John Baron, R.E.T.

- 34 years experience in corrosion/materials specializing in non-metallics (predominantly for Shell)
- International experience (Russia, Middle East, USA)
- Currently owner/operator of J. Baron Project Services Inc.
- Past NACE chairman for Calgary/Northern Area and Board of Director for National Membership
- Currently Chairman CSA Z662 Plastics Task Force

Dale Toews

- 5+ years experience in corrosion field (Contract with EnCana Corp.)
- Currently Facilities Integrity Coordinator – EnCana (Suffield)
- ABSA In-service pressure vessel inspector
- CGSB Level II NDE (U.T., M.P.I.)

NACE International

Medicine Hat Seminar

November 22, 2005

CSA Z662- Clause 13.3
High Density Polyethylene Pipelines
Proposed Amendments 2007 Edition

John Baron
J. Baron Project Services Inc

13.3 Polyethylene Pipelines- General

- PE approved for gas gathering, multi-phase, LVP
- For gas gathering pipelines H2S < 1%, same as fiberglass pipelines.
- PE not approved for HVP liquid.
- manufacturer's properties to be used for design
- warning given for hydrocarbon effects on PE.

PE Pipelines- Design

- HDB is based on a 11.4 year life projection in accordance with ASTM 2837
- ASTM 2837 is long term hydrostatic pressure testing and time to failure under constant internal pressure
- HDB is determined from extrapolation to 11.4 years of shorter term data ie 1.5 years.

PE Pipelines- Design

- Design Pressure
- $P = (2S / R-1) \times 10^3 \times F \times T$

  where: S = HDB @ 23C

  F = Fluid Service Factor

  T = Temperature Factor

  R= OD / wall thickness

F = Table13.2

T = Table 13.3

PE Pipelines- Design

- Allowed design stress(HDB) at 23C supplied by manufacturer.
- Service fluid factors are given
  - .5 for water and "dry" gas.
  - .25 for "wet" gas, multiphase,LVP
- Temperature de-ration table for > 23C
- 60C maximum design temperature for all services.

Dry gas is a fluid containing no liquid hydro-carbons and is above the hydro-carbon dew point. Water is okay.

PE Pipelines- Materials

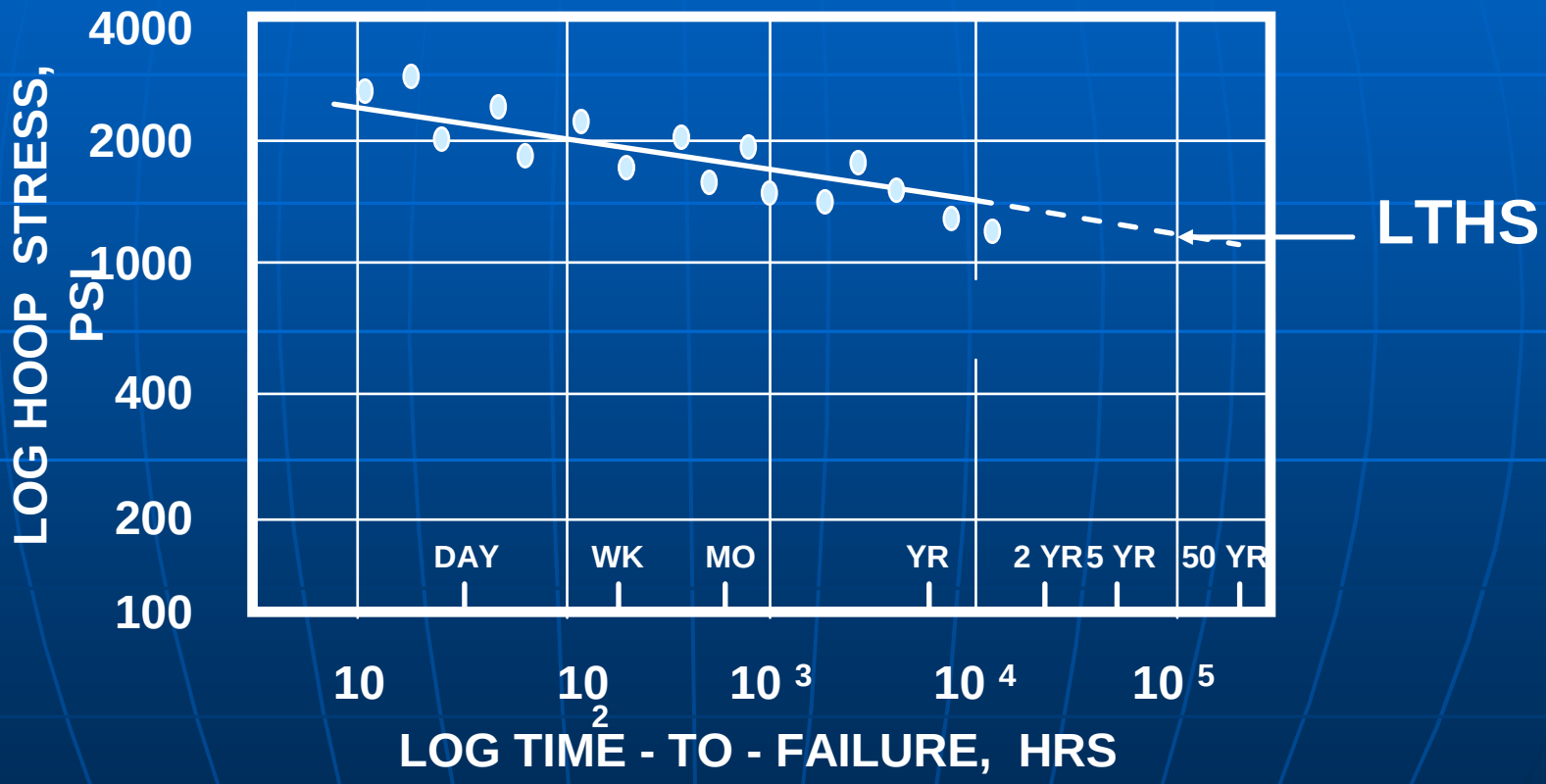
- PE 3408 required
  - Manufactured in accordance with API 15LE, sections 1-9.
  - minimum HDB of 11.0 MPa

