Piping Codes and Welding for Mechanical Contracting Managers

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Objective

- To make management of mechanical contractors aware of requirements associated with doing work to ASME B31 Piping Codes and to instill awareness of the need to be aware of customer specification requirements.

- Existence of the B31 Codes as standard industry practice.
- Fabrication, installation practices under ASME B31 codes
- Inspection requirements of the various B31 Code Sections compared.
- Contract and specification issues, supplementary examinations and "death clauses"

Notice

All statements by the speakers represent their opinions alone and do not necessarily represent the position of the ASME Boiler and Pressure Vessel Code Committee. All requests for interpretations or other inquiries relative to ASME Code and Standards should be addressed to the Secretary, ASME Boiler and Pressure Vessel Code Committee, ASME International, Three Park Avenue, New York, NY 10016-5990.

Why do we have Codes. . .

- Industrial Revolution
- Steam became a prime mover for transportation, factories, space heating
- Boilers would blow up and kill people

Historical Background

- Boiler Code Committee was formed in 1911 to prepare a uniform code that could be adopted by local jurisdictions for safe design, manufacture and testing of steam boilers.
- The first edition of this safety code was published in 1914 (Boiler Code). 5 X 8 format, 119 pages
- The Boiler Code was expanded to include pressure vessels in 1928 (P&PV Code).
- The first piping code “B31” was published in 1935

BOILER AND PRESSURE VESSEL CODE

I Rules for Construction of Power Boilers
II Materials
III Division 1 -- Nuclear Components
IV Rules for Construction of Heating Boilers
V Nondestructive Examination
VIII Rules for Construction of Pressure Vessels
Division 1
Division 2 -- Alternative Rules
Division 3 -- Alternative Rules for Construction of High Pressure Vessels
IX Welding and Brazing Qualifications
XI Rules for In-service Inspection of Nuclear Power Plant Components
XII Transport Tanks
XIII Pressure Relief Valves (in preparation)

ASME B31 Code for Pressure Piping

ASME B31.1	Power Piping
ASME B31.3,	Process Piping
ASME B31.4,	Pipeline Transportation Systems for Liquids and Slurries
ASME B31.5	Refrigeration Piping
ASME B31.8	Gas Transmission and Distribution Piping Systems
ASME B31.9	Building Services Piping
ASME B31.12	Hydrogen Piping

ASME CODES

When is Code required to be followed

1) By law:
   - ASME BPVC is adopted by law in most states.
   - Piping Codes are generally not adopted by law
   - Piping Codes are invoked in industrial facilities as a result of OSHA Process Safety Management laws.
   - Some States invoke API Standards (e.g., API 510 in Indiana)
   - Some cities invoke piping codes, others refer to the IMC or UMC which have some rules on piping
   - NFPA 99 is invoked for Medical Gas Piping
   - NFPA 13 is invoked for Fire Protection Piping
   - Laws are available on jurisdictional web sites.

ASME CODES

When is Code required to be followed?

2) By contract:
   - When the code is not imposed by law, Owners and their engineers will elect to follow the Code and impose it on fabricators and contractors.
   - Most commonly occurs with piping since piping codes are not typically adopted by law.
   - Also occurs with pressure vessels when Pressure Vessel Code is not adopted by law.

3) Just to follow industry-accepted practices. (Due diligence to follow standard industry practice)

Consensus Aspects

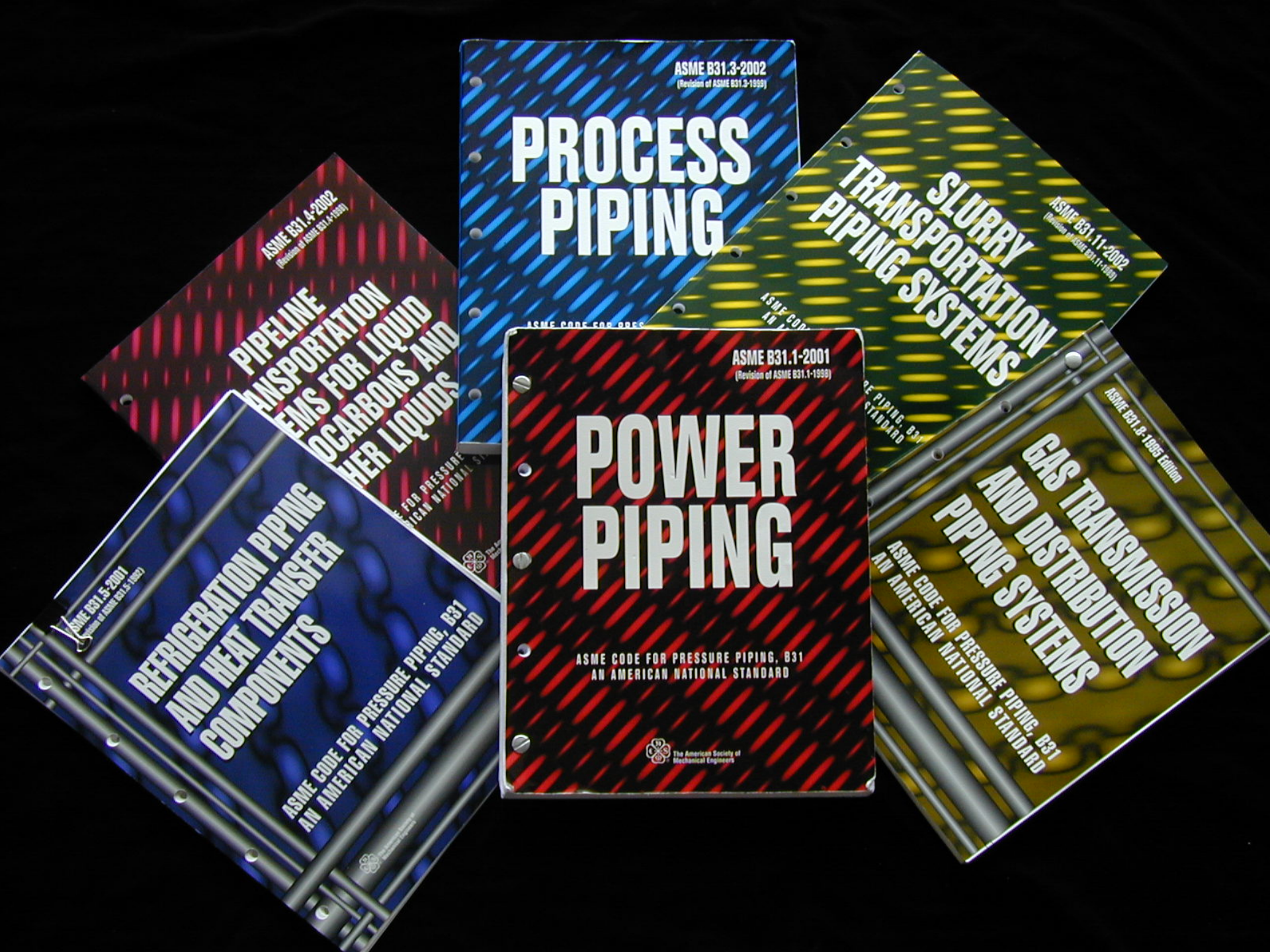
- Code is a consensus standard.
- ASME Committees membership represents: designers, fabricators, fabricator/constructors, inspectors, regulators, owners and general interest members.
- Representation of these interest groups is balanced on the committees. No domination by any group is permitted.
- Code rules are issued only when consensus is reached and negative votes have been addressed.

Consensus Aspects

- Code represents Standard Industry Practice
- Standard Industry Practice (SIP) describes how an industry generally does what it does. Under contract law, *SIP is recognized by the courts* as a basis for supporting the activities of one party or another in a contract dispute.
- Codes are prepared by balanced committees, representing all sides of establishing the SIPs given in the Codes
- Codes are in writing, clearly defining SIP

Selection of Piping Code Sections

- The most commonly referenced codes governing piping are those covered by the American Society of Mechanical Engineers ASME *B31 Code for Pressure Piping.*
- It is written in several Sections which address specific industries.


ASME B31.3-2002
(Revision of ASME B31.3-1999)
PROCESS PIPING
SLURRY TRANSPORTATION PIPING SYSTEMS
ASME B31.11-2002
ASME B31.4-2002
PIPELINE TRANSPORTATION EMS FOR LIQUID OCARBONS AND HER LIQUIDS
ASME B31.1-2001
(Revision of ASME B31.1-1998)
POWER PIPING
ASME CODE FOR PRESSURE PIPING, B31
AN AMERICAN NATIONAL STANDARD
The American Society of Mechanical Engineers
REFRIGERATION PIPING AND HEAT TRANSFER COMPONENTS
ASME CODE FOR PRESSURE PIPING, B31
AN AMERICAN NATIONAL STANDARD
ASME B31.8-1995 Edition
GAS TRANSMISSION AND DISTRIBUTION PIPING SYSTEMS
ASME CODE FOR PRESSURE PIPING, B31
AN AMERICAN NATIONAL STANDARD

ASME B31 Code for Pressure Piping

ASME B31.1	Power Piping
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ASME B31.5	Refrigeration Piping
ASME B31.8	Gas Transmission and Distribution Piping Systems
ASME B31.9	Building Services Piping
ASME B31.12	Hydrogen Piping

Selection of Code Sections

Each Section Covers:

- materials which are permitted,
- design formulae,
- sets limits on stresses,
- specifies fabrication, installation methods and techniques,
- specifies the extent and acceptance criteria for examinations, inspections and tests
- Maintenance and repair activities (recently added to some sections)

SELECTING APPLICABLE PIPING CODES

Introduction to every B31 Code Section says:

It is the owner's responsibility to select the Code Section(s) that most to a proposed piping installation. . . . Each Code Section should be applied as a whole to a given selection of piping. The owner is also responsible for imposing requirements supplementary to those of the Code to assure safe piping for the proposed installation

For the Owner's and your convenience, the scopes for all B31 Code Sections are posted at:

http://cstools.asme.org/csconnect/pdf/CommitteeFiles/22855.pdf

or

Search "Selecting ASME B31 Codes"

Contents of a Typical Engineering Package

Most important, the ***very first thing to look for in the Engineer's Specification or Drawings*** is:

1) Reference to a specific B31 Piping Code Section for the job or for each system.

Contents of a Typical Engineering Package

- If the specification lists all the codes and standards known to God related to piping, welding, bricklaying and steelwork. . . .

Contents of a Typical Engineering Package

Then the specification says:

“Install the piping in accordance with the applicable Code Section. . . “

Look out!!!

Why?

B31 Code for Pressure Piping

It is possible for more than one of the Sections of B31 to apply. For example, within a refinery, there may be a power plant, there may be refrigeration or cooling systems and there may be office buildings.
Your contract is to install the HVAC piping in the office building. . .

Which B31 Section applies?

B31 Code for Pressure Piping

- B31.1, Power Piping, covers piping used in power generation facilities and central district heating plants, including water, steam, gas, vacuum and compressed air.
- B31.3, Process Piping, covers all piping within chemical process plants and petroleum refineries.
- B31.5, Refrigeration Piping, covers ammonia, chlorofluorocarbon and other gas piping used in refrigeration piping.
- B31.9, Building Services Piping, covers water, air and steam piping which is inside or services buildings such as office buildings, motels, hospitals, etc.

If a B31 Code is not specified in contract documents, state in your quote which Section you will follow:

- Recognized Standards
- safety standards that are widely used
- They Provide basis for contractual defense of the quality of installed work
- They present Standard Industry Practice which is recognized by the courts under contract law in the resolution of disputes.

A word on Welding Safely

Safety Documents

At www.aws.org . . . And they're Free!!!

AWS/ANSI Z49.1, *Safety in Welding and Cutting and Allied Processes*

Health and Safety Fact Sheets -- suitable for lunch-box talks.

