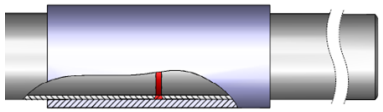
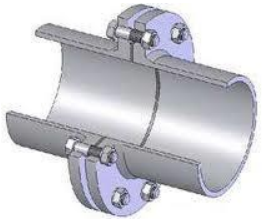
Mechanical Joining of Pipes
Interference Fit Coupling

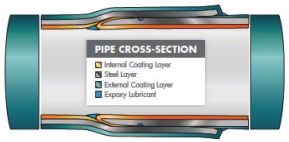
Dr. Peter Singh
Jetair International
Division of Marubeni Itochu Tubulars Inc.

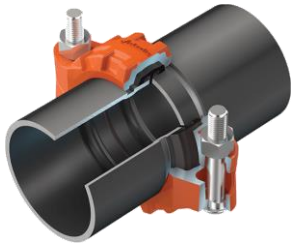
Pipe Joining Technologies



- Many types of Joining methods for metal pipes
  - Butt welded, overlap welded, flanges, sleeves, threaded, adhesive, mechanical, ……



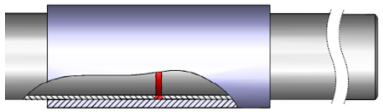




EU(External upset)

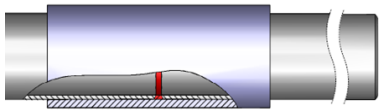
- Joining
  - Mechanical joining
    - Mechanical fastening
      - Threaded fastener
      - Non-threaded fastener
    - Mechanical interlocking
  - Adhesive bonding
  - Welding
    - Fusion welding
      - Arc welding
      - Gas welding
      - High-energy beam welding
      - Resistance welding
    - Non-fusion welding
      - Cold pressure welding
      - Hot pressure welding
      - Friction welding
      - Diffusion welding
    - Brazing and soldering
  - Welding automation

Welding



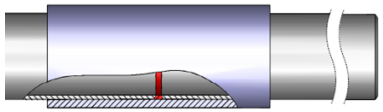
- Welding - Dominant joining technology
- Mostly manual with skilled labor
- Welder/Procedure qualification required
- Critical part of pipeline construction
  - requires most skill and time

Welding Issues



- One of the leading causes of pipeline failures behind third party damage and corrosion
- Low productivity with high reject/repair rates of 10 to 40%
  - Not following qualified procedure
  - Weld misalignment,
  - Improper wall thickness transitions,
  - Early clamp release/Arc burns, etc
- Retraining for new welding techniques
- Heat effect on pipe coating external and internal if present
- High Cost

Drivers for change

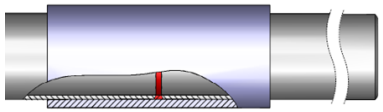


- Speed
  - Faster pipeline completion time
- Safety
  - Less people and equipment on construction site or laybarge
- Technical
  - Lower heat effects on steel, internal coatings/liners
- Cost
  - Better life cycle economics

Alternative joining methods

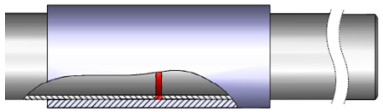
Mechanical Interference Fit Coupling

Joint Performance Criteria



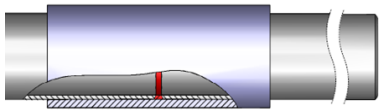
- Ability to handle pipeline operation environments
  - Pressure, Temperature, Compatible with pipe material
- Perform under various stress environment
  - During construction (tension, bending, torsion)
  - Operational (thermal expansion)
  - External environment
- Compatible with pipeline operations
- Long term performance and reliability
- Easy to implement
- Fits with Industry practice
- Regulatory codes/standards compliance
- Cost advantages