- *Proposal* for 2007 to include ISO rated HDPE and a Separate Design Equation
  - Use MRS values, not HDB
  - ISO PE 80- MRS= 8.0 MPa
  - ISO PE 100 MRS= 10.0 MPa

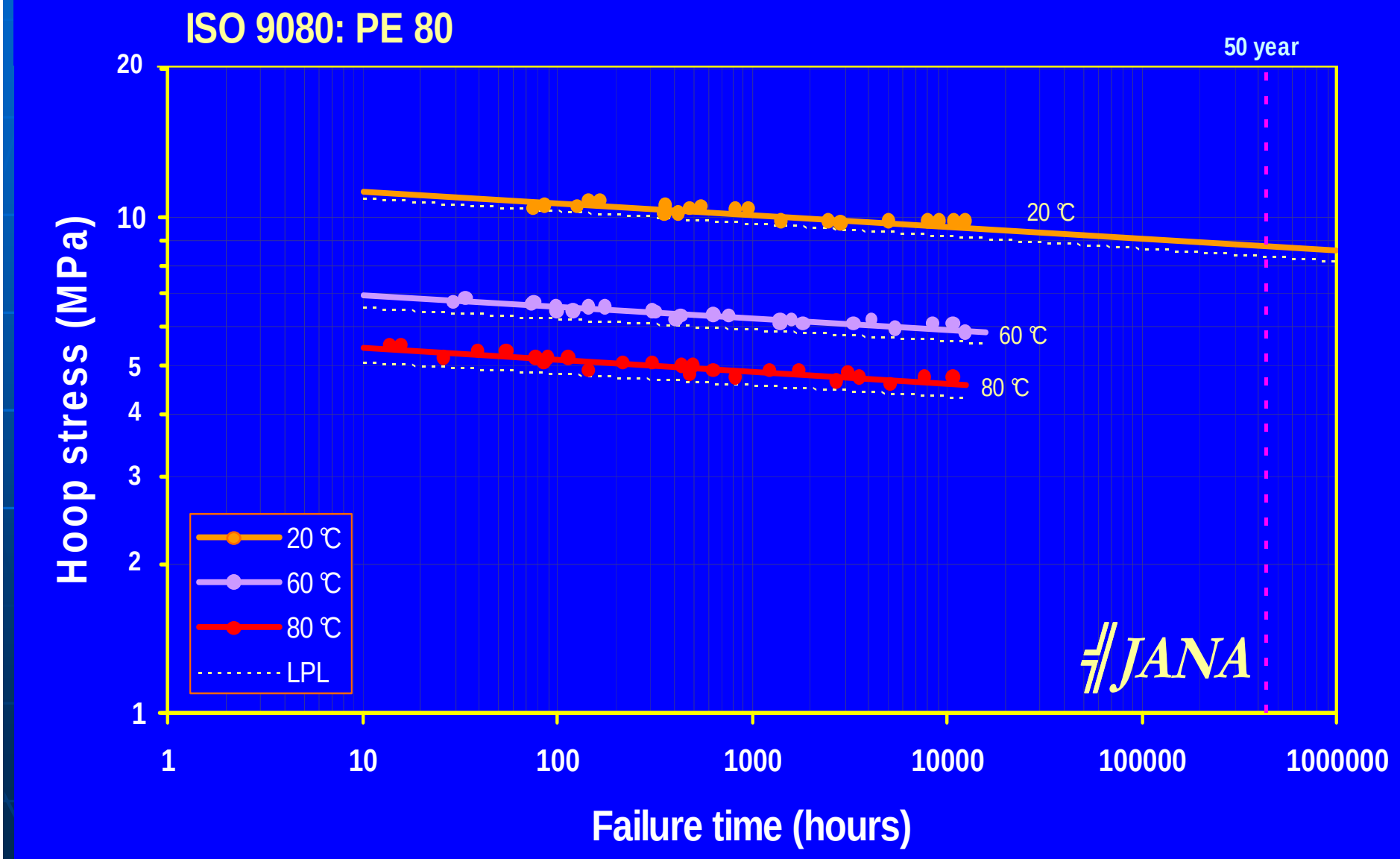
Comparison- ASTM and ISO PE Pipe

Property	ASTM PE 3408	ISO PE 80	ISO PE 100
	ASTM D2837	ISO TR 9080	
Extrapolation	100000 hours/11.4 years	438000 hours/50 years	438000 hours/50 years
LTHS	100000 hours intercept	438000 hour intercept	438000 hour intercept
Design Stress	HDB= 1600 psi (1530-1910 psi)	MRS= 1160 psi (1160-1436)= 8.0 MPa	MRS= 1450 psi (1450-1610)= 10.0 MPa
Value	Mean value	LCL	LCL
Temperatures	23C	20,60,80C	20,60,80C
Design/Service Factors	0.5*	1.25**	1.25**

ESTABLISHING LTHS PER ASTM D 2837



ISO 9080


ISO 9080: PE 80
50 year
20
10
5
4
3
2
1
Hoop stress (MPa)
20 ℃
60 ℃
80 ℃
20 ℃
60 ℃
80 ℃
LPL
JANA
1
10
100
1000
10000
100000
1000000
Failure time (hours)

Pressure Ratings- Proposal for 2007

SDR Ratio	CSA Calculation PE 3408 P=((2S)/R-1)*F*T	ISO Calculation with PE80 P=((2*MRS)/(R-1))/Ca/Cm	ISO Calculation with PE100 P=((2*MRS)/(R-1))/Ca/Cm
5	400	414	518
6.3	302	313	391
7	267	276	345
7.3	254	263	329
9	200	207	259
11	160	166	207
13.5	128	133	166
15.5	110	114	143
17	100	104	129
21	80	83	104
	P=Pressure Rating @ 23C	P=Pressure Rating @ 20C	P=Pressure Rating @ 20C
	S= HDB =1600 psi	MRS(LCL)=1160 psi	MRS(LCL)=1450 psi
	R=SDR	R=SDR	R=SDR
	F=0.5 for water and dry gas	CSA Design Coefficient, Ca= 1.12	CSA Design Coefficient, Ca=1.12
	T= T correction (1.0@<23C)	CSA Manufacturing Coefficient, Cm=1.25	CSA Manufacturing Coefficient, Cm=1.25

PE Pipelines- Installation

- any above ground portions protected from mechanical damage, and weathering.
- Metallic marker required
- trench similar to fiberglass, smooth and uniform support. No rocks within 150 mm.

