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TOTAL CAPABILITIES IN THE PIPELINE INDUSTRY

UTILITY TECHNOLOGIES INTERNATIONAL CORPORATION

Cincinnati Columbus West Jefferson

Common Natural Gas Engineering Problems – And Solutions

Ohio Gas Association
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Hoby Griset, P.E.
Steve Cremean, P.E.
John Vassaux
Brad Rode
Utility Technologies International
4700 Homer Ohio Lane
Groveport, Ohio 43125
(614) 482-8080

DISCLAIMER

Some portions of 49 CFR Part 192 are open to interpretation and federal or state regulators may not agree with the opinions expressed in this seminar. Attendees are urged to research the facts and arrive at their own conclusions.

Steel Pipe Design:

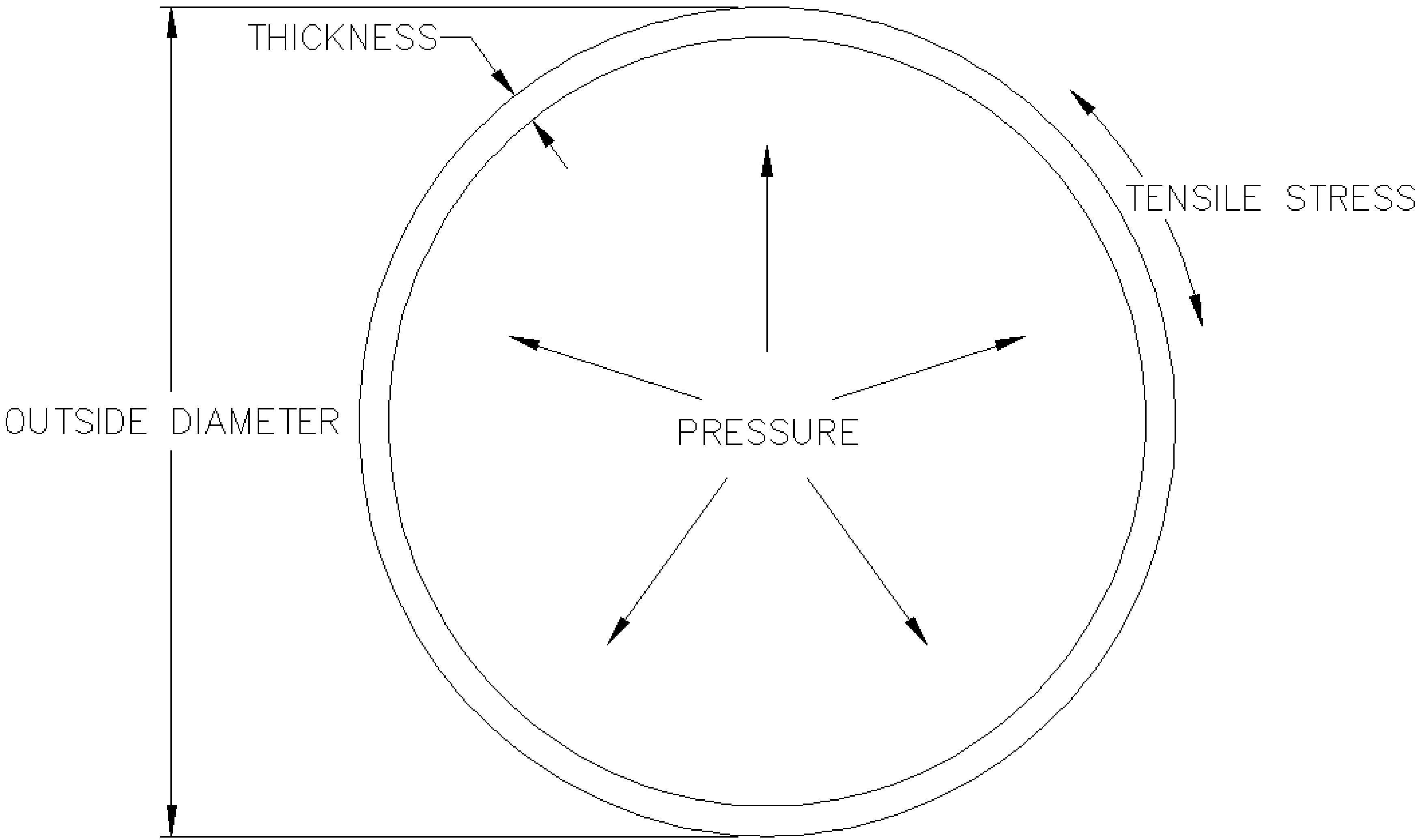
- Design formula for steel pipe
- Other design considerations
- Additional design requirements for using an alternate MAOP
- Specifications when ordering steel pipe
- Record keeping for steel pipe
- Double stamped pipe