Regulatory Codes



- Mechanical Joints allowed in Regulatory Codes
  - CFR 49 TRANSPORTATION OF NATURAL AND OTHER GAS BY PIPELINE: MINIMUM FEDERAL SAFETY - CFR 192 Subpart F—Joining of Materials Other Than by Welding
    - § 192.273 General.
    - (a) The pipeline must be designed and installed so that each joint will sustain the longitudinal pullout or thrust forces caused by contraction or expansion of the piping or by anticipated external or internal loading.
    - (b) Each joint must be made in accordance with written procedures that have been proven by test or experience to produce strong gastight joints.
    - (c) Each joint must be inspected to insure compliance with this subpart.
  - CSA Z662
    - 7.16 Mechanical interference fit joints
    - 7.16.1.2 The axial tensile, axial compressive, and hoop strengths of the joint shall be as specified by the designer of the mechanical interference fit joining system and shall be based upon test data or experience acceptable to the company.]
    - 7.16.2 Qualification of joining procedure specifications - The designer of the mechanical interference fit joining system shall develop detailed joining procedure specifications that include the end preparation and the joining operation requirements. Qualification of such specifications shall be supported by engineering test data and field trials. The acceptability of such qualifications shall be determined by the company.
    - 7.16.4 Inspection procedures

Standards Compliance



Regulatory Codes not prescriptive enough?

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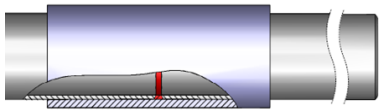
No Industry Standards Exist?

