NPS 2, Sch.160	3500 psi	125°F
Railroad	2004	Hydraulic Lines on Equipment	CS, A53 Seamless, NPS 1/2, NPS 1, Sch. 80	3000 psi	Ambient
Steel Manufacturing	1999	Hydraulics	CS, NPS ½ – NPS 2, Sch. 40	3000 psi	Ambient
Petrochem	1998	Gas Dehydration	NPS 1, NPS 1-1/2, NPS 2, Sch. 80	1500 psi	250°F
Petrochem	1993	Hydrogen	NPS 1-1/2	2400 psi	
Petrochem	1993	Hydrogen	NPS ½	2400 psi	Ambient
Petrochem	1992	Helium	NPS 1/2, Sch. 40	2400 psi	Ambient
Pulp & Paper	1993	Hydraulic Oil	NPS 1, Sch. 40	2500 psi	120°F
Chemical	1999	Treated Boiler Feedwater	NPS 1-1/2, Sch. 80	1270 psi	400°F
Chemical	1989	Hydraulics	NPS 1-1/2, NPS 2	1200 psi	Ambient

CS = Carbon Steel SS = Stainless Steel



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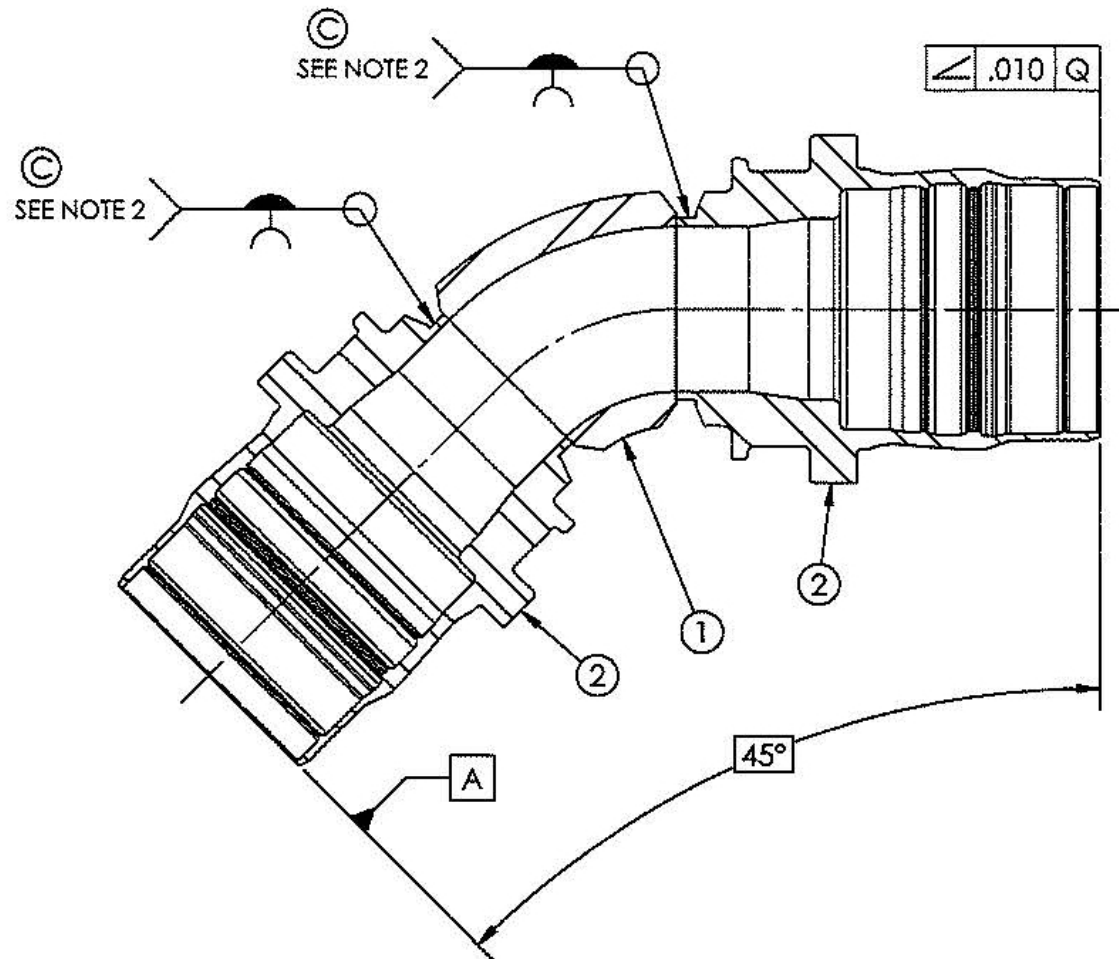
Tensile Strength and Fracture Toughness