Common Welding And Brazing Processes for Piping and Pressure Vessels

Welding Processes

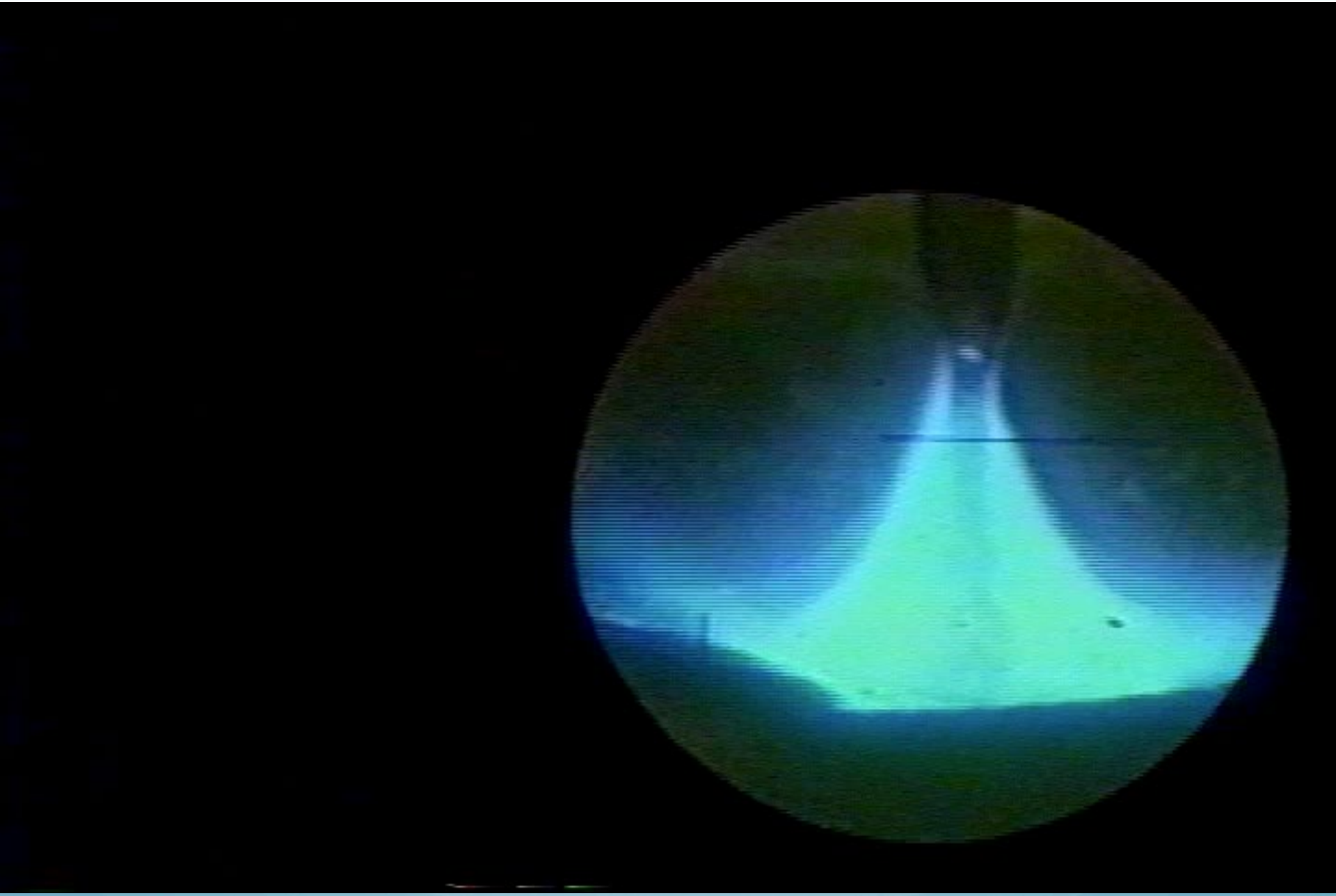
Welding Process Formal Name/Description	Common Name	Relative Cost[1]	Welder/Brazer Skill Level	Equipment Complexity	Shielding Gas [2]	Welding Positions
Shielded Metal Arc (SMAW) Using E6010, E7018, E308-16, etc.	Stick	20	Medium-High	Minimal	None	All
Shielded Metal Arc (SMAW) Using E7024, E7028, E308-26	Stick, Jet-rod	7	Low	Minimal [3]	None	Flat [4]
Gas Tungsten Arc (GTAW)	TIG, Heliarc	100 [5]	High	Simple	Yes	All
Gas Metal Arc (GMAW-S) Short Circuiting Transfer	MIG, Micro-wire	12	Medium-High	Medium	Yes	All
Gas Metal Arc (GMAW) Spray Transfer Mode	MIG	3	Low	Medium to High	Yes	Flat
Gas Metal Arc (GMAW-FC) Flux core Wire	Flux core Dual-shield	8	Medium-Low	Medium	Yes	All
Gas Metal Arc (GMAW-FC) Flux core Wire	Flux core Dual-shield	3	Low	Medium to High	Yes	Flat
Gas Metal Arc (GMAW-FC) Self-shielding Flux core Wire	Innershield	15	Medium-High	Medium-Low	No	All
Submerged Arc (SAW)	Sub-Arc, “Automatic”	1	Medium Low	High	No	Flat

[1] Higher Numbers indicate more costly processes to use.
[2] Protection from wind is needed when shield gas is required.

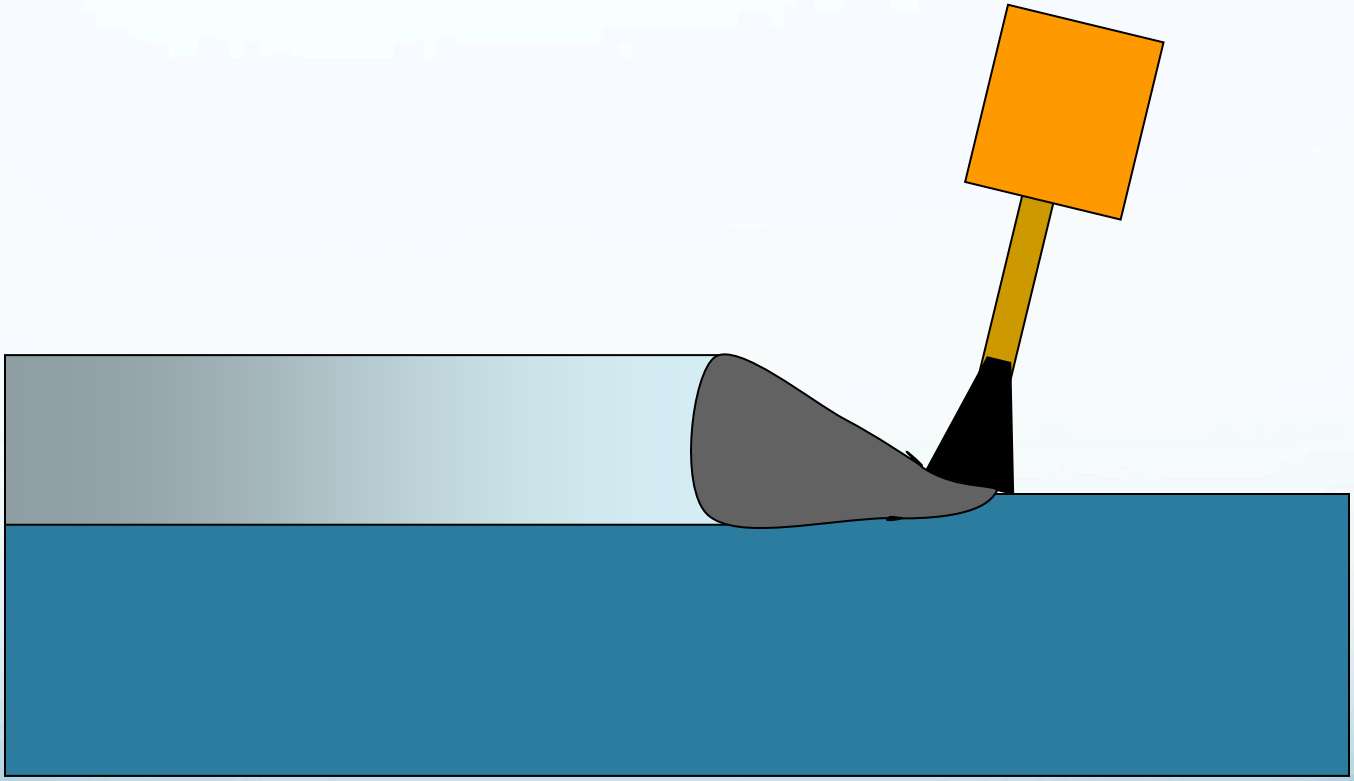
Gas Metal Arc Welding (GMAW)

- Commonly known as ‘MIG (Metal inert Gas).”
- Deposition rates 3 to 4 times SMAW
- Less welder skill required
- Minimal post weld cleaning is required
- All-position capability (with caution)
- Welds can be made without starts and stops when the weld is rotated

elding



GMAW-S – Focused Welder Training Is Needed



Stay at the leading edge of the weld pool. . . .

Modern Pulsed Power Supply waveform control technology

- All Settings are preprogrammed.
- Welder enters filler metal size, type, shielding gas, computer sets basic pulse parameters.
- Welder can adjust wire feed speed and arc intensity.
- Makes a so-so welder into a great welder using waveform control technology

Miller Pipe Pro

PipePro™ Welding System

The one-package pipe welding solution for both field and shop fabrication. Multiprocess capabilities include new patented RMD Pro and Pro-Pulse which are optimized for steel and stainless steel pipe.

PipePro 450 RFC shown with PipePro Bench Feeder and Bernard PipeWorx Gun

See the Advanced Software Technology featured on the PipePro System CD:

RMD™ Pro (Regulated Metal Deposition) - Precisely controlled short-circuit transfer technology provides welders with an easy to use welding process with excellent puddle control for the root pass. Calm, stable arc/puddle reduces weld training and improves quality.

Pro-Pulse™ - This method of pulse welding is easier to use than conventional pulse in out-of-position pipe welding applications. This is accomplished through precise control of the arc and puddle even in narrow joints, which provides optimum molten puddle control for out-of-position welding.

The **PipePro 450 RFC** power source

Lincoln Invertec STT

Invertec STT II 208/230/460/3/60

Featuring the Surface Tension Transfer (STT) Process

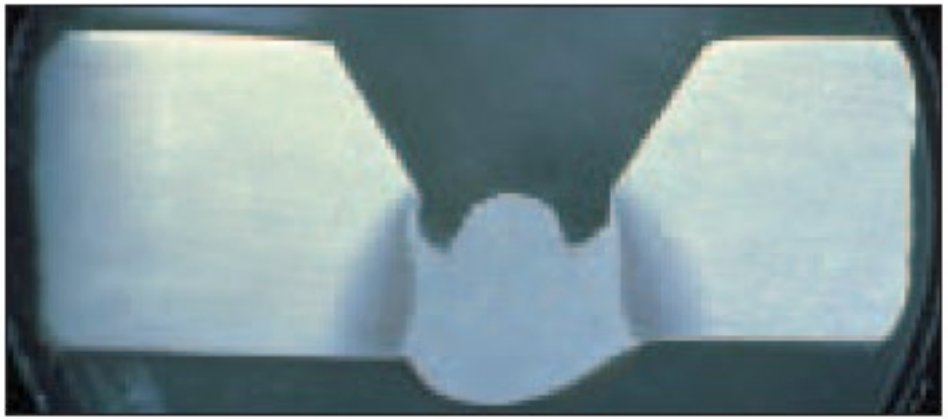
Product Number: K1525-1

Industrial Price: 8672.00 (USD) *See Details

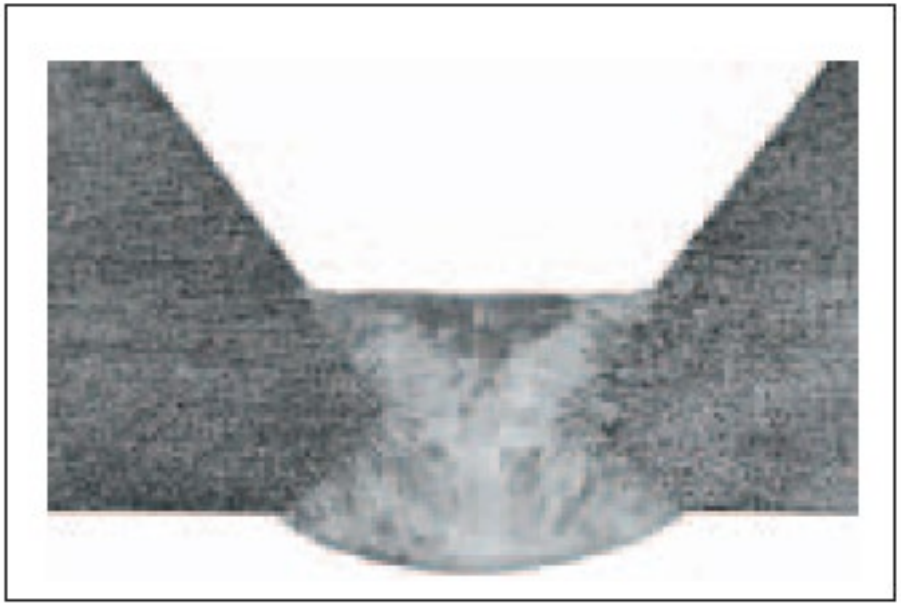
The revolutionary STT II power source combines high frequency inverter technology with advanced Waveform Control Technology™ to provide a better welding solution than traditional short arc MIG. Unlike CV MIG machines, the STT machine has no voltage control knob. STT uses current controls to adjust the heat independent of the wire feed speed, so

Root Pass Bead Shape

ROOT PASS?

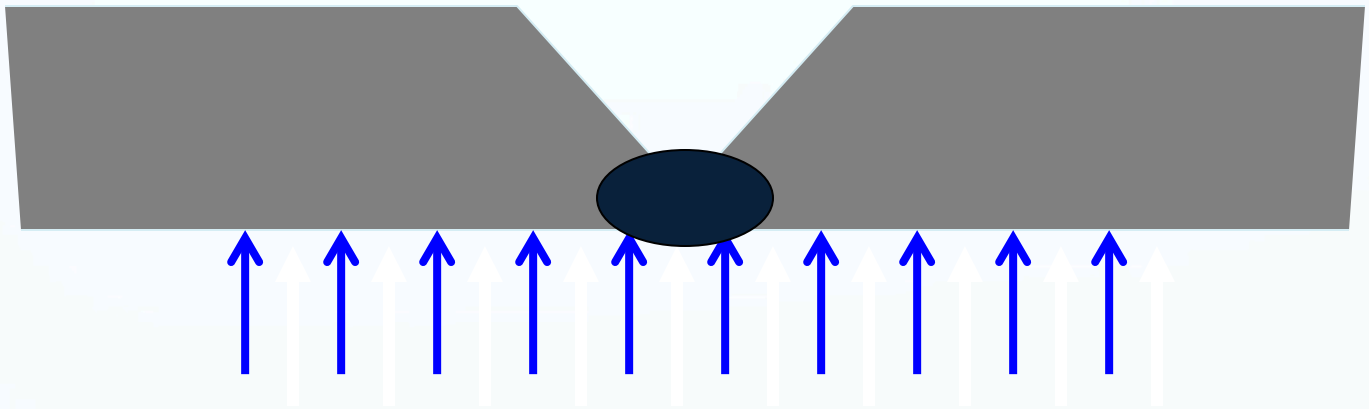


Open Root Pass with Stick Electrode



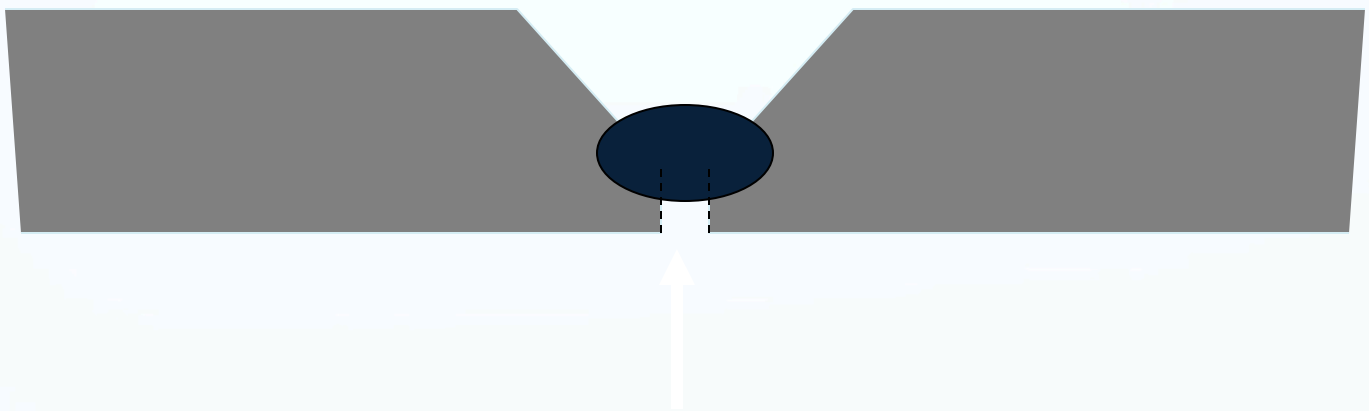
Open Root Pass with STT provides a weld ligament thickness of approximately 0.22˝.