PE Pipelines - Joining

- Heat fusion, special fittings, flanges.
- Threads not allowed.
- Joining procedure qualified by the pipe manufacturer or pipe installer.
- Joint strength within 5% of pipe strength
- Minimum elongation of 25% in weld zone
- Welding personnel trained and qualified by pipe manufacturer or pipe installer.

- *Proposals* for 2007 will require:
- fusion procedure documentation, (AEUB ID 022)
- qualification and
- testing of completed fusions,
- cutout frequency. 1/15 sweet, 1/10 for sour.

PE Pipelines- Pressure Testing

- 125% of MOP for 8 hours using water.
- 125% of MOP for 24 hours with air.

PE Pipelines- Operation

- Repairs by cutting out cylinder, or flanges.
- Temporary repair (1 year) allowed with clamps.
- Repair to be leak tested to 110% for 1 hour.

- *Proposals for 2007*: to allow repair to be leak tested at normal operating pressure for 4 hours.
- Tie-in joint of a new PE pipeline to an existing PE pipeline does not have to be pressure tested but subject to a service test at operating pressure and gas detection test within 1 month (gas gathering only).

SMALL DIAMETER POLYETHELENE PIPE

Dale Toews, EnCana Corporation

Purpose of this presentation

- To provide familiarity with
  - General characteristics
  - Installation of pipe
  - Fusion procedures
  - Repair issues
  - Quality issues

General Characteristics

Last 30 years, 80,000 miles of polyethelene pipe (2004)

Expansion, Contraction 70 F, 1000 ft, 8 feet

Cold Flow, self stress relieve

23 degree C, softening begins (Z662 60 C)

Insulating ability .001 inch, 300 volts static spark

- static electricity danger

Price Comparison (2, 3 inch pipe)

- HDPE pipe $ 15,000 per inch mile.
- Steel pipe $ 28,000 per inch mile.