Tensile Stress:

- A force that attempts to pull apart or stretch a material

Tensile Strength:

- A materials ability to resist tensile stress


THICKNESS
TENSILE STRESS
OUTSIDE DIAMETER
PRESSURE

Barlow's formula: P = 2St/D

Tells us that the Tensile Stress (which is also called the Hoop Stress) on the pipe = Pressure x Outside Diameter / 2 x Thickness, i.e. S = PD/(2t)

SO,

1000 psig x 10.75 in / (2 x 0.250 in) = 21,500 psig tensile stress
2000 psig x 10.75 in / (2 x 0.250 in) = 43,000 psig tensile stress

And yes, size does matter!!

2000 psig x 20.00 in / (2 x 0.250 in) = 80,000 psig tensile stress

How much tensile stress can we put on pipe?

For our purposes:

- Maximum tensile/hoop stress allowed in pipe ≈ Yield Strength "S", or Specified Minimum Yield Strength, "SMYS"

    - Grade A = 25,000 psi
    - Grade B = 35,000 psi
    - API 5L X-42 = 42,000 psi
    - API 5L X-52 = 52,000 psi
    - API 5L X-60 = 60,000 psi
    - API 5L X-65 = 65,000 psi

- Pipe used for projects regulated under Part 192 must be a listed specification in 192.7

192.105 Design Formula for Steel Pipe

$$P = (2St/D) \times F \times E \times T$$

- Design Pressure “P”
- Yield Strength (or SMYS) “S”
- Nominal Wall Thickness “t”
- Nominal Outside Diameter “D”
- Design Factor “F”
- Longitudinal Joint Factor “E”
- Temperature De-rating Factor “T”

Design Factor “F” is our safety factor

192.105 Design Formula for Steel Pipe

$$P = (2St/D) \times F \times E \times T$$

- Step 1: Choose a pipe and enter "S" (Yield Strength), "t" (Wall Thickness), and "D" (Outside Diameter)
  - For new pipe this should be straight forward
  - For existing pipe, you need to rely on existing records. If "S" is unknown, use 24,000 psi or determine "S" in accordance with Section II-D of Appendix B
  - If "t" is unknown, it must be determined in accordance with 192.109

$$P = (2St/D) \times F \times E \times T$$

- Step 2: Determine the Design Factor "F"
  - Class 1 Locations, F = 0.72
  - Class 2 Locations, F = 0.60
  - Class 3 Locations, F = 0.50
  - Class 4 Locations, F = 0.40
  - Exceptions: 0.60 for pipe in Class 1 Locations that (1) Cross the right-of-way of an unimproved public road without casing; (2) Crosses without a casing, or makes a parallel encroachment on, the right-of-way of either a hard surfaced road, a highway, a public street, or a railroad; (3) Is supported by a vehicular, pedestrian, railroad, or pipeline bridge.

$$P = (2St/D) \times F \times E \times T$$

- Step 2: Determine the Design Factor “F”
  - Class 1 Locations, F = 0.72
  - Exception: 0.60 for pipe in Class 1 Locations that (4) Is used in a fabricated assembly, (including separators, mainline valve assemblies, cross-connections, and river crossing headers) or is used within five pipe diameters in any direction from the last fitting of a fabricated assembly, other than a transition piece or an elbow used in place of a pipe bend which is not associated with a fabricated assembly.