Full Root Penetration



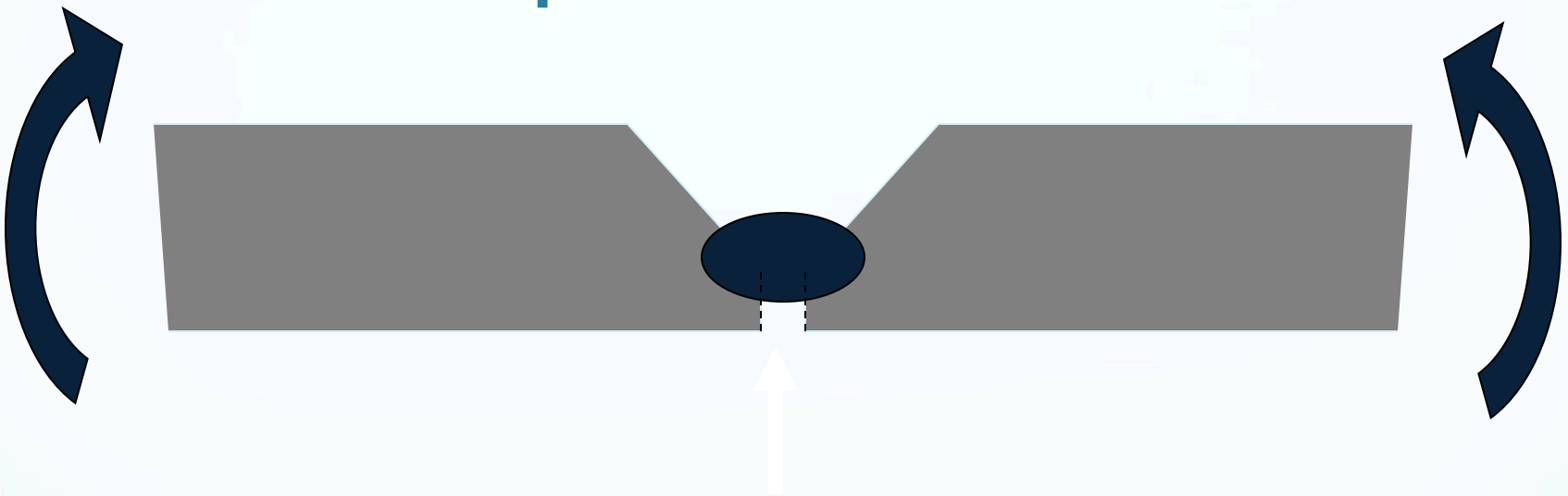
Continuous metal surface from one member across the weld to the other member without backing

Incomplete Penetration



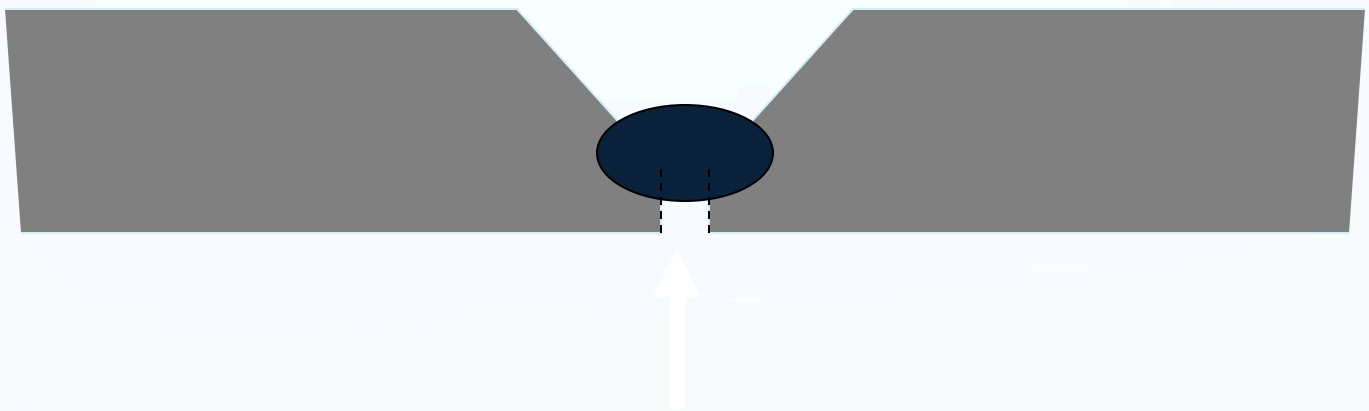
Disrupted metal surface from one member across the weld to the other member

Incomplete Penetration



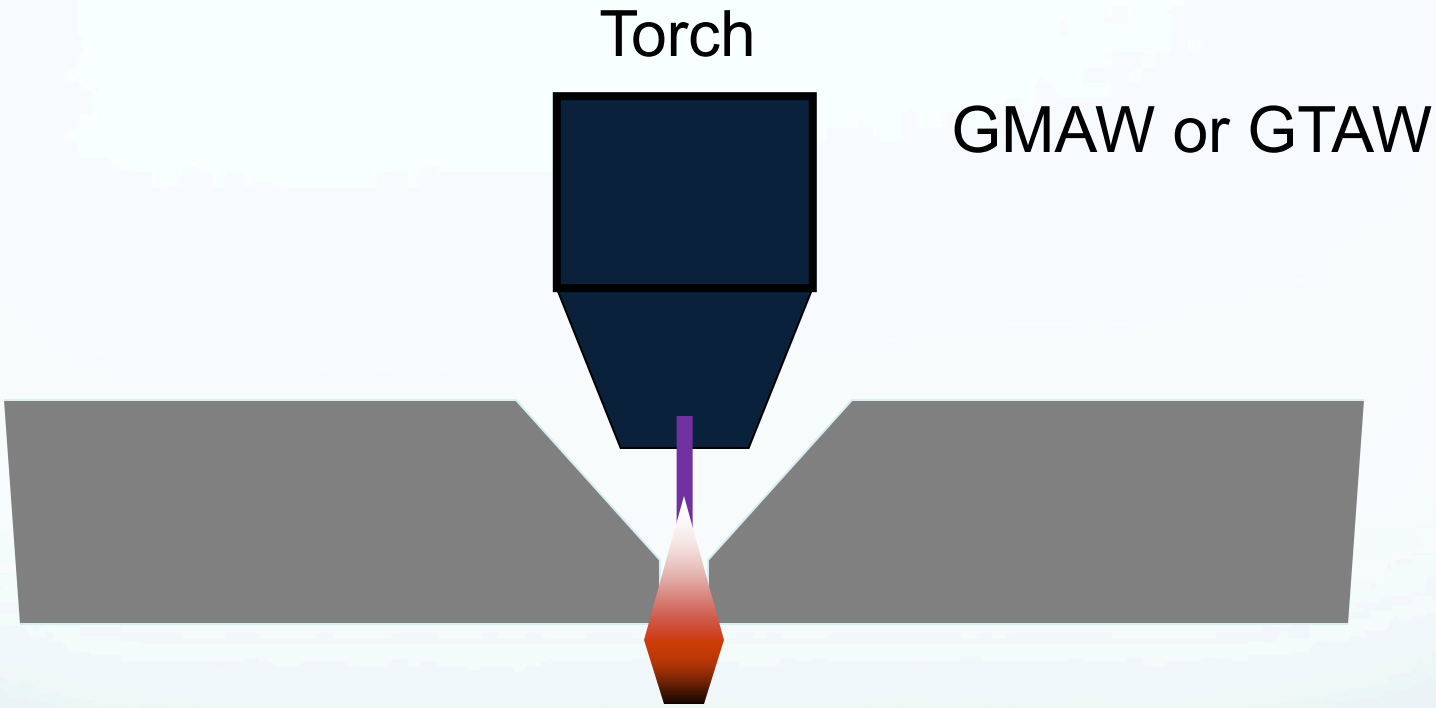
Disrupted metal surface forms a notch which can increase local stress up to 20 times the bulk section stress

Incomplete Penetration



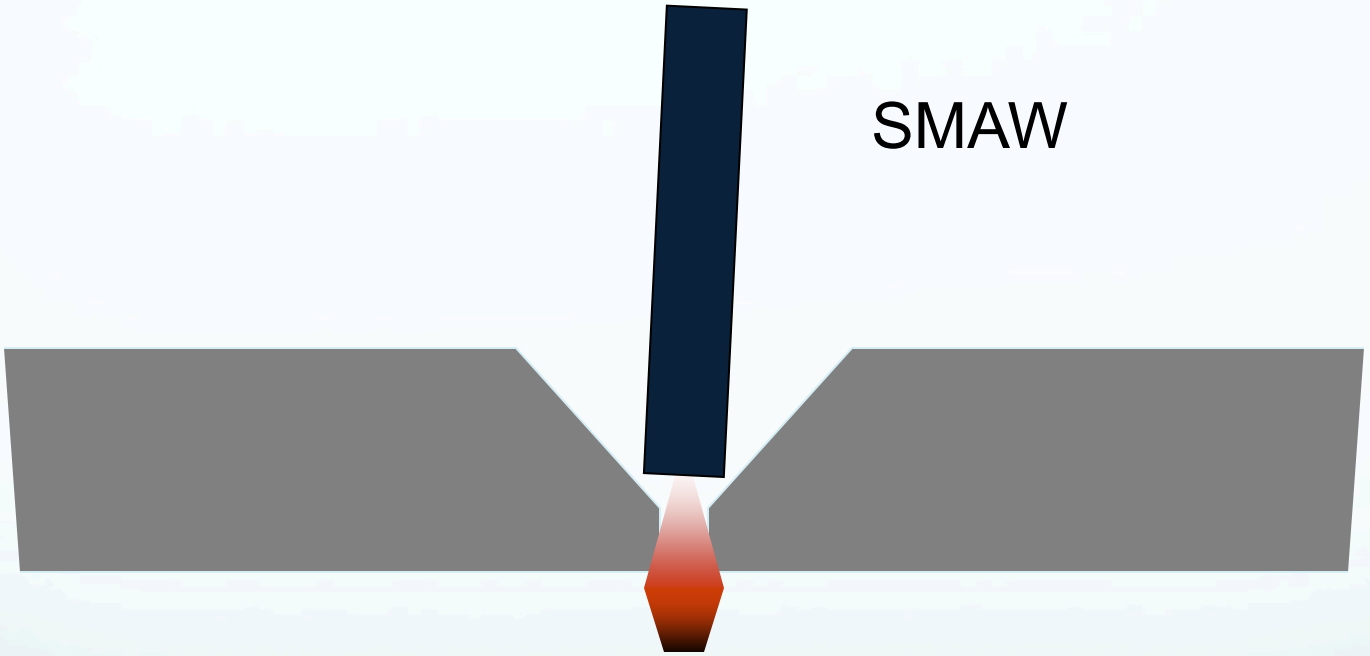
Crevice is a site for potential accelerated (local) corrosion, crud trap, bacteria trap, etc

Key to Achieving Full Penetration



1. Blast the arc force through the root opening
2. Melt the edges of the metal, then
3. Fill the opening with filler metal