Putting pipe underground.

- Trench is plowed.
- Pipe is fed into the ground.
- Trench is closed in.

Caterpiller with anchor applies 70 ton pull on spool tractor.

Pipe and tracer wire fed into the ground.

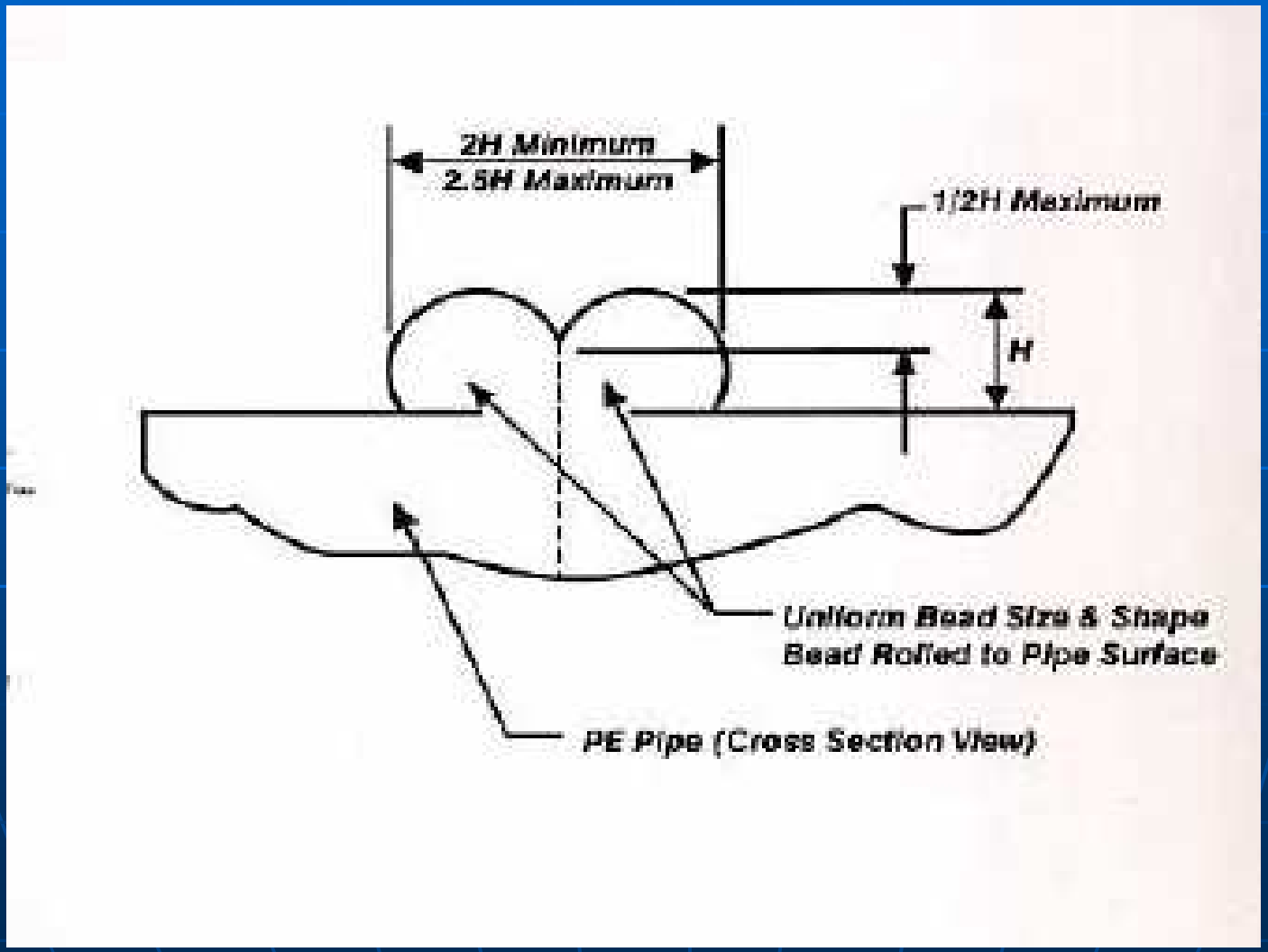
Sample pieces

- Visual examination of beads
  - Round, no corners
  - Tight together, partly fused.
  - Same size as each other
  - Same size for full circumference of the pipe.
  - Note: Normally not able to reach in and feel the inside lips.