$$P = (2St/D) \times F \times E \times T$$

- Step 2: Determine the Design Factor "F"
  - Class 1 Locations, F = 0.72
  - Class 2 Locations, F = 0.60
  - Exception: For Class 2 locations, a design factor of 0.50, or less, must be used … for uncased steel pipe that crosses the right-of-way of a hard surfaced road, a highway, a public street, or a railroad.
  - Exception: For Class 1 and Class 2 locations, a design factor of 0.50, or less, must be used … in a compressor station, regulating station, or measuring station

$$P = (2St/D) \times F \times E \times T$$

- Step 3: Longitudinal Joint Factor "E"

Specification	Pipe Class	Longitudinal Joint Factor (E)
ASTM A53/A53M	Seamless	1.00
	Electric Resistance Welded	1.00
	Furnace Butt Welded	0.60
ASTM A106	Seamless	1.00
~	~	~
API 5L	Seamless	1.00
	Electric Resistance Welded	1.00
	Electric Flash Welded	1.00
	Submerged Arc Welded	1.00
	Furnace Butt Welded	0.60
Other	Pipe over 4 inches	0.80
Other	Pipe 4 inches and less	0.60

$$P = (2St/D) \times F \times E \times T$$

- Step 4: Temperature De-rating Factor “T”

  - For gas temperature below 250° F = 1.000
  - For gas temperature above 250° F, see 192.115

Examples

What’s the design pressure for 12”, API 5L X-42, 0.250w, ERW, in a Class 3 location?

$P = (2St/D) \times F \times E \times T$

$P = 2 \times 42{,}000 \times 0.250 / 12.75 \times 0.50 \times 1.00 \times 1.00$

$P = 823.53$ psig$\leftarrow$

What wall thickness do I need for a 20”, API 5L X-52, ERW, Class 1 road crossing if I want a 1000 psig MAOP?

$P = 2 \times 52{,}000 \times 0.250 / 20.00 \times 0.60 \times 1.00 \times 1.00 = 780$ psig

$P = 2 \times 52{,}000 \times 0.320512821 / 20.00 \times 0.60 \times 1.00 \times 1.00 = 1000$ psig

$P = 2 \times 52{,}000 \times 0.375 / 20.00 \times 0.60 \times 1.00 \times 1.00 = 1170$ psig$\leftarrow$

For other pipe besides road crossings and valve settings:

$P = 2 \times 60{,}000 \times 0.250 / 20.00 \times 0.72 \times 1.00 \times 1.00 = 1080$ psig$\leftarrow$

- Other Considerations

  - Distribution vs. Transmission (need to keep below 20% SMYS)

How do I calculate 20% SMYS?

12”, API 5L X-42, 0.250w, ERW. SMYS = 42,000

20% of 42,000 = 0.2 x 42,000 = 8400 psi

Use Barlow’s formula: P = 2St/D (do NOT use E, F, or T)