Key to Achieving Full Penetration



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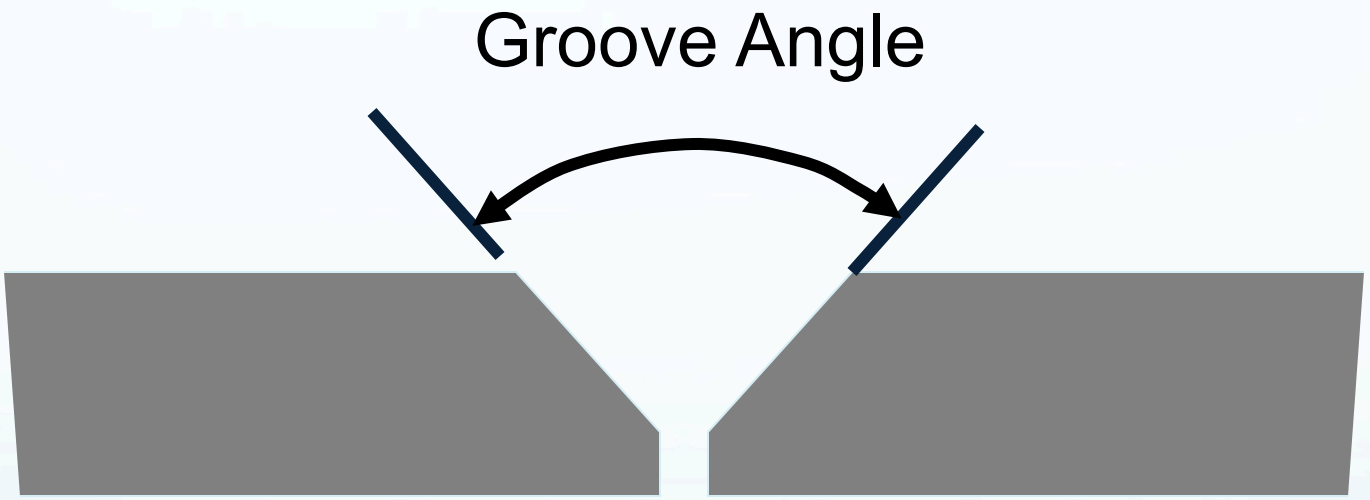
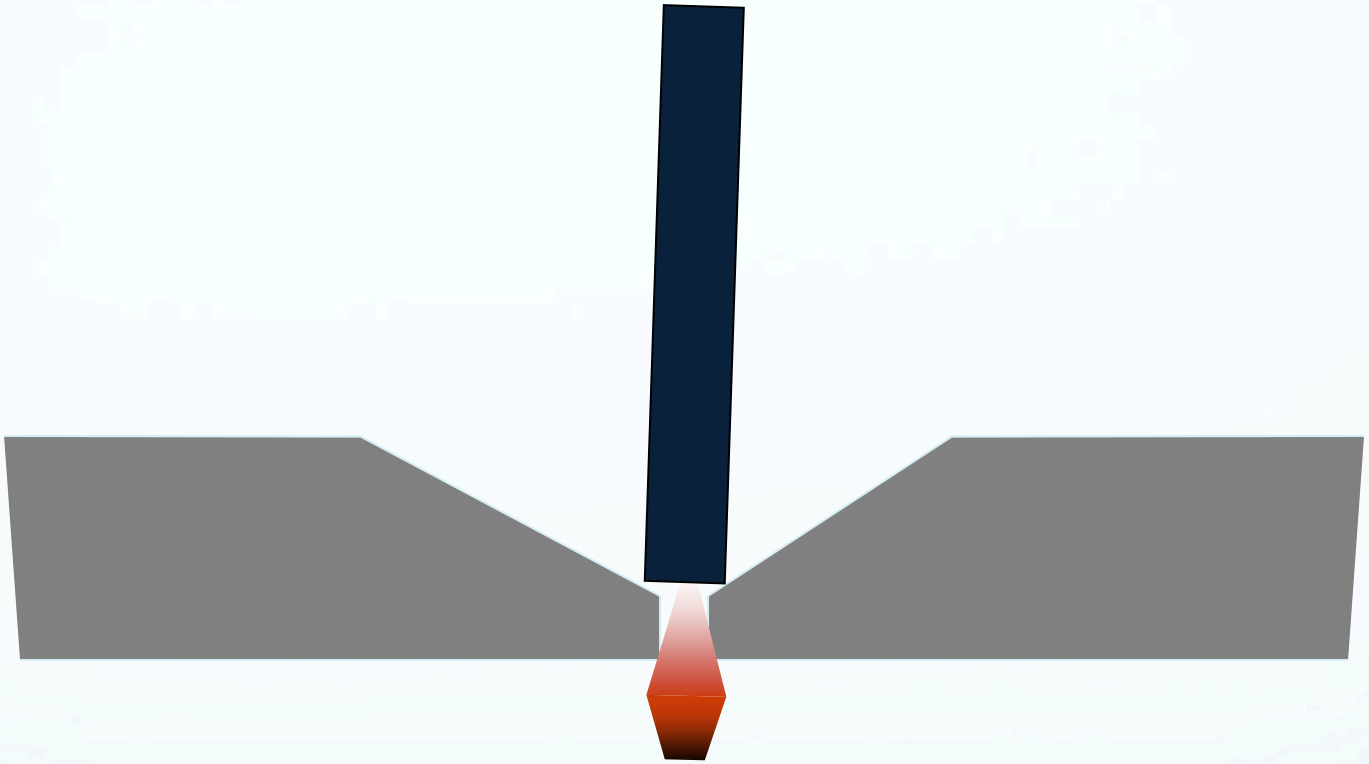
Weld Joint Groove Design



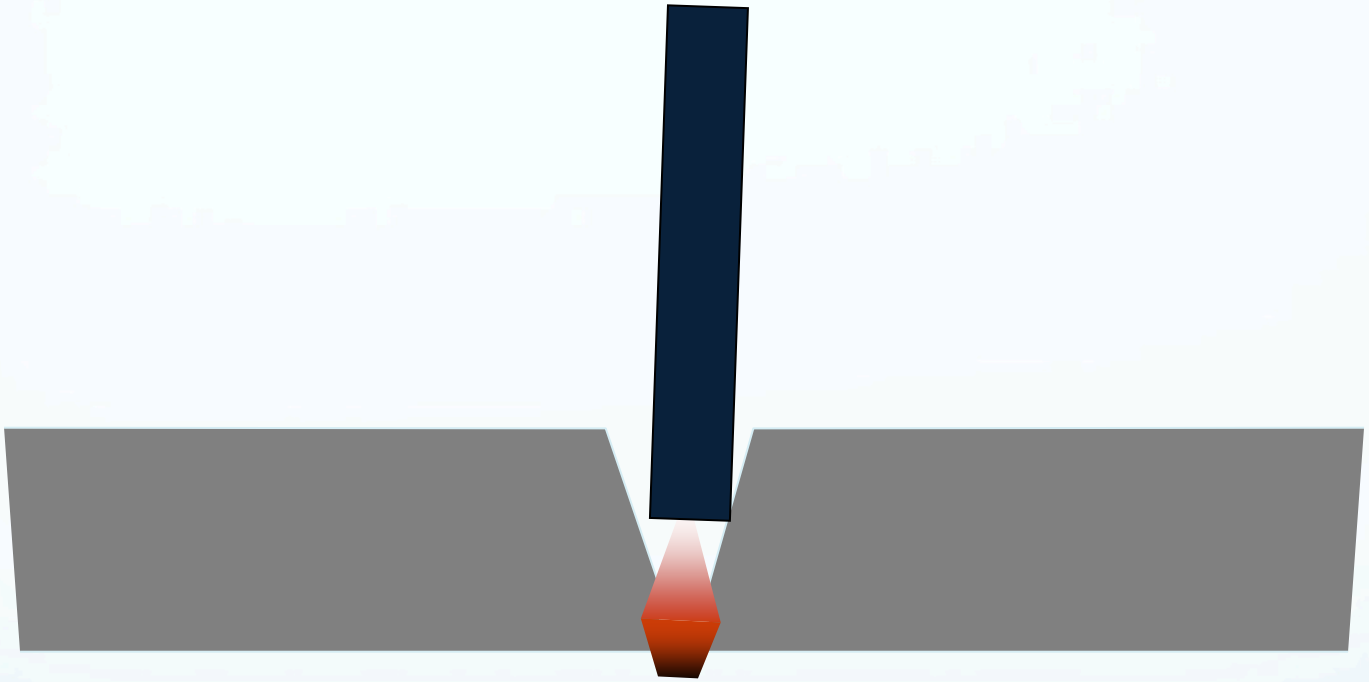
Effect of Included Angle



LARGE groove angle makes it easy to get the electrode close to the root and easy to direct the arc into the root.

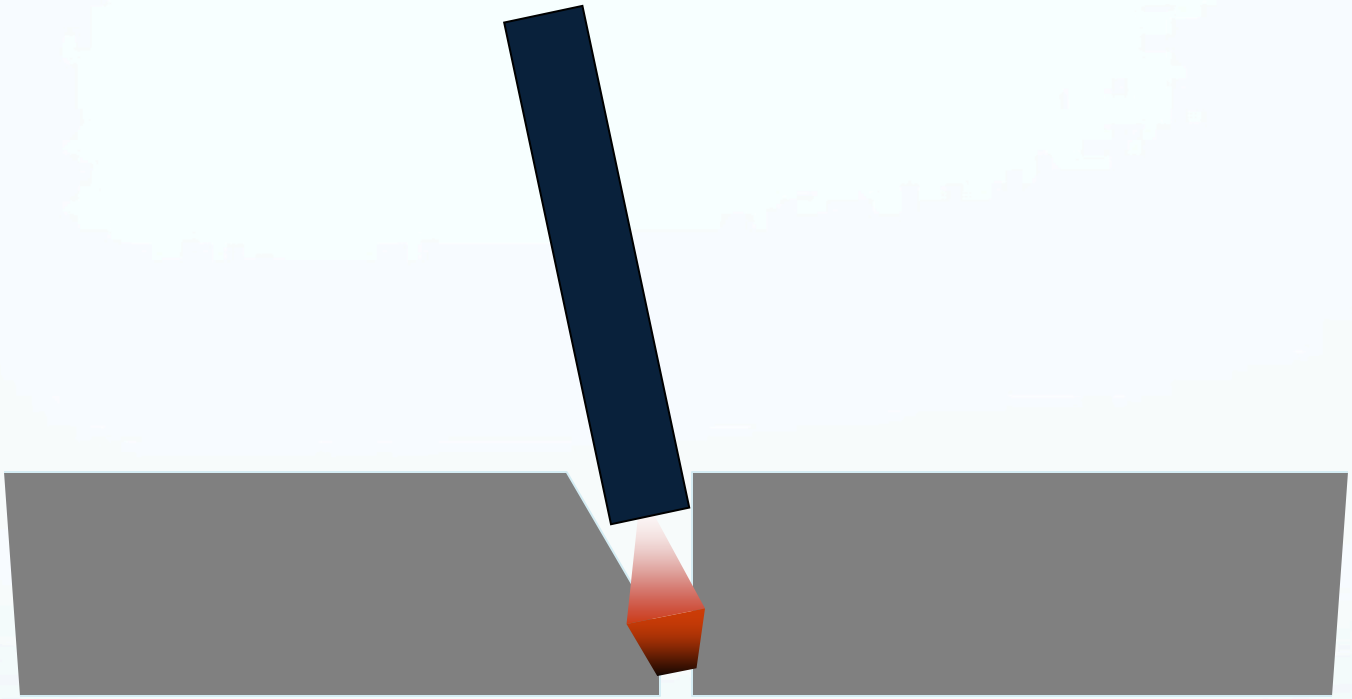
To much opening however, means more filler metal and DOLLARS

Effect of Included Angle



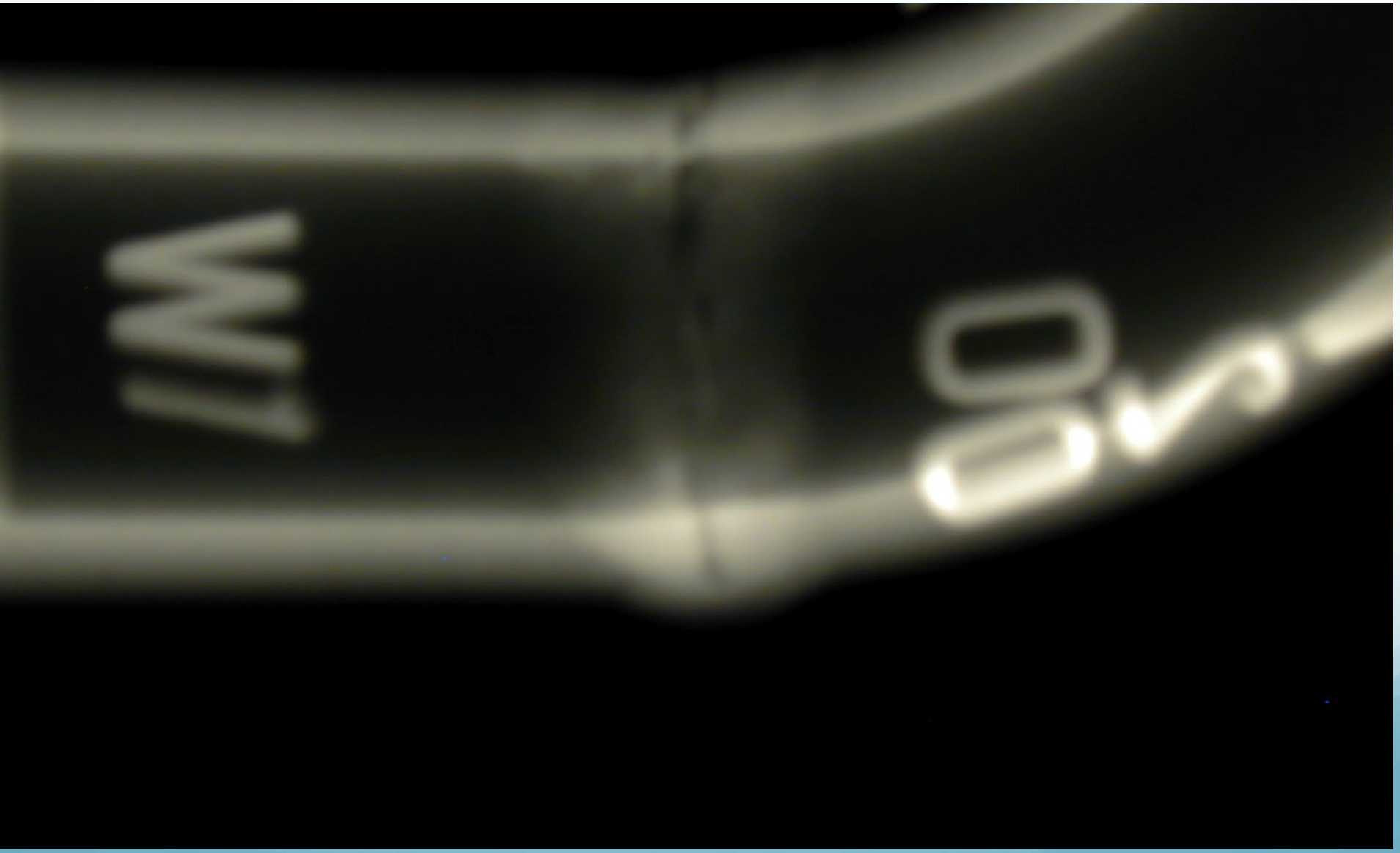
Small groove angle holds the electrode away from the root and makes it difficult to get enough arc force into the root.