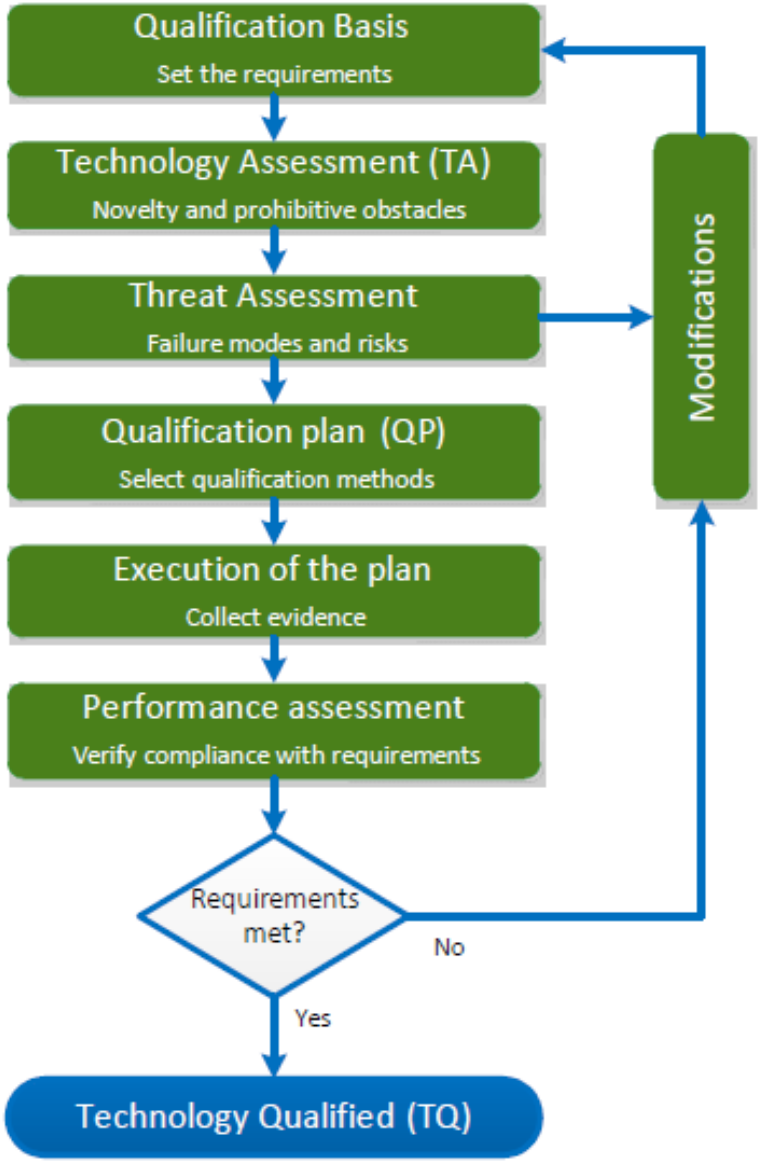
→

DNV Technology Qualification Process

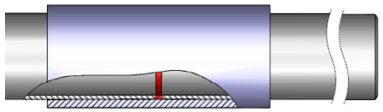
DNV Technical Qualification



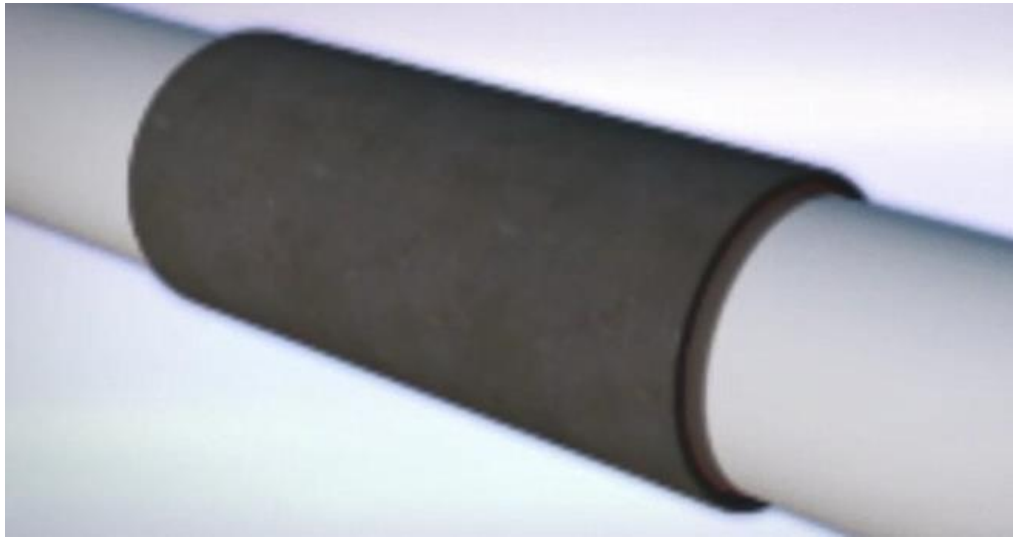
- RECOMMENDED PRACTICE DET NORSKE VERITAS AS DNV-RP-A203 - Qualification of New Technology



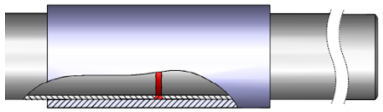
CASE STUDY – JETAIR PSC



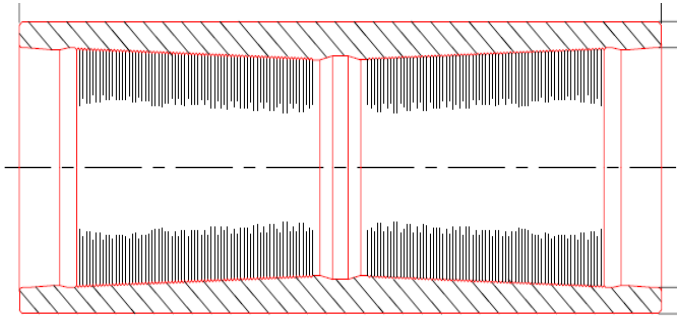
MECHANICAL INTERFERENCE FIT COUPLING



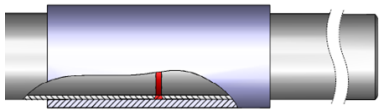
PSC Design



- Machined high grade steel coupling
- ID directed serrations/threads
- ID tapered and smaller than pipe OD
- Designed for controlled interference fit on seamless and ERW pipes to API 5L PSL2 specification tolerances.
- Pipe or pipe ends are not modified
- Elastic/plastic deformation of pipe external surface on insertion.
- High frictional force between pipe and coupling