- Minimum tensile strength: 110 ksi
- Maximum tensile strength: 130 ksi
- Fracture toughness is difficult to determine, because material is too thin to obtain impact test specimens.
- Maximum thickness of Lokring fittings for use with NPS 2 Schedule 80 pipe is $\sim 3/8$ in.
- Impact testing is not required by B31.1.
- Impact testing is exempted by Section III, NC/ND-2311, based on section thickness $< 5/8$ in., and based on diameter $< \text{NPS } 6$.

Welding Variables

- P-Number of Micro-alloyed, 80ksi Steel
 - This material has no P-Number assigned by ASME.
 - Separate Welding Procedure Qualification was performed using the micro-alloyed, 80ksi steel.
- Filler Material
 - ER70, plain carbon steel, corresponding to the properties of the A106 Grade B (or equivalent) pipe, tee, or elbow to which the Lokring fitting is attached.
- Preheat and Postweld Heat Treatment
 - Preheat temperature is 70°F minimum.
 - No PWHT is permitted, as it would degrade the required mechanical strength.

Weld Configuration



Welding Qualification Test Results

- PQR Test Results

- Tensile Strength 81 ksi
- Tensile specimen fracture was ductile and in the weld metal
- Procedure qualification base metal tensile strength is 114 ksi. Base metal hardness corresponds to 114 ksi. HAZ hardness with no preheat or PWHT corresponds to 124 ksi.
- Bend tests were acceptable.

Structural Integrity and Qualification Methods

- Lokring fittings, with Case N-879 material, have extensive testing and service experience.
- Proven by testing in accordance with Section III, NC/ND-3671.7 and NC/ND-3649.
- Stress analysis is impractical, due to fitting configuration.
- Testing performed:
 - Burst
 - Fatigue
 - Tensile (pull out)
 - Torsion
 - Vibration
- Extensive use in similar, but non-safety-related, service in multiple applications.

Structural Integrity and Qualification Methods

- Burst Testing
 - Lokring performs proof tests in accordance with ASME B16.9, MSS SP-97, or Section VIII, Division 1, UG-101, and Section 1
 - Test per ASME B31H



Standard Method to Establish Maximum Allowable Pressure for Metallic Piping Components

ASME B31H-2015 (8-Sep-15 DRAFT)

Structural Integrity and Qualification Methods



Burst pressure test chamber

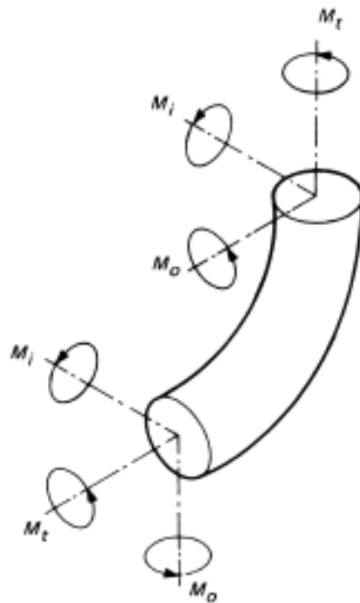
Structural Integrity and Qualification Methods