Effect of Included Angle

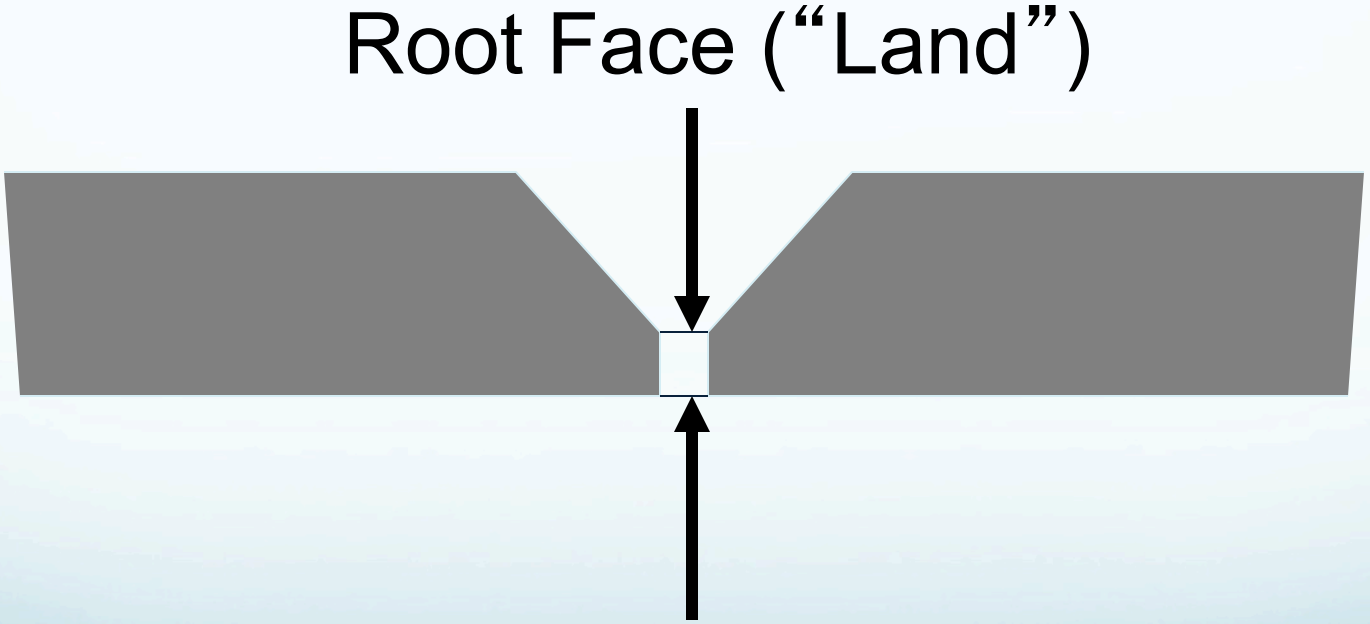


Square end to beveled fitting will lead to incomplete penetration

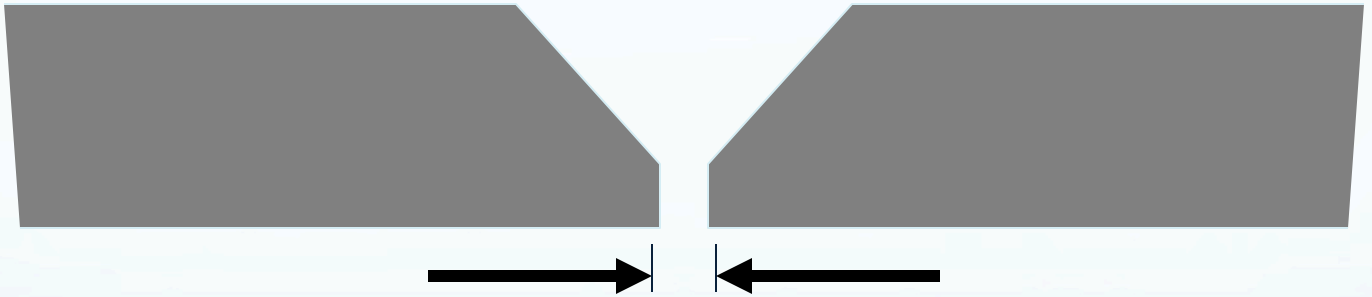
Incomplete Penetration



Weld Joint Groove Design

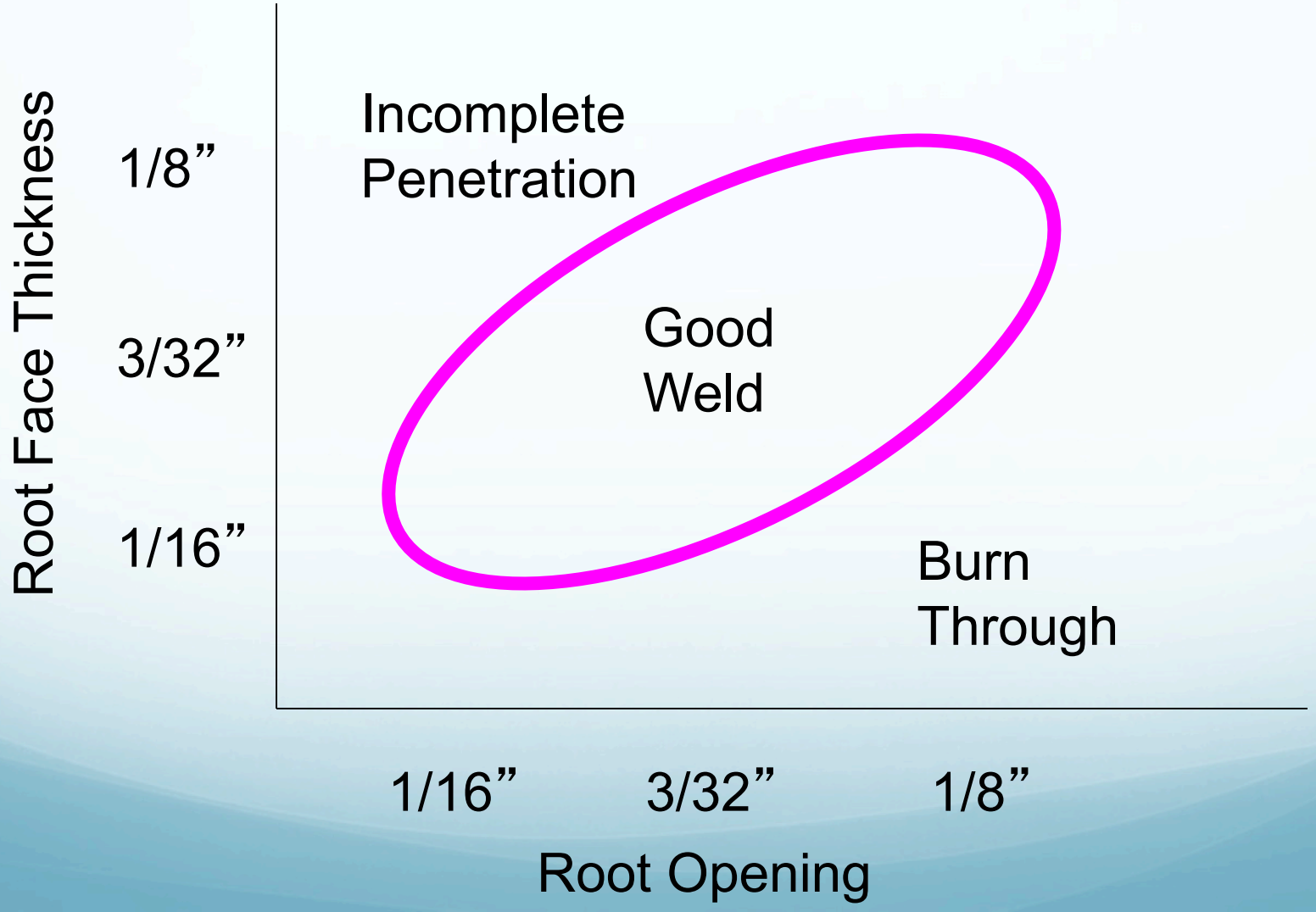


Weld Joint Groove Design



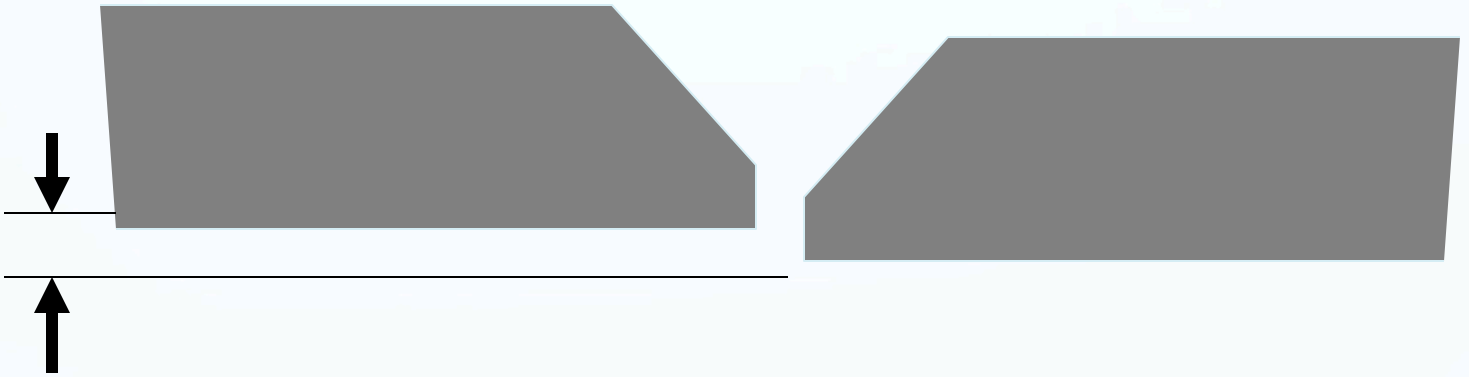
Root Opening (“Root Gap”)

Root opening – Root Face relationship

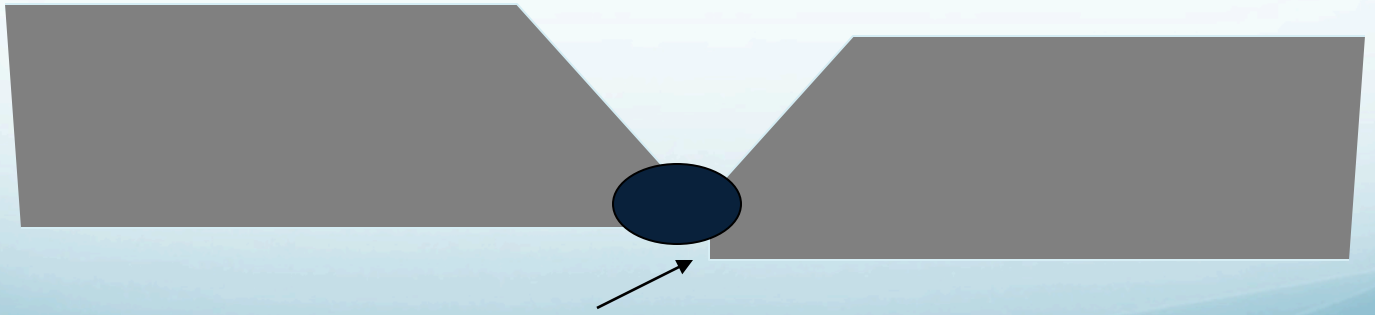


Internal Mismatch

Excessive mismatch makes it difficult to get a good root. . . .



Internal (ID) Mismatch



Incomplete Penetration

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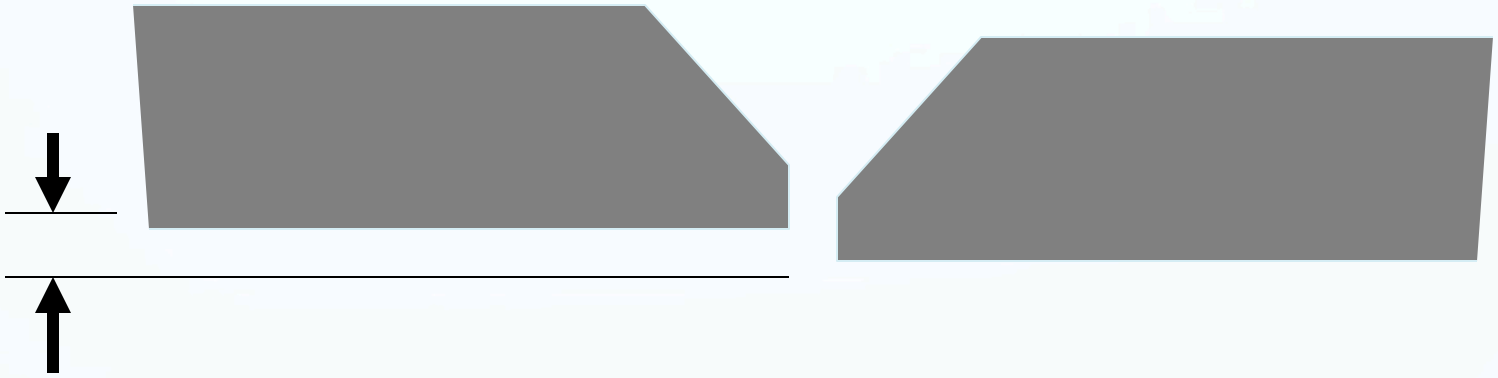
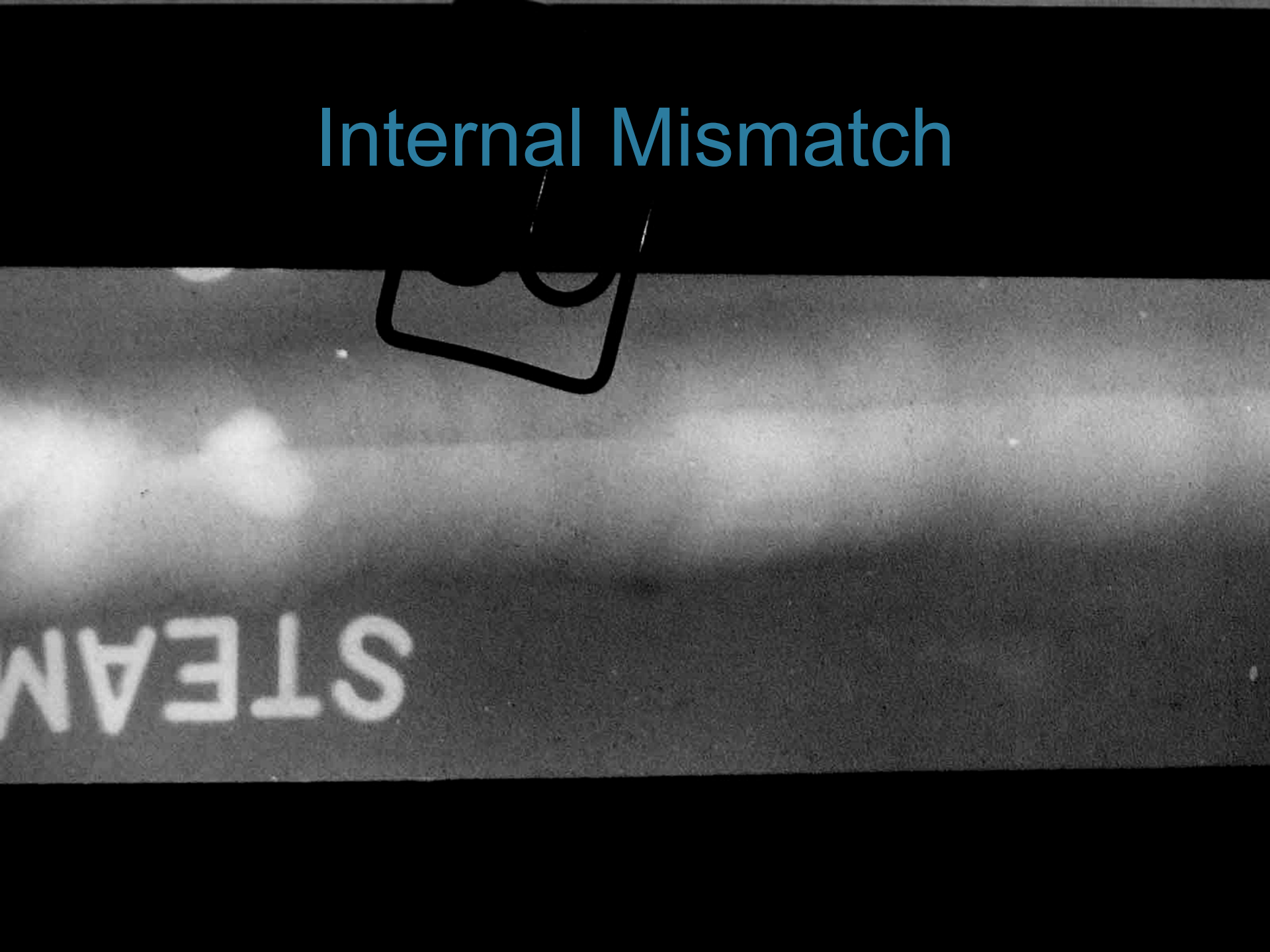


1/16” max per B31.1, as specified by the WPS in other B31 Sections.