Failure - Cold Fusion

- There are no voids in the plastic
- Most difficult to detect with NDE methods.
- Beads may appear even and round so visual inspection passes.
- Causes
  - Low heat input
  - Pressure input incorrect - too much, too slow, too fast, not enough.
  - Very cold conditions.

Cross Section of proper bead



AVERAGE COMBINED BEAD SIZES

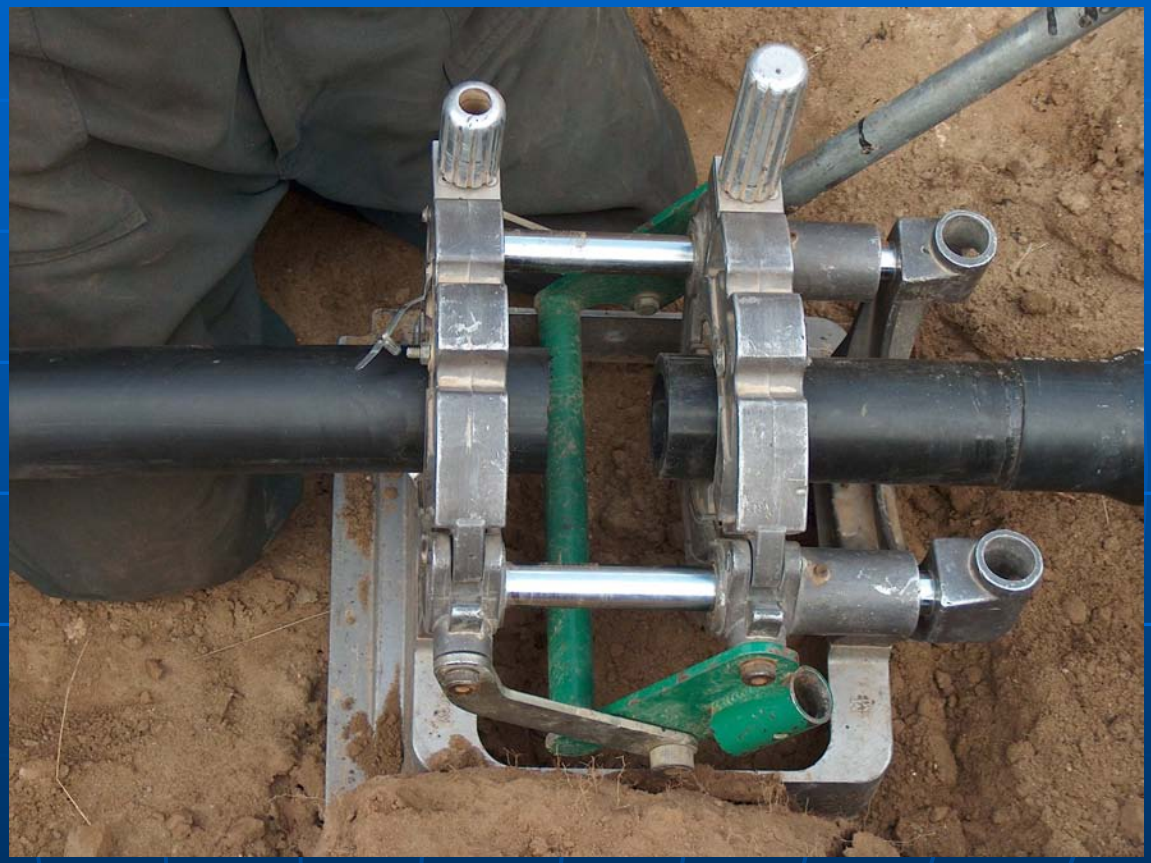
PIPE OD (mm)	PIPE OD (inches)	Individual Melt Bead Size	Average Combined Final Fusion Bead Size
15.9mm	½"	1 - 2 mm (1/32" - 1/16")	3 - 5 mm (1/8" - 3/16")
26.7mm	¾"		
33.4mm	1"		
42.2mm	1 ¼"		
48.3mm	1 ½"	2 - 3 mm (1/16" - 1/8")	4 - 6 mm (5/32" - 7/32")
60.3mm	2"		
73.0mm	2 ½"		
88.9mm	3"	3 - 5 mm (1/8" - 3/16")	6 - 8 mm (5/32" - 5/16")
114.3mm	4"		
168.3mm	6"	4 - 6 mm (5/32" - 7/32")	8 - 12 mm (5/16" - 15/32")
219.1mm	8"		

Fusion Tools

- Press
- Rotary file
- Isopropyl alcohol
- Heat iron.

Fusion Procedure

- Align pipe in the press.