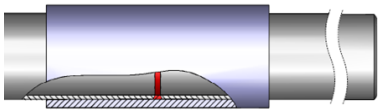


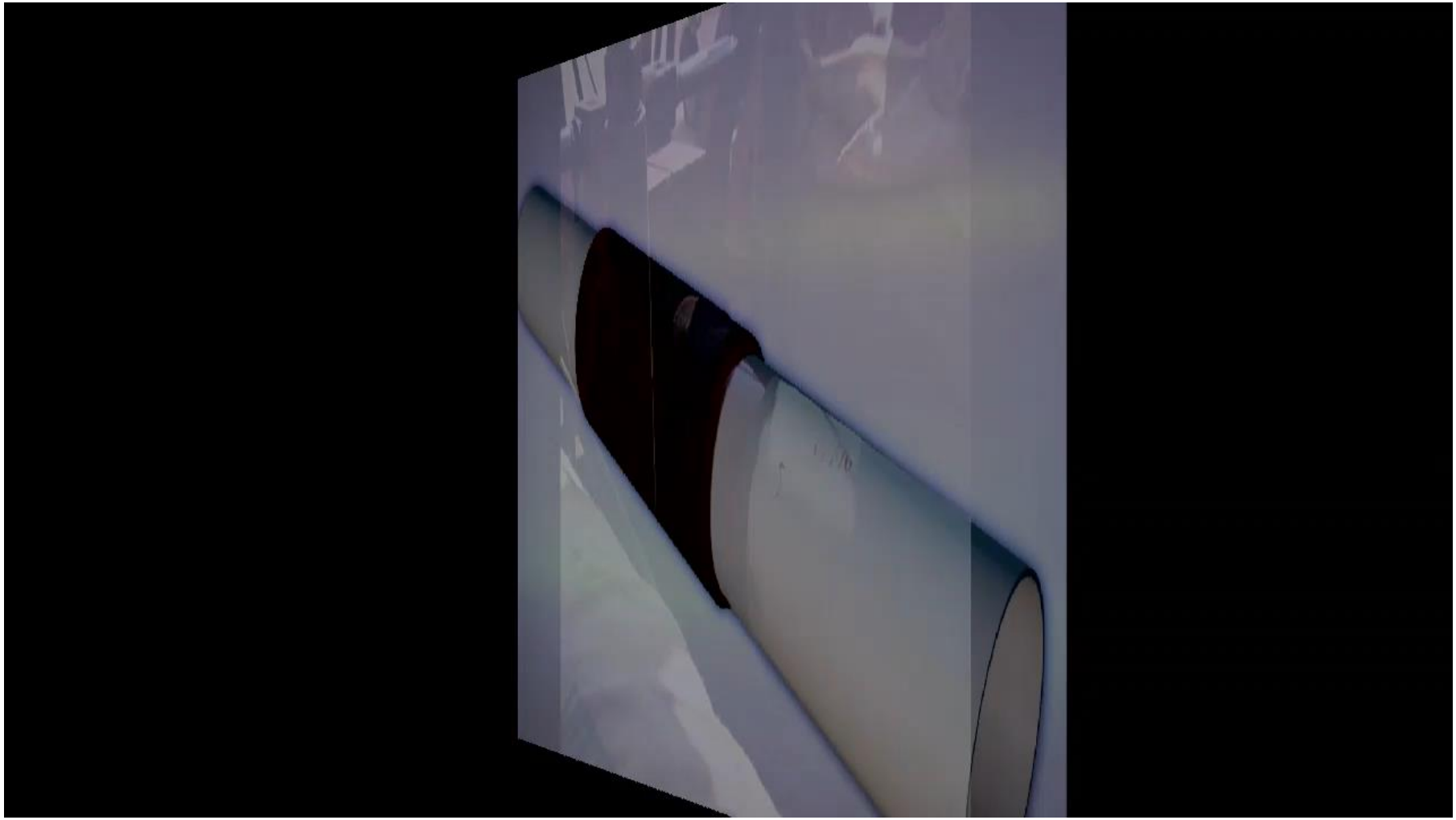
Features



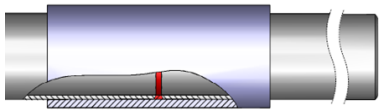
- Patented Mechanical Interference Fit Sleeve (US Patents 9,310,007, 9,453,602)
- 2” thru 12” NPS to API 5l PSL2
- Pipe or pipe end modification is not required
- Pipe internal dimensions are not significantly affected thus eliminating any flow turbulence or pigging interference
- Pipe has only frictional heating reducing risk of ID coating damage
- Cathodic protection compatible with electrical continuity between joints
- Fast and simple Installation with time and cost savings compared to other joining methods
- Long track record of experience with proven performance and reliability
- Ideal for ID coated, lined, clad and difficult to weld pipes
- Designed to exceeds 100% design capability under piping codes ANSI/ASME B31.3, B31.4, B31.8, CAN/CSA Z183, Z184, and to comply with the requirements of the U.S. Department of Transportation 49 CFR Parts 192 and 195.