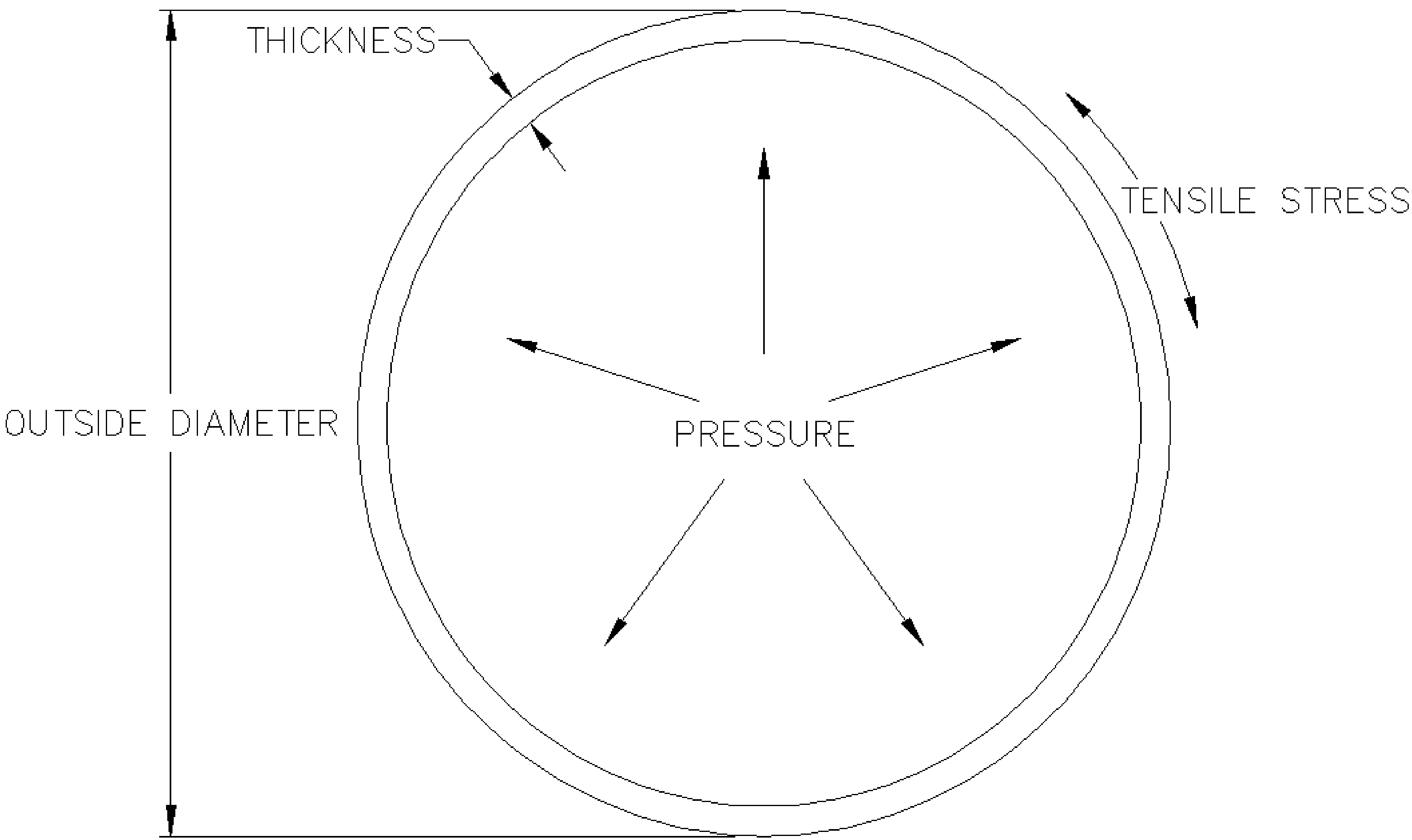
P = 2 x 8400 x 0.250 / 12.75 = 329.41 psig←

Class 3 design = 2 x 42,000 x 0.250 / 12.75 x 0.50 x 1 x 1 = 823 psig
But anything over 329 MAOP will cause it to be a transmission line

- Other Considerations
  - Availability of fittings
  - Future Class location changes
  - Road, railroad crossings
  - Bridges
  - Compressor, regulator/meter stations, valve settings, other above ground facilities
  - Damage prevention
  - Corrosion allowance
  - Ohio Power Siting Requirements
  - External loading

External loading on the pipe is additive and must be considered separately using API 1102 or other external loading calculations

UTI



Additional requirements for alternative MAOP

- Allows for Design Factor “F” up to 0.80 in Class 1, 0.67 in Class 2, and 0.56 in Class 3
- Significant additional requirements for almost every aspect, including pipe manufacturing, design, construction, testing, and operations and maintenance
- See 192.112 for further details

Specifications for ordering steel pipe

- Diameter
- Pipe manufacturing specifications
- Grade
- Wall thickness
- Product Specification Level (PSL) for API 5L pipe

Current reference standard in Part 192.7 is ANSI/API Specification 5L/ISO 3183 "Specification for Line Pipe", 44th edition, 2007, including January 2009 errata and February 2009 Addendum 1