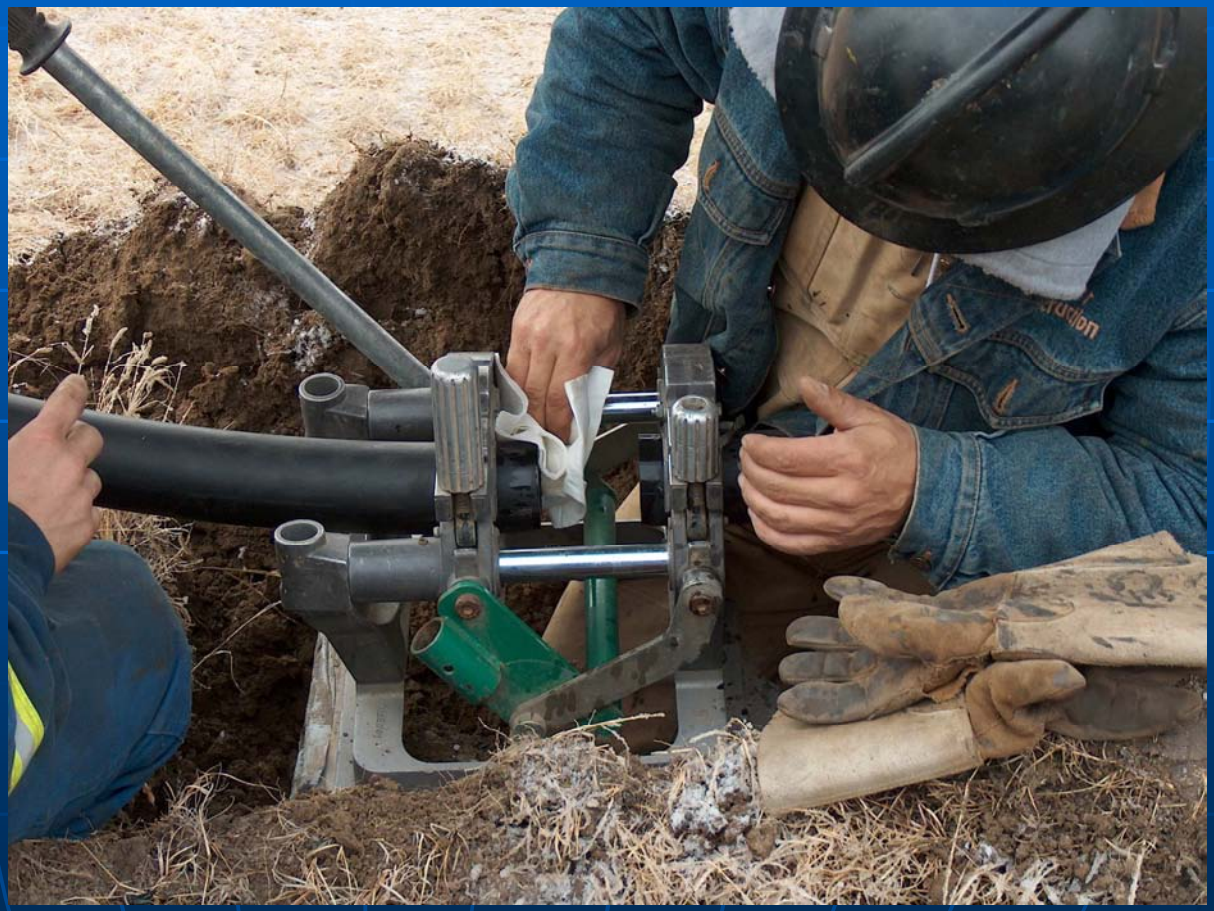


Fusion Procedure

- Shave ends of pipe. This cleans and makes the two surfaces parallel.

Fusion Procedure

- Clean with isopropyl alcohol, reduce static (>99%)
- Ensure no debris.



Fusion Procedure

- Clean heater

Fusion Procedure

- Apply even heat.

Fusion Procedure

- Press together, fusion pressure approximately 25 psi
  - Pressure too small, bad fusion
  - Pressure too great, bad fusion

Fusion Procedure

- Let cool, visual check of beads.

QC issues – Procedure is Key

- Operator perception can lead to unwarranted procedure change.
  - Skip the isopropyl alcohol cleaning.
  - Don’t use the right material.
  - Slam the press closed instead of steady smooth pressure. Too much pressure.
  - Lack of care with what is inside the pipe.
- Adherence to procedure is key.