Installation Animation

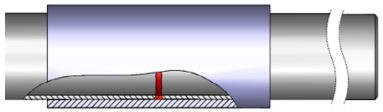




Offshore Installation Animation

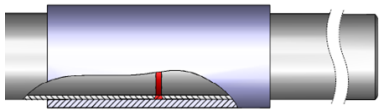


Experience - Onshore



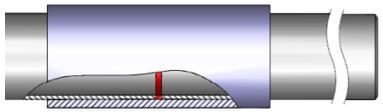
Client	Services	PSC per Diameter (pcs)					Total PSC (pcs)	Total Pipeline Length (km)
		10-in	8-in	6-in	4-in	3-in		
Various US-Based Companies (1979-1987)	Various	33,682	19,581	15,511	19,204	17,204	105,182	1,282
	TOTAL	33,682	19,581	15,511	19,204	17,204	105,182	1,282
Saudi Aramco (1988-2017*)	Water Injection	30,585	23,725	15,282	16	-	69,608	835
	Oil Flowlines	675	5,917	5,476	2,437	-	14,505	177
	Drainlines	-	766	281	-	11,518	12,565	150
	TOTAL	31,260	30,408	21,039	2,453	11,518	96,678	1,160
Petroleum Develoment Oman (1998-2014)	Water Injection	153	92	395	397	175	1,212	15
	Oil Flowlines	-	-	14,100	-	-	14,100	172
	TOTAL	153	92	14,495	397	175	15,312	187
Abu Dhabi for Onshore Oil Company (1999-2013)	Water Injection	3,258	4,671	3,941	6,014	244	18,128	221
	TOTAL	3,258	4,671	3,941	6,014	244	18,128	221
	GRAND TOTAL	68,353	54,752	54,986	28,068	29,141	235,300	2,823

Experience – Offshore



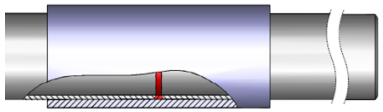
Client	Services	PSC per Diameter (pcs)					Total PSC (pcs)	Total Pipeline Length (km)
		6-in	4-in	3-in	2.5-in	2-in		
Fina Oil & Chemical Co., (1990-1994)	Various (Natural Gas, Oil, Salt Water, Oil/Water Mix)	-	927	1,086	139	410	2,562	31
	TOTAL	-	927	1,086	139	410	2,562	31
Louisiana Land & Exploration Co., (1990)	Various (Natural Gas, Oil, Salt Water, Gas Lift)	-	-	199	-	210	409	5
	TOTAL	-	-	199	-	210	409	5
Murphy Oil (ODECO), (1989)	Oil & Gas Production	-	460	-	-	-	460	6
	TOTAL	-	460	-	-	-	460	6
Shell Offshore Inc., (1987-1991)	Water Injection	-	530	-	-	-	530	6
	TOTAL	-	530	-	-	-	530	6
Unocal Corp., (1994-1995)	Various (Natural Gas, Condensate, Oil, Salt Water, Water)	299	24	90	150	-	563	7
	TOTAL	299	24	90	150	-	563	7
	GRAND TOTAL	**299**	**1,941**	**1,375**	**289**	**620**	**1,962**	**55**