Internal Mismatch




24
32
40
48
3
8
16
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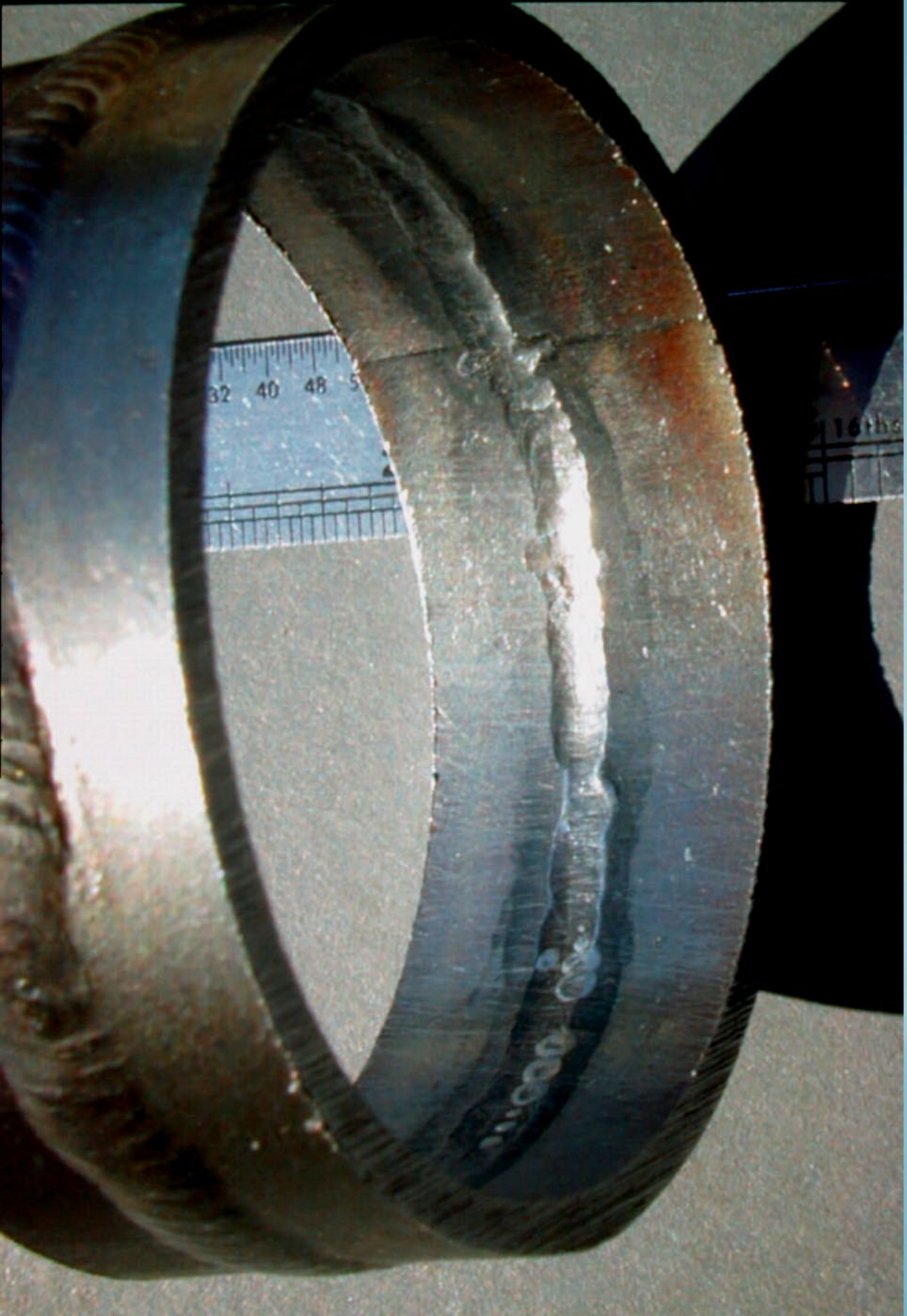
16ths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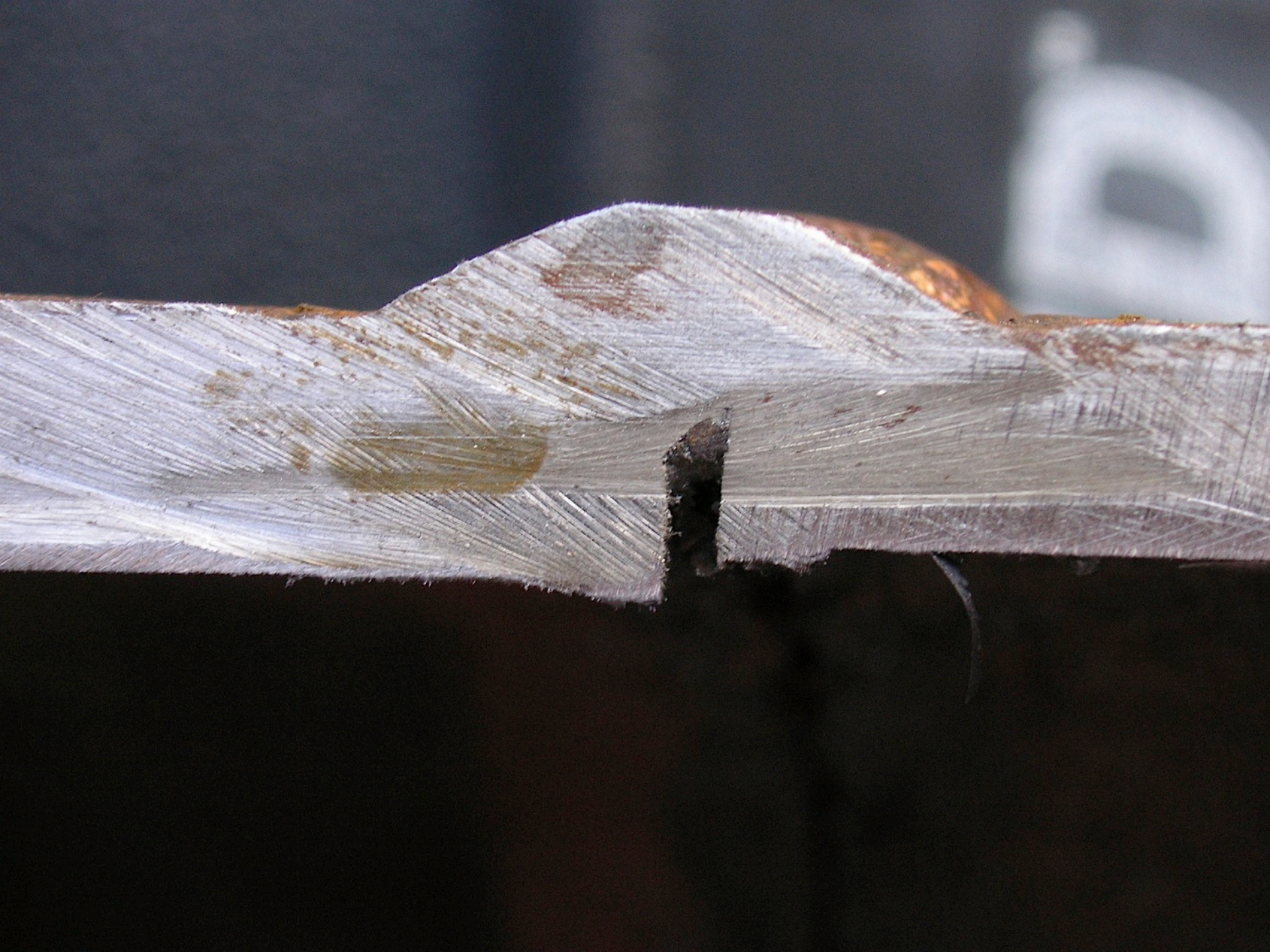


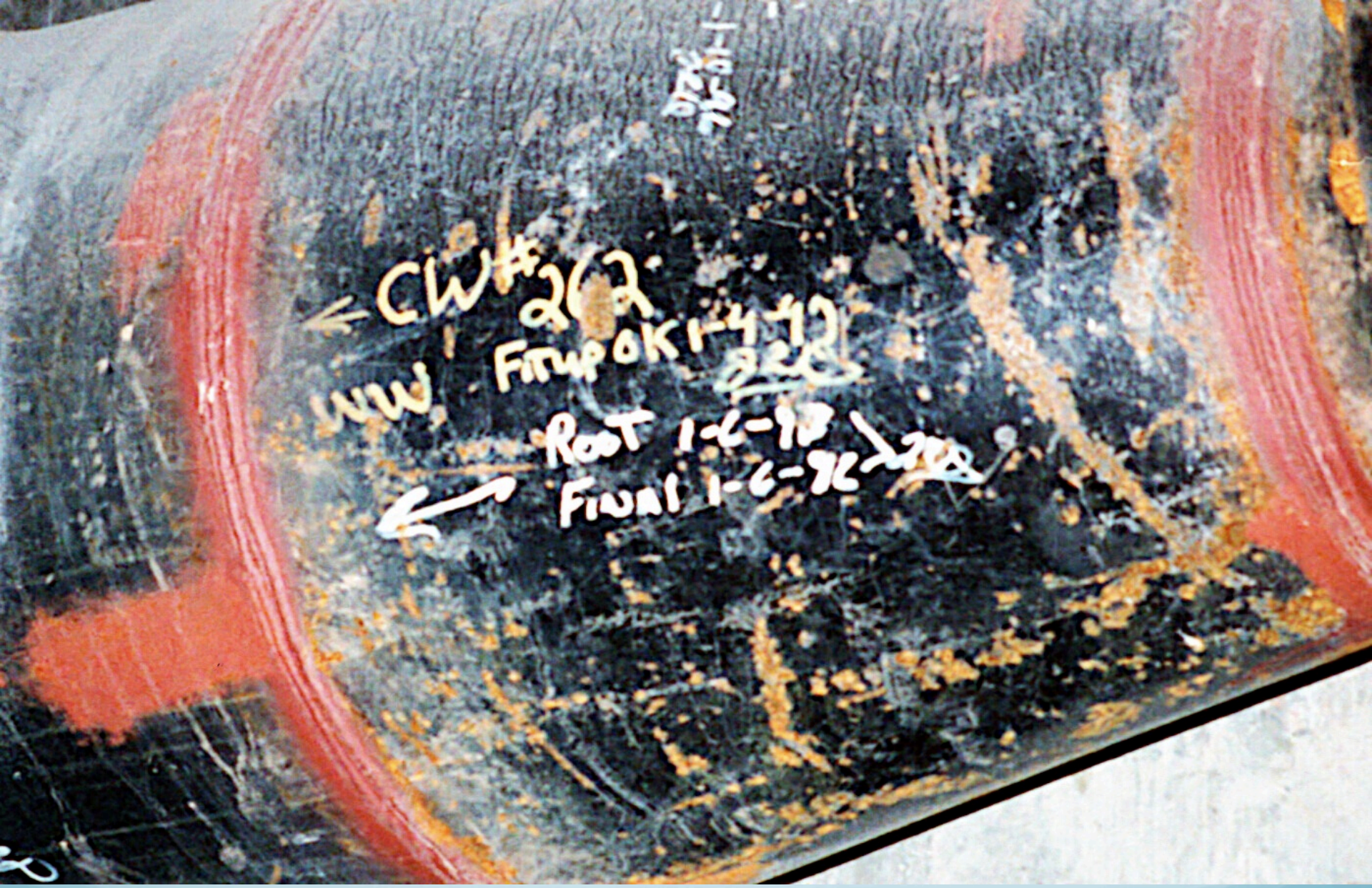
What is the most cost-effective inspection hold point?

How do I avoid this?