Summary of Differences Between PSL 1 and PSL 2

Parameter	PSL1	PSL2
Grade range	A25 through X70	B through X80
Size range	0.405 through 80	4.5 through 80
Type of pipe ends	Plain-end, threaded end	Plain-end
Seam welding	All methods: continuous welding limited to Grade A25	All methods except continuous and laser welding
Electric welds: welder frequency	No minimum	100kHz minimum
Heat treatment of electric welds	Required for grades > X42	Required for all grades (B through X80)
Chemistry: max C for seamless pipe	0.28% for grades >= B	0.24%
Chemistry: max C for welded pipe	0.26% for grades >= B	0.22%
Chemistry: max P	0.030% for grades >= A	0.025%
Chemistry: max S	0.030%	0.015%
Carbon equivalent	Only when purchaser specifies SR18	Maximum required for each grade
Yield Strength, maximum	None	Maximum required for each grade
UTS, maximum	None	Maximum required for each grade
Fracture toughness	None required	Required for all grades
Nondestructive inspection of seamless	Only when purchaser specifies SR4	SR4 mandatory
Repair by welding of pipe body, plate by skelp	Permitted	Prohibited
Repair by welding of weld seams without filler metal	Permitted by agreement	Prohibited
Certification	Certificates when specified per SR15	Certificates (SR 15.1) mandatory
Traceability	Traceable only until all tests are passed, unless SR15 is specified	Traceable after completion of tests (SR 15.2) mandatory

Record Keeping for Steel Pipe

- Purchase orders (vs. phone call)
- Invoice
- Shipping receipt/bill of lading
- Mill test report (MTR's)
- Documentation on where pipe was actually installed

MTR's should be requested and retained whenever possible

IPSCO

CERTIFICATE OF TESTING
IPSCO TUBULARS (KY) INC

Certificate Number:	184425-4
Friday, February 18, 2011, 10:34:38 AM	

Diameter: 16.00 in	Gage: 0.375 in	Grade: X42/52-2M	Mill Order No:	Customer PO:
Specification: API 5L, FORTY-FOURTH EDITION GRADES X42/X52 PSL2	Customer: QAC STOCK			