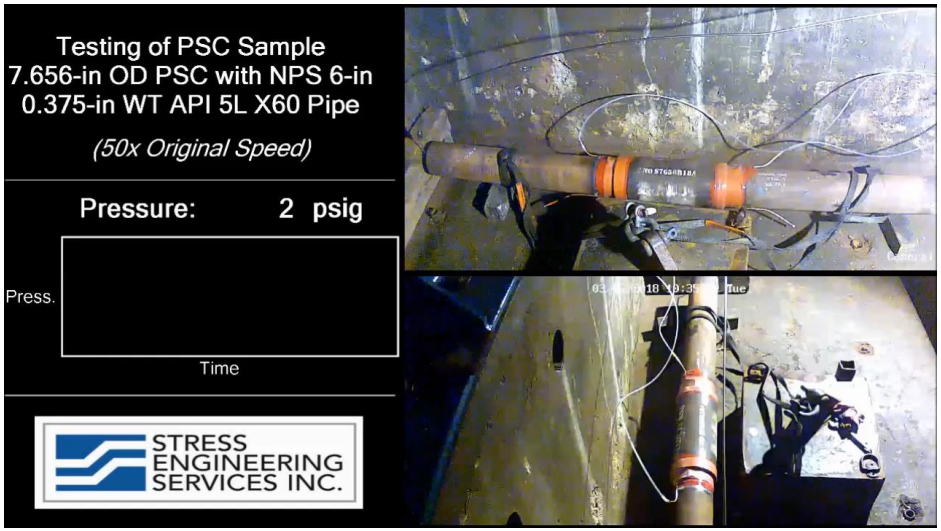
Qualification Plan



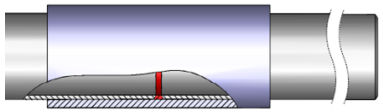
- Hydrostatic
- Tension
- Bending
- Others to be identified in FMECA process

Burst Pressure Test - PSC





Burst Pressure Test



STRESS ENGINEERING SERVICES INC.

13602 Westland East Blvd.
Houston, Texas 77041-1205
Phone: 281-469-2177
Texas Registered Engineering Firm F-195

Certificate of Test

Client:	JetAir International 750 Town & Country Blvd. Suite 300 Houston, TX 77024	**Date:** **SES Document No.:** **Project Manager:**	19 March 2018 1203920-TS-CT-01 (Rev 0) Matt Sanders, PE
Client Contact:	Ariel Agustin	**Date of Testing:**	6 March 2018
PO Number:	P18R&D.01		

Project/Test Description: JetAir International contracted SES to perform an internal pressure burst test on a 6.625" API 5L PSL-2 Grade X-60 PSC. The Sample was prepared with a leak detection system as per ISO 13679:2002.

Procedure: Increase internal water pressure until leakage or burst.

Results: Test was completed with no leakage from the coupling. The pipe body ruptured with a maximum pressure of 10,125 psi.

Prepared by: Matt Sanders, PE, Sr. Associate

Reviewed by: Patrick Whalen, Project Engineer II

Witnessed by: Arial Agustin, Jetair

Witnessed by: Jianmin Li, Jetair

10125 psi

List of Attachments:

Attachment 1: Test Plots and Photos

Attachment 2: Calibration Documentation

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Houston, Texas 77041-1205
Phone: 281-469-2177
Texas Registered Engineering Firm F-195

Certificate of Test

Client:	JetAir International 750 Town & Country Blvd. Suite 300 Houston, TX 77024	**Date:** **SES Document No.:** **Project Manager:**	19 March 2018 1203920-TS-CT-02 (Rev 0) Matt Sanders, PE
Client Contact:	Ariel Agustin	**Date of Testing:**	6 March 2018
PO Number:	P18R&D.01		

Project/Test Description: JetAir International contracted SES to perform an internal pressure burst test on a 6.625" API 5L PSL-2 Grade X-60 Welded Pipe.

Procedure: Increase internal water pressure until burst.

Results: The pipe body ruptured with a maximum pressure of 10,287 psi.

Prepared by: Matt Sanders, PE, Sr. Associate

Reviewed by: atrick Whalen, roject Engineer II

Witnessed by: Arial Agustin, Jetair

Witnessed by: mmin Li, ir

10287 psi

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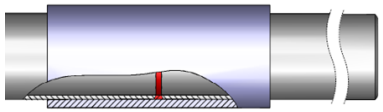
Tension Test - PSC