Burst test specimen- MAS 3000 CAP P16 installed on ASTM A106 B, A53 B, API 5L B schedule 80

Structural Integrity and Qualification Methods

- Fatigue Testing
 - Lokring performs proof tests in accordance with ASME B31.1 Section 119.7.3 method to determine Flexibility and Stress Intensification Factors for components of piping systems
 - Test per ASME B31J



ASME B31J-2017
[Revision of ASME B31J-2008 (R2013)]

Stress Intensification Factors (*i*-Factors), Flexibility Factors (*k*-Factors), and Their Determination for Metallic Piping Components

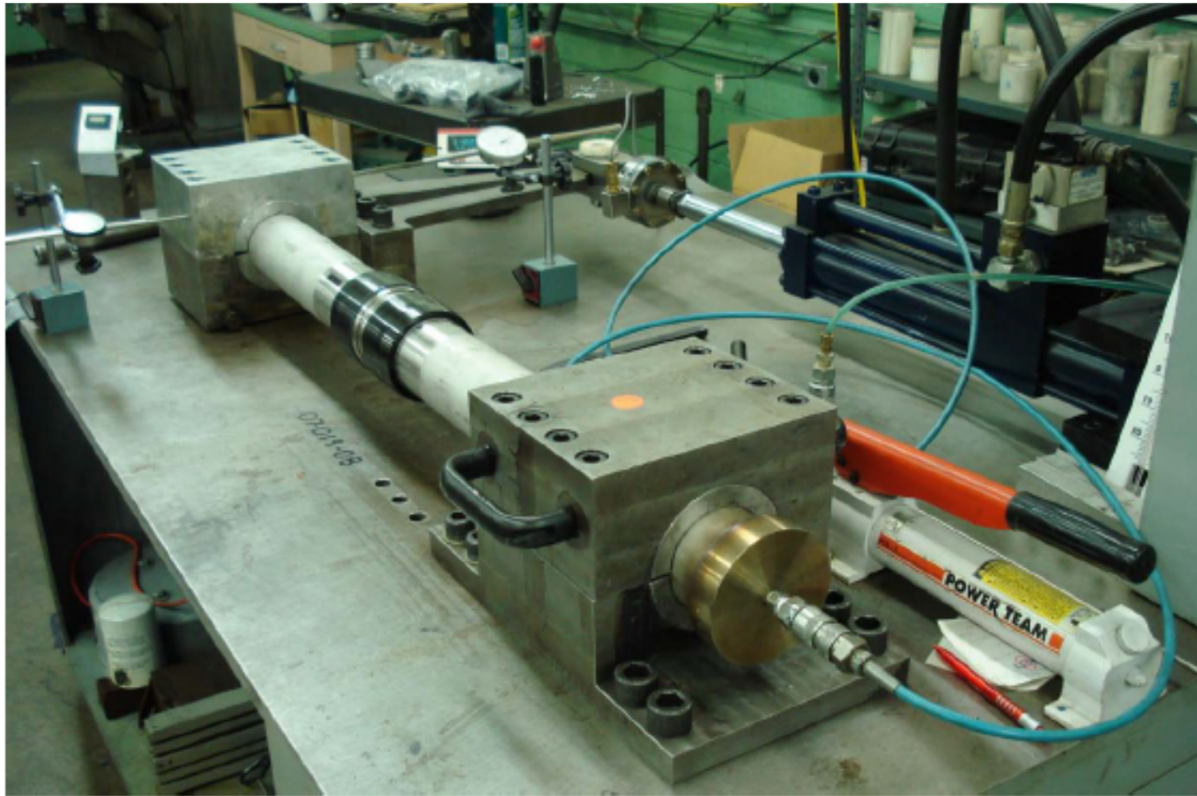
ASME Code for Pressure Piping, B31

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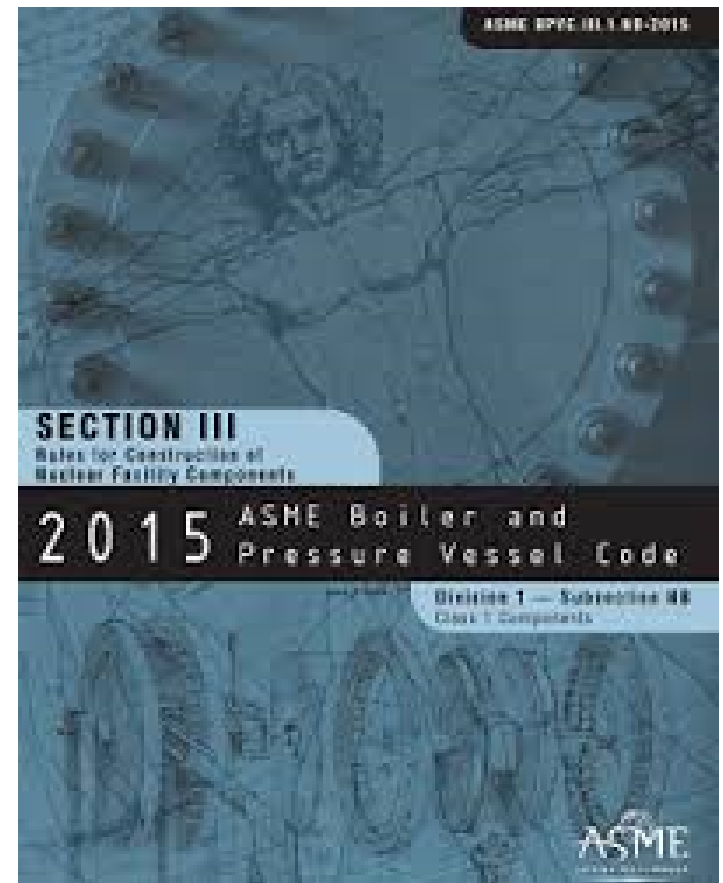
Structural Integrity and Qualification Methods



A bending moment is created from the Hydraulic Cylinder and Bending Arm, which creates a moment in a plane passing through the neutral axis of the Pipe and Coupling specimen assembly. In one complete flexural cycle, the Pipe and Coupling specimen assembly bends an equal distance to either side of the neutral axis.