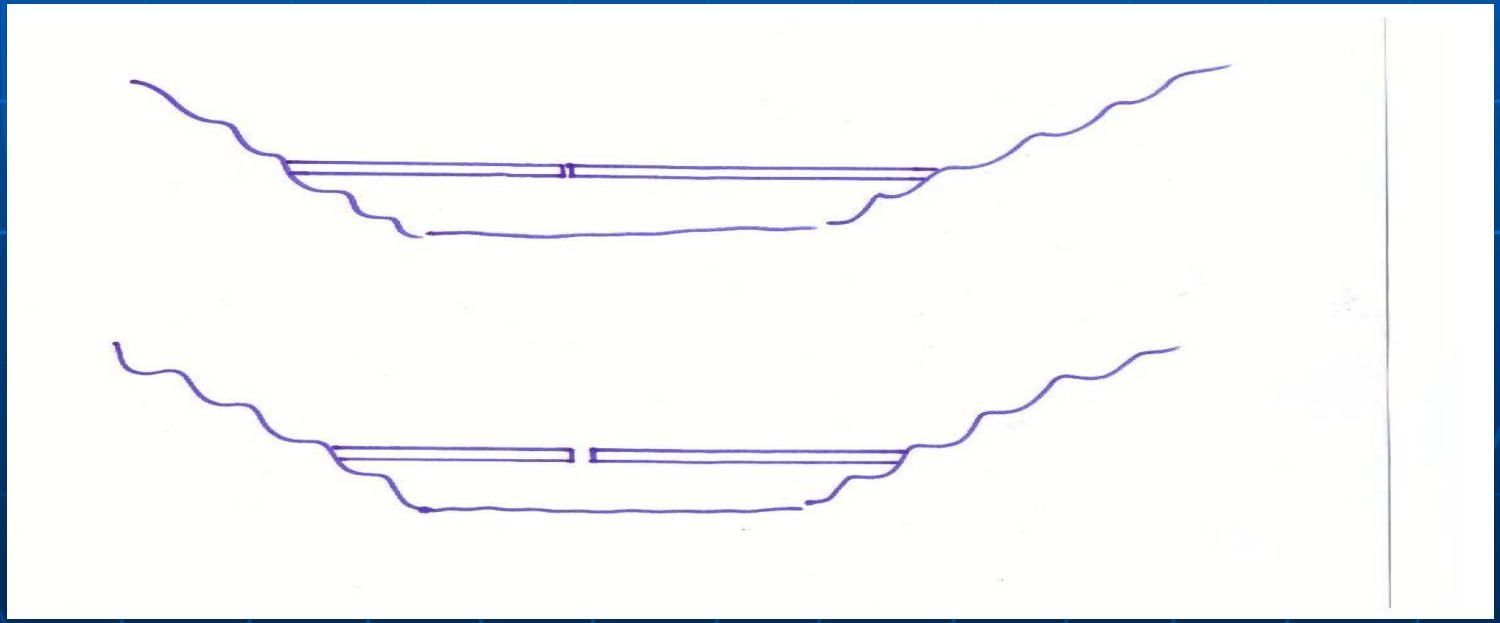
Cold Fusion

Cold Fusion

- Note portion of failed fusion that is quite smooth.