Testing of PSC Sample
7.656-in OD PSC with NPS 6-in
0.375-in WT API 5L X60 Pipe

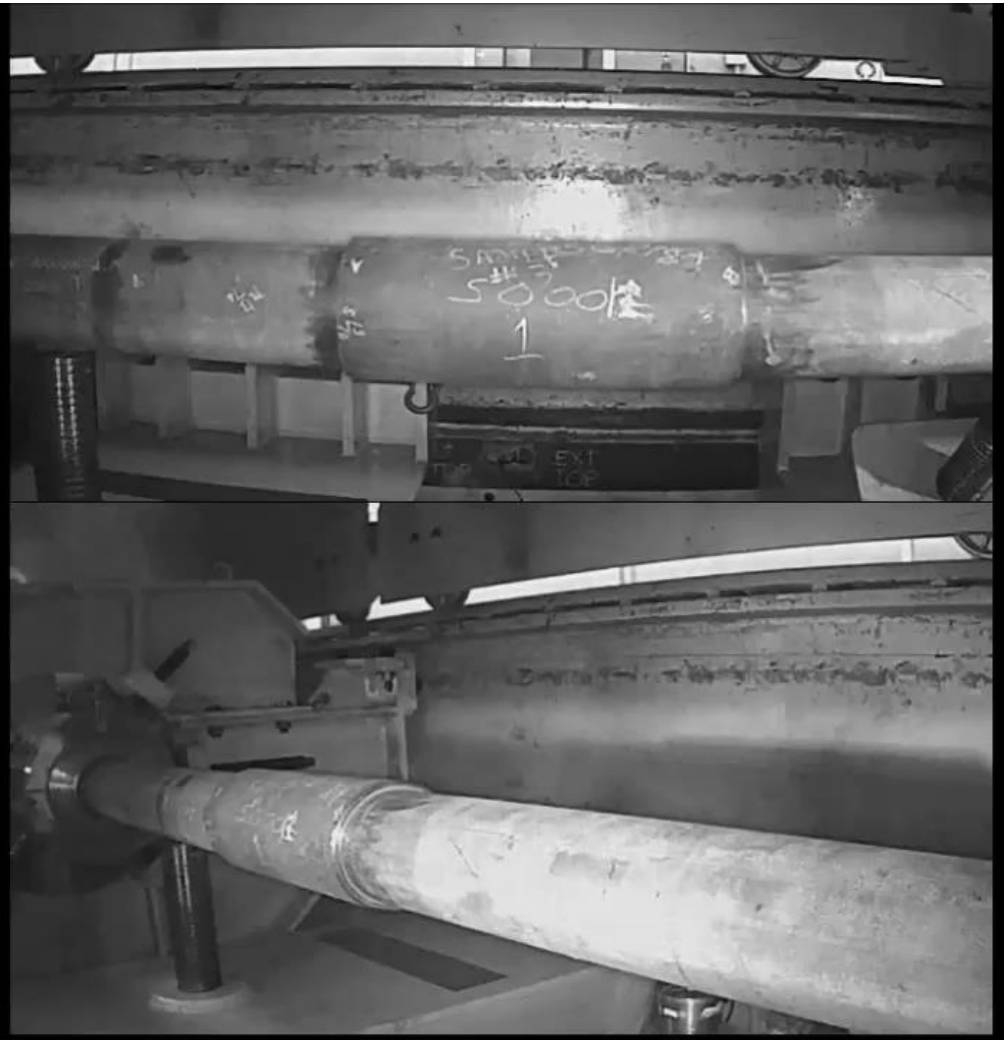
(30x Original Speed)

Load: 0 kip
Disp: -2 mils

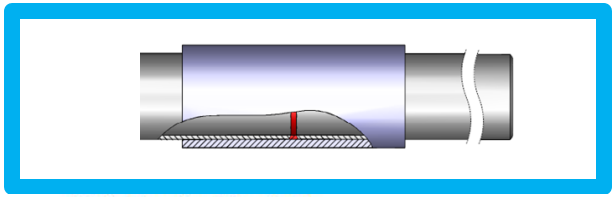
Load

Time

STRESS ENGINEERING SERVICES INC.



Testing – Axial Tension



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Houston, Texas 77041-1205
Phone: 281-469-2177
Texas Registered Engineering Firm F-195

Certificate of Test

Client:	JetAir International 750 Town & Country Blvd. Suite 300 Houston, TX 77024	**Date:** **SES Document No.:** **Project Manager:** **Date of Testing:**	19 March 2018 1203920-TS-CT-03 (Rev 0) Matt Sanders, PE 6 March 2018
Client Contact:	Ariel Agustin		
PO Number:	P18R&D.01		

Project/Test Description: JetAir International contracted SES to perform a tension to failure test on a 6.625" API 5L PSL-2 Grade X-60 PSC Pipe-Coupling.