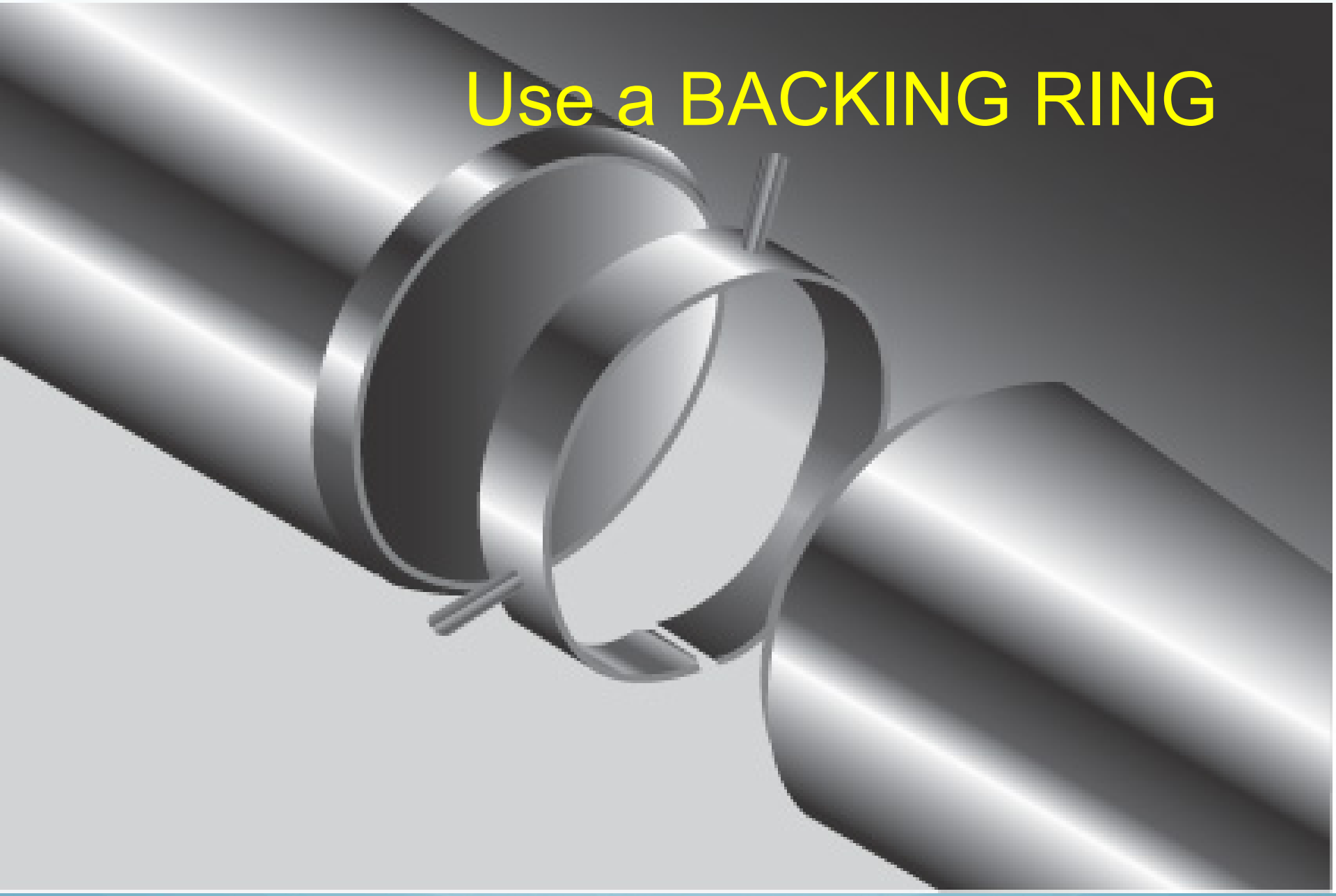
FIT-UP Inspection

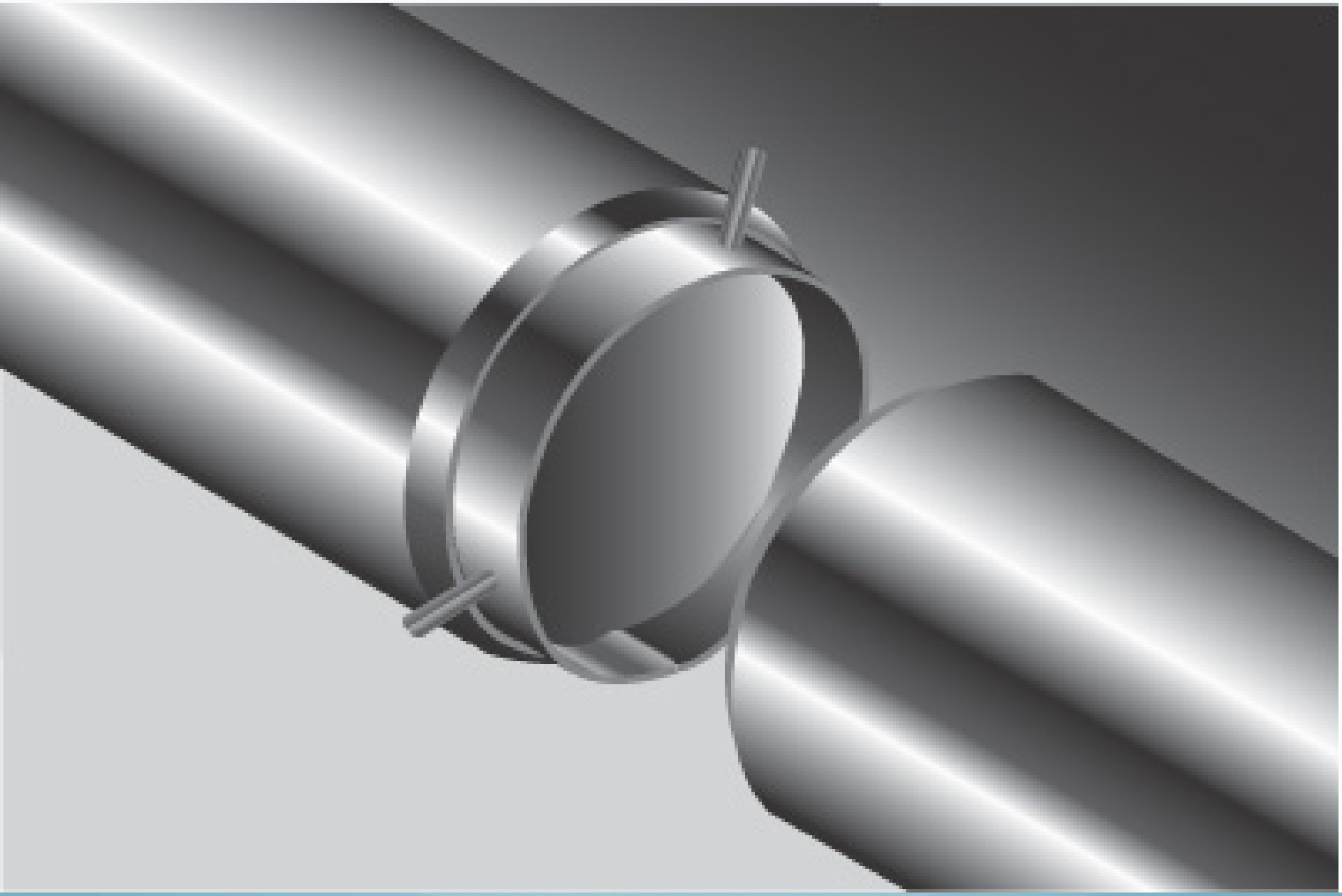
i.e., after the pipe has been cut, beveled, tack welded and ready to make the root pass

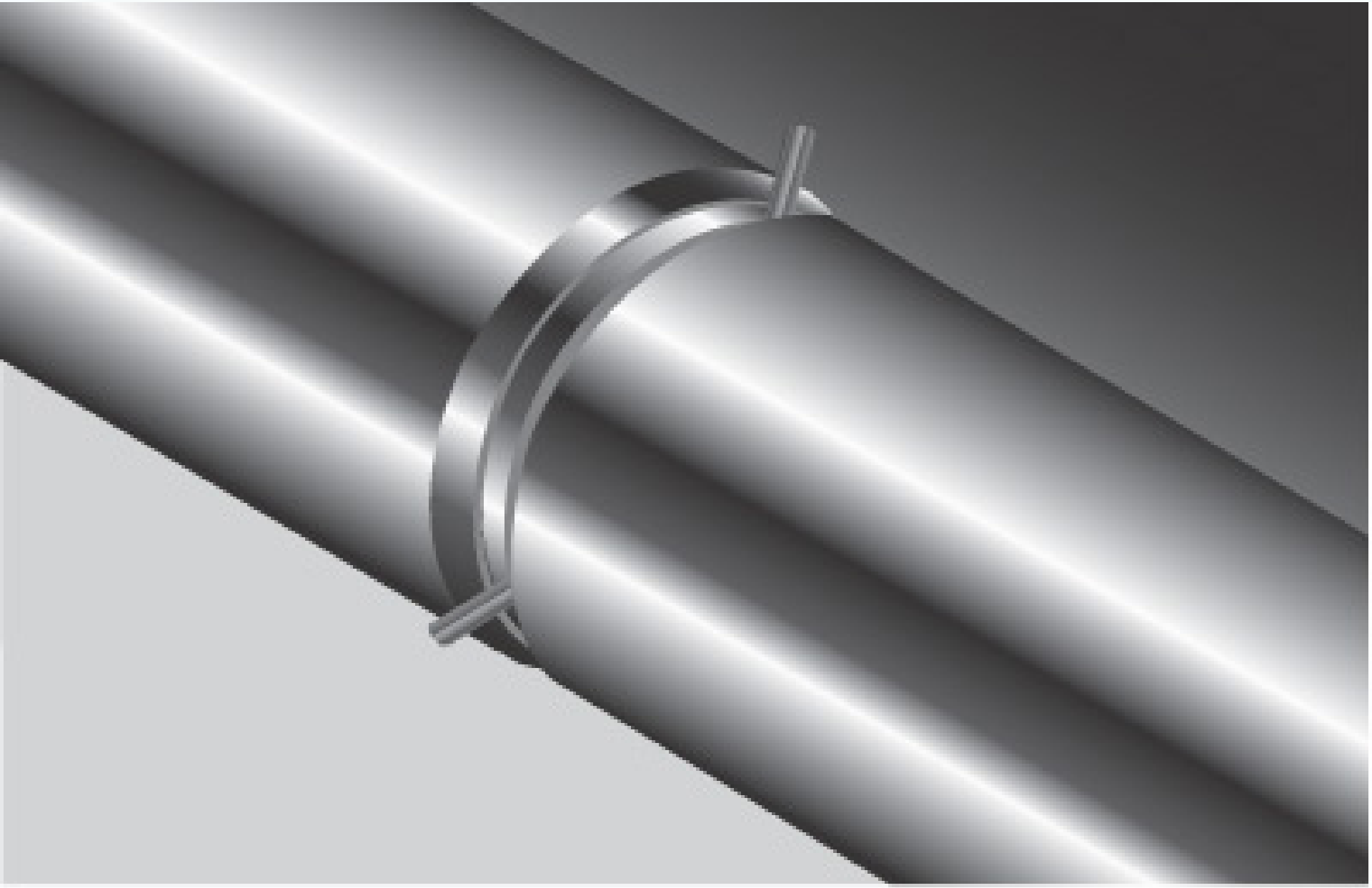
- Make sure your welders are doing a good job cutting, beveling and fitting.
- **Have someone other than the welder perform fit-up inspection**.
- Welders weld to meet the level of inspection imposed on them

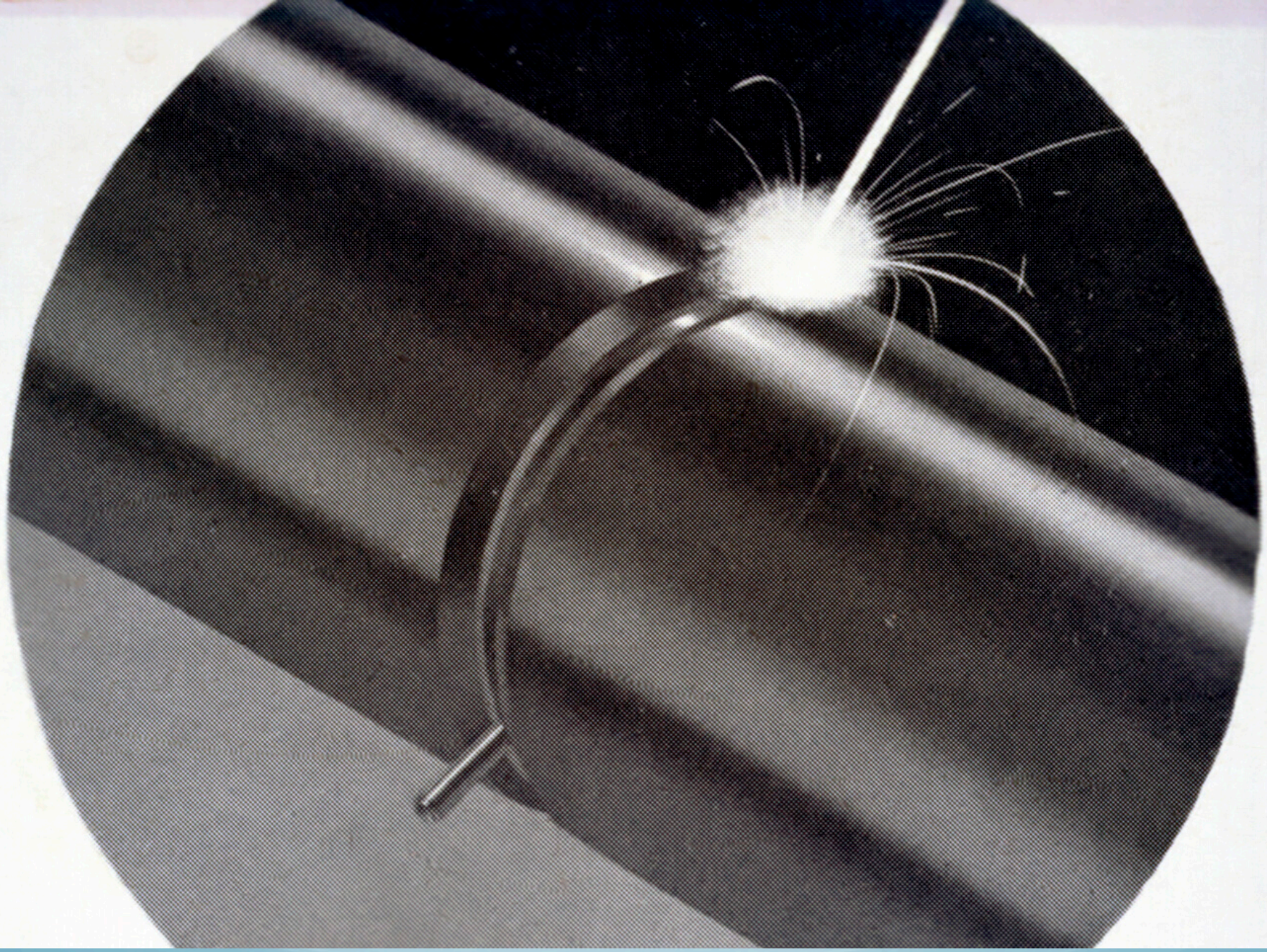

CW#2
NW
FITUP OK
ROOT
FINAL

Use a BACKING RING

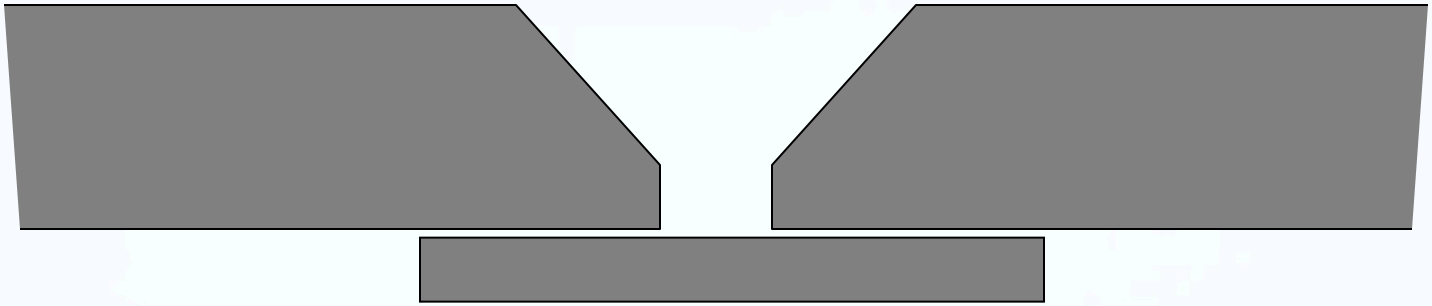









Good root gap (3/16") ensures penetration of the root pass even with a lower-skilled welder.