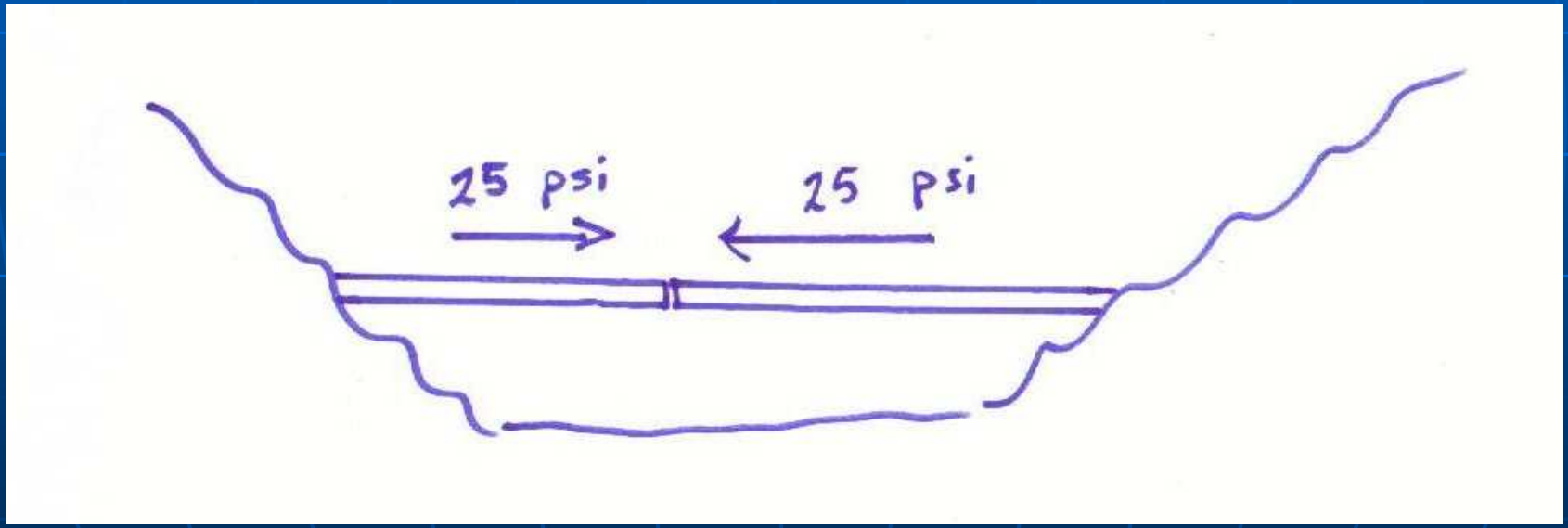
Repair issues

- Pipe failure – ends in perfect position.
- After shaving pipe, there is a slight space.



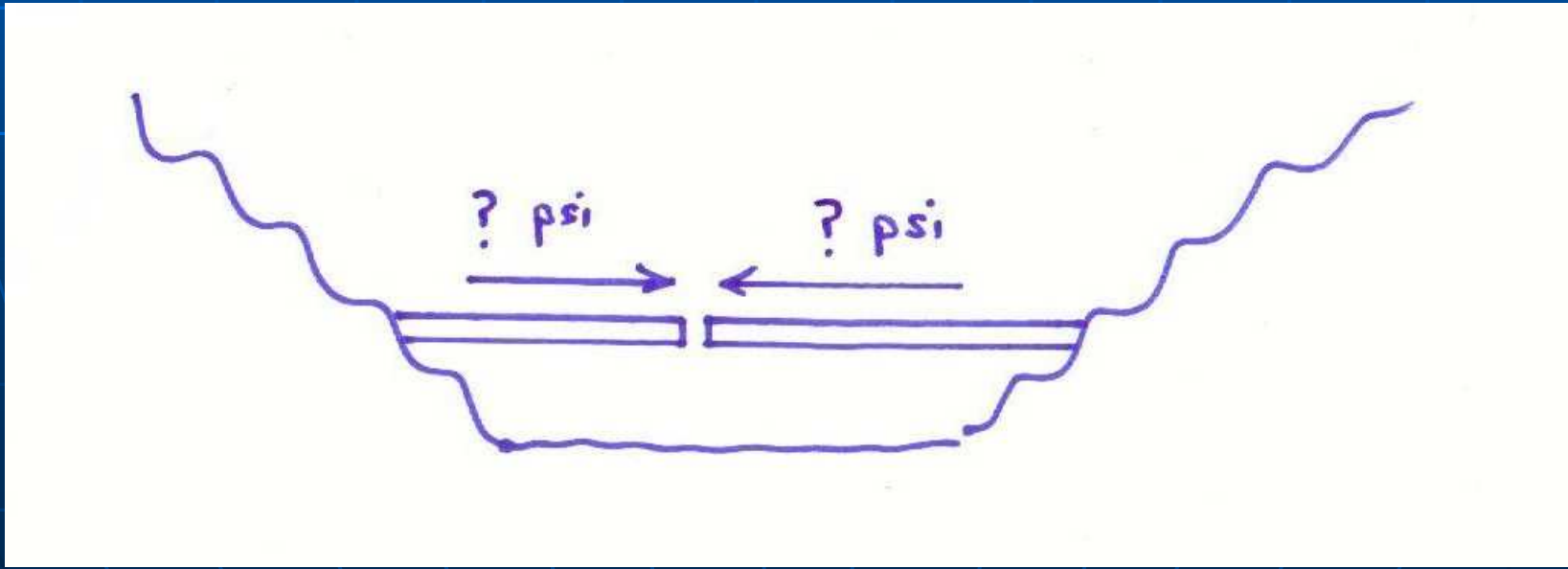
Repair Issues

- If no space between pipe:
  - Fusion pressure = 25 psi



Repair Issues

- After shaving to clean and make pipe true:
  - Fusion Pressure = 25 psi + force required to pull pipe together.



QC issues – Steel vs Plastic

Steel welder goes through more training.

Steel Welder

- Theory training
- Apprenticeship
- Journeyman
- Qualification welding
- NDE of welds
- Years invested

Plastic Fuser

- One day course
- Support of employer.

QC issues – Steel vs Plastic

Many more variables with steel welding.

Steel Variables

- Heat input, current
- Speed of welding
- Rod size, material
- Pre-heat, post-heat
- Weld prep, gap
- Parent material
- Positions
- Direction of welding
- Contamination

Plastic Variables

- Fusion pressure and speed.
- Contamination
- Temperature

NDE Challenges

- Cold Fusion
  - no voids within plastic.
  - Beads may appear acceptable
  - difficult defect to detect with NDE

- Currently no acceptance criteria for NDE