Heat	Product ID		Test Type / Wgt (%)	C	Mn	Orientation / P	S	Si	Cu	Width (in) / Ni	Cr	YS (psi) / Mo	Sn	UTS (psi) / Al	V	Elong%(2 in) / Cb	Ti	Y/T / B	PCM
B115441																			
	WL-H72	970	Product	0.06	1.12	0.011	0.004	0.22	0.07	0.03	0.03	0.009	0.005	0.026	0.002	0.041	0.01	0.0002	0.13
	WL-H72	970B	Product	0.06	1.12	0.011	0.004	0.22	0.07	0.03	0.03	0.008	0.005	0.025	0.002	0.041	0.01	0.0001	0.13
B115442	WL-H72	964	MILL CONTROL			PIPE TPA				1.509		64000		75900		38.0		0.84	
	WL-H72	964B	MILL CONTROL			PIPE TPA				1.518		64100		75700		38.0		0.85	
	WL-H72	964W	MILL CONTROL			PIPE TWA				1.514				86300		0.0		0.00	
	WL-H72	964WB	MILL CONTROL			PIPE TWA				1.517				81100		0.0		0.00	
			Heat	0.03	1.09	0.010	0.001	0.22	0.07	0.02	0.03	0.011	0.001	0.030	0.001	0.045	0.01	0.0005	0.10
	WL-H72	964	Product	0.06	1.09	0.011	0.004	0.22	0.08	0.03	0.03	0.009	0.005	0.025	0.002	0.039	0.01	0.0001	0.12
	WL-H72	964B	Product	0.06	1.10	0.011	0.003	0.22	0.08	0.03	0.03	0.009	0.005	0.026	0.002	0.039	0.01	0.0001	0.12
B115443	WL-H72	966	MILL CONTROL			PIPE TPA				1.508		66600		77100		40.0		0.86	
	WL-H72	966B	MILL CONTROL			PIPE TPA				1.503		65200		76500		39.0		0.85	
	WL-H72	966W	MILL CONTROL			PIPE TWA				1.507				79300		0.0		0.00	
	WL-H72	966WB	MILL CONTROL			PIPE TWA				1.514				77800		0.0		0.00	
			Heat	0.04	1.12	0.011	0.001	0.25	0.08	0.02	0.03	0.011	0.002	0.034	0.001	0.046	0.01	0.0006	0.11
	WL-H72	966	Product	0.06	1.12	0.012	0.003	0.24	0.09	0.03	0.04	0.009	0.005	0.029	0.002	0.040	0.01	0.0001	0.12
	WL-H72	966B	Product	0.06	1.13	0.011	0.002	0.24	0.09	0.03	0.04	0.009	0.005	0.030	0.002	0.040	0.01	0.0001	0.13
B115448	WL-H72	973	MILL CONTROL			PIPE TPA				1.512		67000		77500		40.0		0.86	
	WL-H72	973B	MILL CONTROL			PIPE TPA				1.510		68700		79000		40.0		0.87	
	WL-H72	973W	MILL CONTROL			PIPE TWA				1.516				81800		0.0		0.00	
	WL-H72	973WB	MILL CONTROL			PIPE TWA				1.513				81500		0.0		0.00	
			Heat	0.04	1.08	0.009	0.001	0.22	0.08	0.03	0.03	0.013	0.002	0.032	0.001	0.046	0.01	0.0006	0.11
	WL-H72	973	Product	0.06	1.10	0.011	0.003	0.22	0.09	0.04	0.04	0.012	0.005	0.031	0.003	0.040	0.01	0.0002	0.13
	WL-H72	973B	Product	0.06	1.10	0.011	0.003	0.22	0.09	0.04	0.04	0.012	0.005	0.030	0.002	0.040	0.01	0.0001	0.13
B115446	WL-H72	968	MILL CONTROL			PIPE TPA				1.510		66500		77300		40.0		0.86	
	WL-H72	968B	MILL CONTROL			PIPE TPA				1.511		64700		75400		40.0		0.86	

TPA - Transverse Pipe Axis
LPA - Longitudinal Pipe Axis
TWA - Transverse Weld Axis
FST - Full Section Testing
FBN - Full Body Normalized
Q&T - Quenched and Tempered
SR - Stress Relieve
form CRTR3001

Flattening Test Acceptable
Ultrasonic Weld Line Inspection Acceptable
Electric Resistance Welded (Type E)
UT Cal. to 1/8" Drilled Hole and/or N10 ID/OD Notches
Melted and Manufactured in the USA
Hydrostatic Test Pressure: 1720 PSI for 5 secs
Minimum Weld Seam Heat Treatment Temperature: 1800 (F)

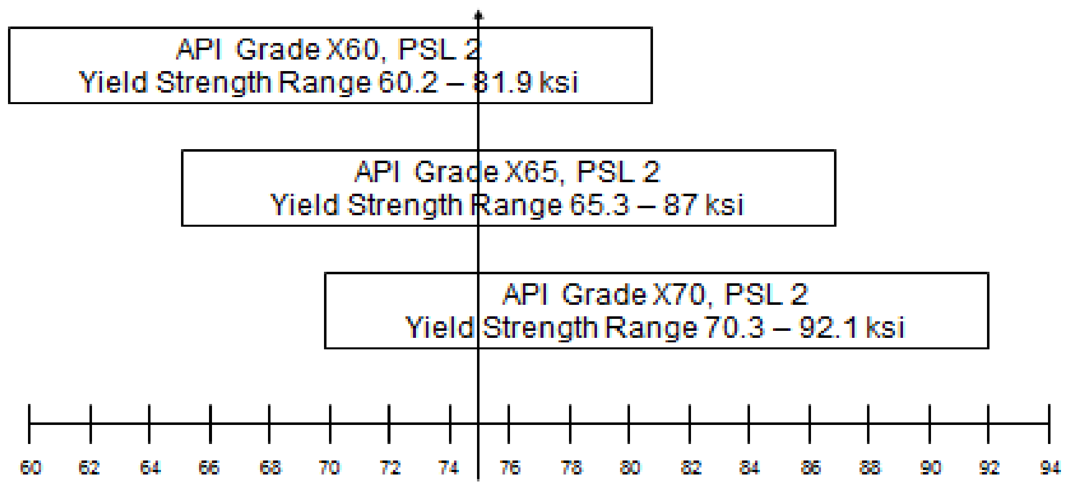
We certify that the product described above has been manufactured, sampled, inspected, and tested in accordance to the referenced specification. The product has been found to be in compliance with all requirements.