Procedure: Increase axial tension until load can no longer be maintained.

Results: Test was completed with the Pipe pulling out of the coupling at 440 kips.

Prepared by: Matt Sanders, PE, Sr. Associate

Reviewed by: Patric[illegible]halen, Proje[illegible]ngineer II

Witnessed by: Arial Agustin, Jetair

Witnessed by: Jia[illegible], Je[illegible]

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Attachment 2: Calibration Documentation

440 kips

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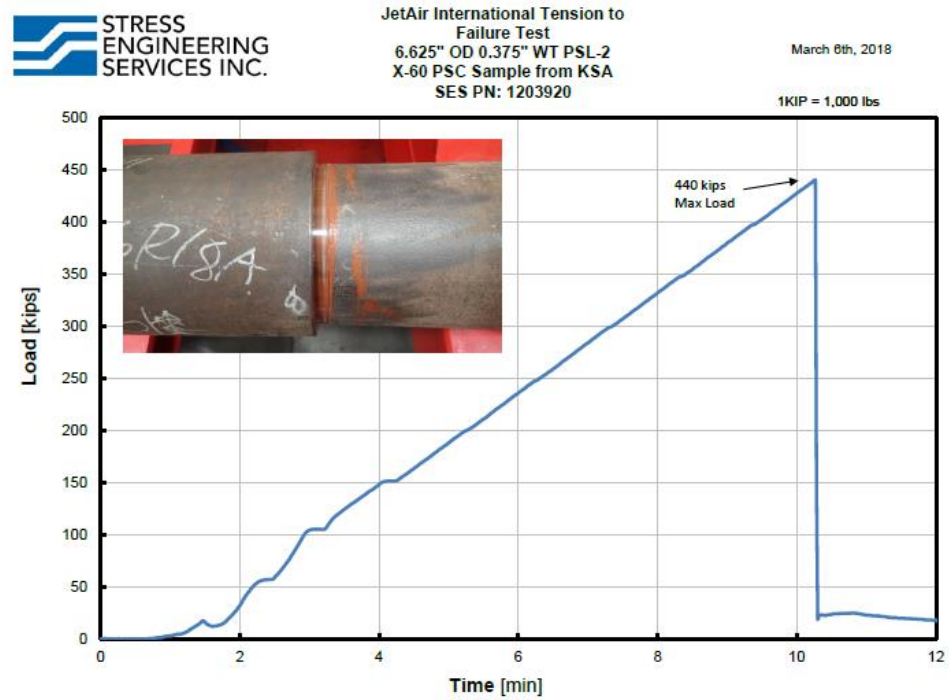
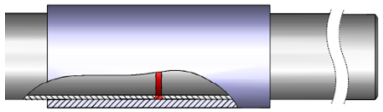


PSC tension test	**440 kips**
Pipe body X60 (calculated)	**423-576 kips @ yield**
	530-775 kips @ strength

Summary



Benefits - PSC Mechanical Interference Fit Coupling

Technical Strength

- ✓ Meets or exceeds ANSI/ASME design requirements
- ✓ Axial tensile load capacity exceeds pipe yield load
- ✓ PSCs installed on-site with no pipe length loss and minimal pipe end preparation
- ✓ Eliminate damage/repairs of ID coatings - No ID contact, No welding related heat damage
- ✓ No diameter restriction for flow or pigging interference

Fast Pipeline Construction

- ✓ Pipe insertion into PSC takes less than 60 seconds
- ✓ 2 to 4 times faster than traditional stick welding method, resulting in significantly earlier completion

Excellent Performance Record

- ✓ Proven 30+-year experience

Cost Effective

- ✓ Smaller construction crew size
- ✓ Less equipment needed on ROW
- ✓ More efficient than other joining methods / systems

Qualification to Industry Standard in progress

- ✓ DNV Technology qualification in progress

THANK YOU!

Question?

Comments