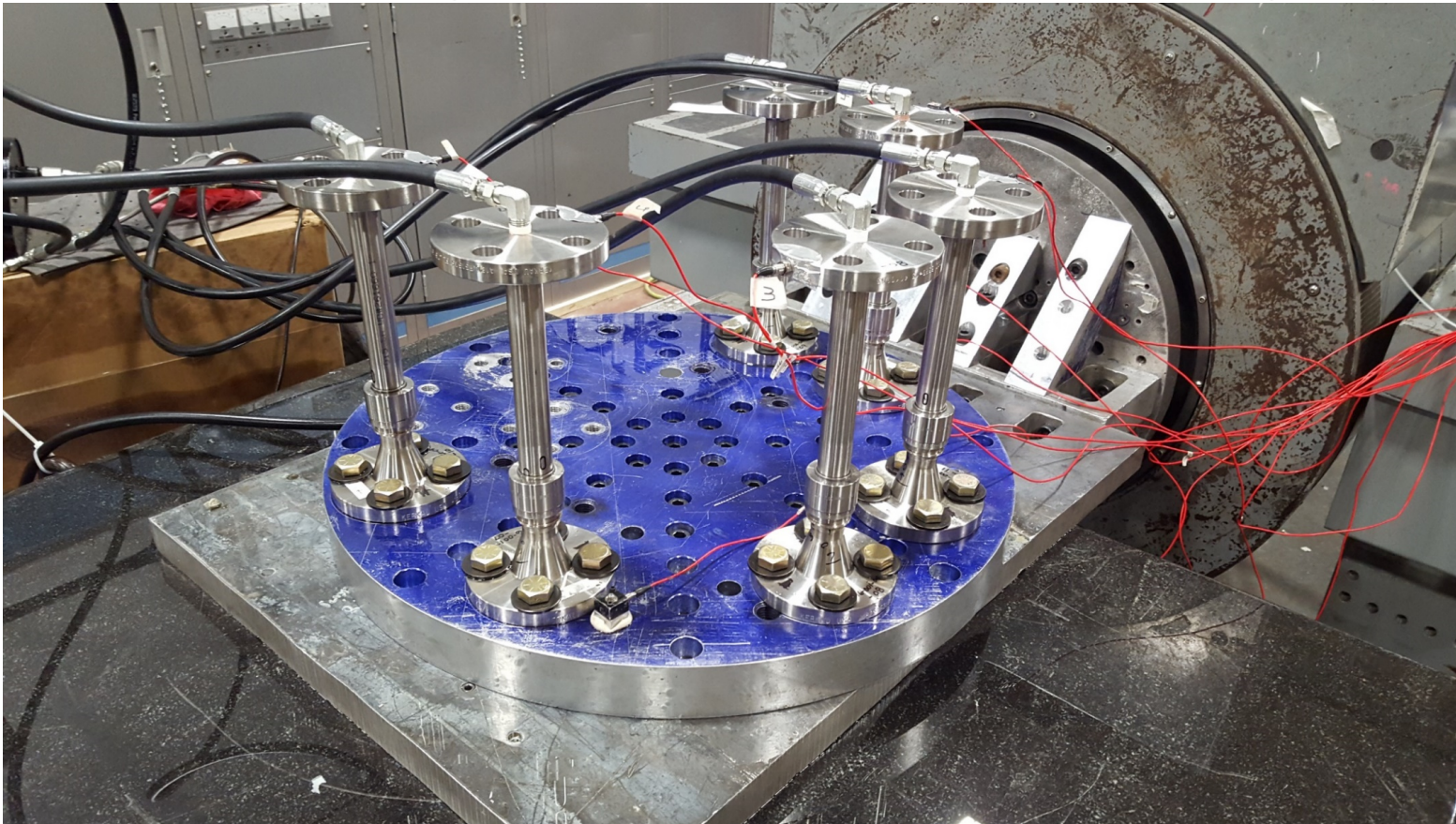
Structural Integrity and Qualification Methods

- Vibration Testing
 - Lokring performs proof tests in accordance with ASME BPVC, Section III Article NB-3200
 - Experimental Stress Analysis Testing for the effects of Vibration (High Cycle, Low Amplitude) fatigue



Structural Integrity and Qualification Methods

- Lokring fittings being tested under low amplitude, high cycle loading.



Design Margins, Load Combinations, Cumulative Usage Factor

- Design Margins and Load Combinations are not relevant, because Lokring fittings are qualified by testing and have been demonstrated in accordance with Section III, NC/ND-3671.7 and NC/ND-3649 to be as good as 2:1 socket welded joints.
- Cumulative Usage Factors are not applicable, because Lokring fittings made from Case N-879 material are used only in applications where fatigue analysis is not required.
- However, Lokring has conducted an extensive testing program to determine appropriate stress indices for its fittings, for use in the piping system design.

Overall Summary

- Requesting use of ASME Case N-879 for alternative material for use in Lokring Pipe Fittings larger than NPS 1 and up to NPS 2.
- Extra alloying elements in CC N-879 Micro-Alloyed Carbon Steel Material, refine the grain size and significantly increase the tensile and yield strengths of the material while still maintaining acceptable ductility, toughness and corrosion resistance.
- Case N-879 has been approved and published by ASME.
- Case N-879 material is permitted by B31.1. NRC acceptance is not required for these applications.
- Case N-879 material is permitted by NC/ND-2121(d) for fittings up to NPS 1. NRC has already accepted the Section III provisions that permit use of this material for this application.
- Lokring mechanical installation reduces radiation exposure and outage time.

Questions and Feedback

- Questions and feedback?