Thursday, June 16, 2011, 7:50:48 AM

MILL ADDRESS - 100 STEEL PLANT RD | WILDER, KY 41071

Double Stamped Pipe

- Why double stamped pipe?



The most common dual grade product has been Grade B/X42, but other common dual-grades are:

X-42/X-46
Grade B/X-42/X-46
X-42/X-52
X-60/X-65
X-60/X-65/X-70

UTI's policy is to design to any single chosen grade but to weld to the highest stamped grade.

Steel Pipe Test Question #1

What is a reasonable 4” pipe to select for a Class 3 distribution system with a MAOP of 400 psig?

(1) 4”, API 5-L Gr B, 0.120w, ERW
(2) 4”, API 5-L Gr B, 0.188w, ERW
(3) 4”, API 5-L X-42, 0.237w, ERW

Steel Pipe Test Question #1

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(2) 4”, API 5-L Gr B, 0.188w, ERW
(3) 4”, API 5-L X-42, 0.237w, ERW

Solution (using Barlow’s Formula to limit at 20% SMYS)

(1) 4”, API 5-L Gr B, 0.120w, ERW
- P = 2 x (35,000 x 0.20) x 0.120 / 4.5 = 373 psig

(2) 4”, API 5-L Gr B, 0.188w, ERW
- P = 2 x (35,000 x 0.20) x 0.188 / 4.5 = 584 psig← My Choice

(3) 4”, API 5-L X-42, 0.237w, ERW
- P = 2 x (42,000 x 0.20) x 0.237 / 4.5 = 884 psig

Steel Pipe Test Question #2

I have an 8", 0.188w, unknown grade transmission pipe in a Class 3 location with a 575 psig MAOP. Is it OK from a pipe design standpoint?

Steel Pipe Test Question #2

I have an 8", 0.188w, unknown grade transmission pipe in a Class 3 location with a 575 psig MAOP. Is it OK from a pipe design standpoint?

Solution (using Design Formula)

P = 2 x 24,000 x 0.188 / 8.625 x 0.50 x 1.00 x 1.00 = 523 psig NOPE

Steel Pipe Test Question #3

What is 50% SMYS in a Class 1 location for 16”, API 5L X-52, 0.250w, Butt Welded pipe?

Steel Pipe Test Question #3

What is 50% SMYS in a Class 1 location for 16”, API 5L X-52, 0.250w, Butt Welded pipe?

Solution (using Barlow’s Formula)

P = 2 x (52,000 x 0.50) x 0.250 / 16 = 812 psig

NOTE: 812 psig of internal pressure will create 50% SMYS for 16” API 5L X-52, 0.250w pipe regardless of class location, seam type, or temperature.

Steel Pipe Test Question #4

Is 12”, API 5L GR B, 0.250w, ERW pipe suitable for a 300 psig MAOP Class 3 distribution pipeline?

Steel Pipe Test Question #4

Is 12”, API 5L GR B, 0.250w, ERW pipe suitable for a 300 psig MAOP Class 3 distribution pipeline?

Solution (using Design Formula)

P = 2 x 35,000 x 0.250 / 12.75 x 0.50 x 1.00 x 1.00 = 686.3 psig

However, since distribution piping is limited to 20% SMYS, calculate “P” at 20% SMYS using Barlow’s formula:

P = 2 x (35,000 x 0.20) x 0.250 / 12.75 = 274.5 psig

This pipe is suitable for a Class 3 design but is NOT suitable for a distribution pipeline since it would exceed 20% SMYS at 300 psig (causing it to be a transmission line)