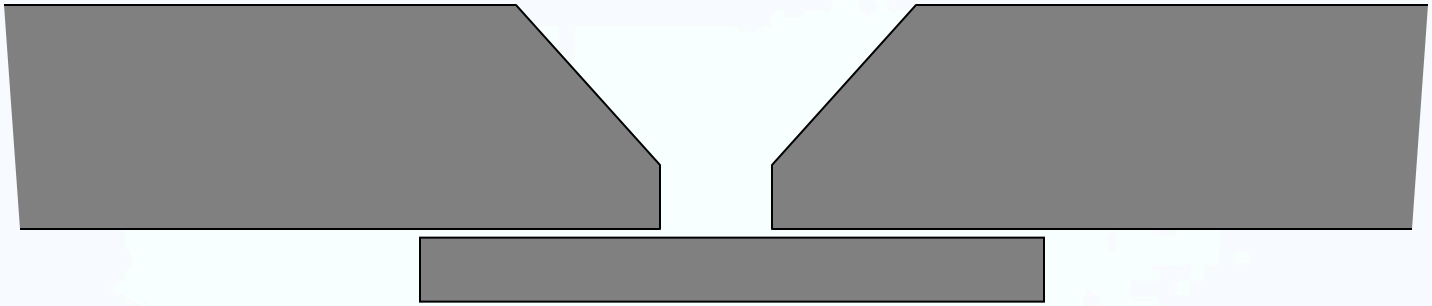


Use of Backing (“Chill”) rings

ensures that the joint will be fully penetrated.

Service Conditions may preclude the use of backing rings. Only the Engineer can determine if backing rings are acceptable.

Backing rings have been used in steam and water service on carbon and low alloy piping since the earliest use of welding for piping



Use of Backing (“Chill”) rings

Contractor bid 100% RT job using backing rings (NPS 10 and smaller Standard Weight) at 60% of LEM rates and still made a bunch of money. His welders whined at first, but once they figured it out, they did well (2 RT rejects on a job of several hundred welds.)

Examination and Inspection Examination Methods

- Radiography (volumetric)
- Ultrasonic (volumetric)
- Magnetic Particle (Surface)
- Liquid Penetrant (Surface)
- Visual (Surface)

NDE in B31.1

- B31.1 Table 136.4: (roughly)
  - 100% radiography of butt welds and branch connections that are in service over 750° F regardless of pressure.
  - 100% radiography of butt welds and branch connections that are in service over 1025 psig *and* over 1-1/8 inches thick *and* between 350 and 750° F.
  - All other welds require only visual examination.

Acceptance Criteria in B31.1

- No cracks, incomplete fusion, incomplete penetration are permitted. Slag, porosity and porosity are more restricted than other B31 Sections permit.
- No incomplete penetration is permitted *even when radiography is not specified*. This was written when backing rings were industry practice. A properly installed backing ring always results in full penetration.

NDE in B31.3 Extent

- B31.3 has Fluid Service Categories is:
  - **Normal** - 5% random radiography of butt welds **and is the default Fluid Service Category**
  - **Category M** – 20% random radiography of butt welds
  - **High Pressure** – 100% radiography of butt and branch connections
  - **Severe Cyclic** – 100% radiography of all butt welds and branch connections.
  - **Category D** – Visual examination only
  - **High Purity –** Pharmaceutical, Food and Beverage, Chip manufacture.

NDE in B31.3 Acceptance

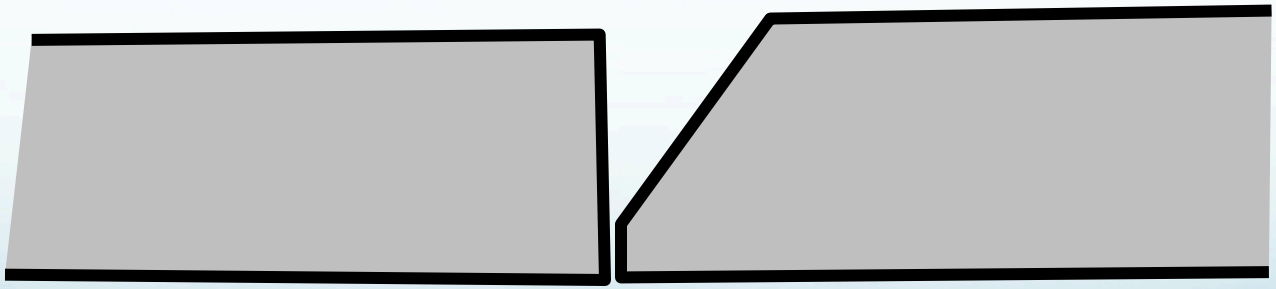
- Each fluid service category has its own radiographic acceptance criteria.
  - **Normal** – Allows some incomplete penetration!
  - **Category M** – Same as Normal Fluid Service.
  - **High Pressure** – Tight limits on reinforcement both OD and ID, no undercut permitted (either OD or ID), and there is a surface roughness limitation of 500 micro-inches. No incomplete penetration is permitted.
  - **Severe Cyclic** – similar to High Pressure
  - **Category D** – Reinforcement, undercut, etc.
  - **High Purity –** Boroscopic examination, no incomplete penetration

B31.5 and B31.9

* B31.5, *Refrigeration Piping*, and B31.9, *Building Services Piping*.
* Neither has any additional examination requirements beyond visual
* Except for B31.5 when the refrigerant is flammable; in that case, 5% radiography is required, but unlike B31.3, there is no escalation clause for rejected radiographs

Horror Stories

- A contractor was working on his 5th new school in a city
- A customer's third-party inspector was wandering about when he found a welder making a weld with one end beveled and one square with a tight butt. . .



Horror Stories

- Inspector had some welds radiographed. 80% were rejected for the expected -- incomplete penetration, incomplete fusion, slag, porosity. . . .
- Contractor did visual examination with a video camera; some incomplete penetration was found. Several welds were repaired due to 360° incomplete penetration.


The root side –
one spot. . .

A little further along. . .


A little
further along. .
.


A little
further along. .
.

Horror Stories

- Fracture mechanics analysis was performed assuming significant incomplete penetration and the welds were determined to be fit for service – 125 psi at 40° F.
- Arguments were made that the owner was not entitled to radiographic quality welds (applicable code was B31.9 which has no examination requirements beyond visual)
- Arbitration committee ruled against the contractor.

Horror Stories (Maybe)

- Owner has had the system 100% radiographed and is currently demanding that any welds exhibiting any incomplete penetration or incomplete fusion be repaired.
- The contractor is attempting to collect $400K for the cost of making the repairs (after almost all the pipe was installed. Good Luck!
- Owner threated to radiograph the welds in the other 4 schools . . .

Horror Stories

- Contractor on a large office complex was installing chilled water and hot water piping.
- The owner radiographed some welds. Rejected some.
- Project manager agreed to make repairs.
- Owner radiographed some more and rejected some
- Project manager balked – this was not part of the deal!
- Owner said: “You agreed to fix the previous bad welds – are these bad welds any different?”

Horror Stories

- Project manager just being accommodating the first time!
- Way bad. Once you establish a precedent, changing the path is very difficult.
- Project managers should be aware -- customers who do not buy radiographic quality welds are not entitled to them. This is not the same a punch list items.
- Pass what you learn here on to your PMs!

Horror Stories

- Owner's inspector caught the contractor's foremen accepting poor fit-up on a B31.9 job and had some welds. Many exhibited a lot of incomplete penetration.
- Owner's inspector insisted on examining and repairing the 30% of the welds already completed plus most of the new ones.
- Contractor complied at a cost of $300K
- Contractor lost the lawsuit because his contract was with the GC, not the Owner, and the GC never directed the contractor to do what he did

Recall the Horror Stories. . . .

* Unreasonable demands by owners and their engineers are frequently found in engineer's specifications,
* The worst situation occurs at the end of a job; the Owner insists on radiographing welds that were not required to be radiographed by Code or by contract.
* Or he radiographs them himself, then tells you how bad your welds are. And wants his money back!

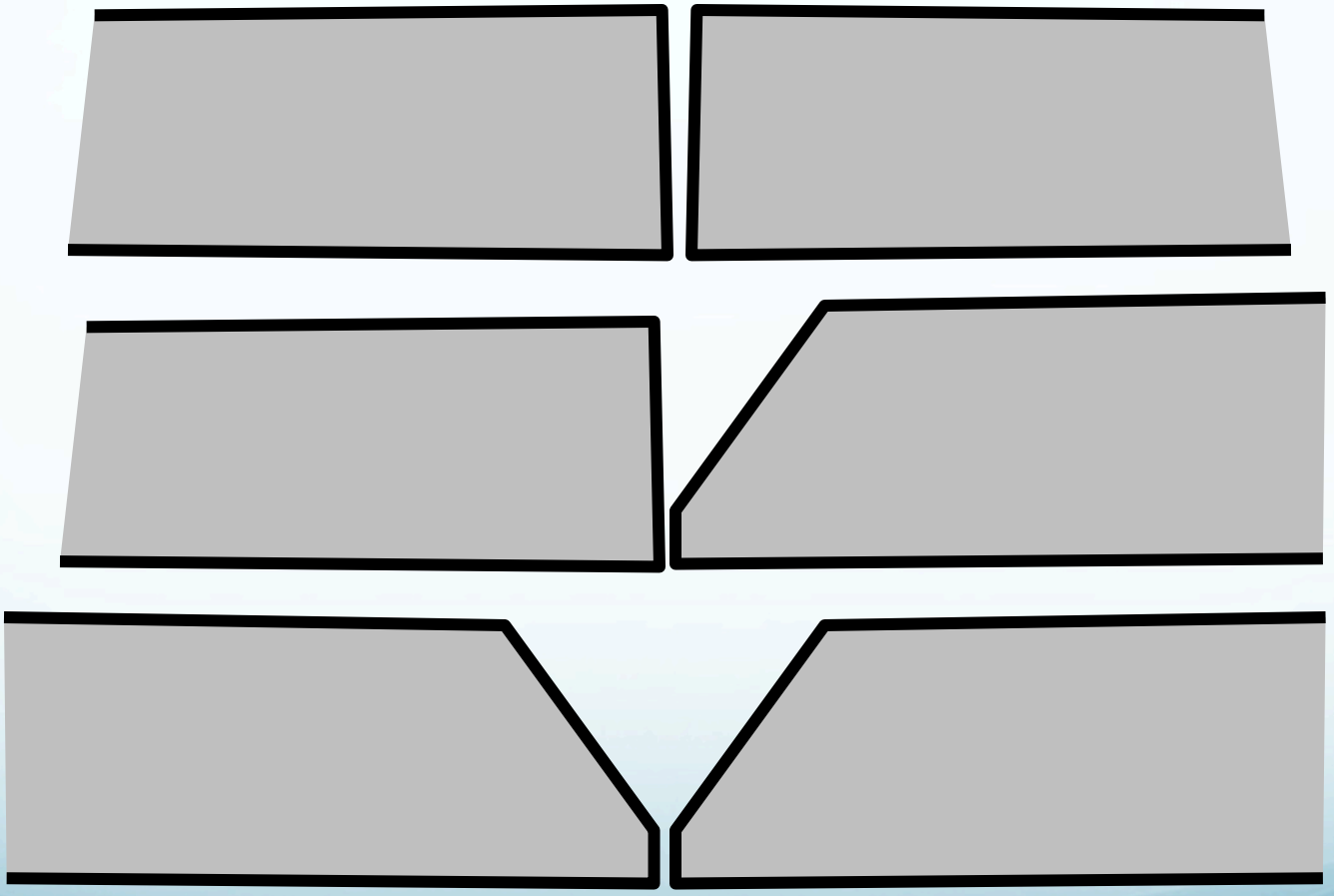
Recall the Horror Stories. . . .

- This violates standard industry practice expressed in ASME B31.1, paragraph 136.1:
  - "The degree of examination and the acceptance standards beyond the requirements of this Code shall be a matter of prior agreement between the manufacturer, fabricator or erector and the Owner."
- Applies to all inspection methods (RT, UT, MT, PT, etc.
- The reason for these words: it costs more to make welds that are radiographic quality than it does for welds that will not be radiographed.

Recall the Horror Stories. . . .

* Standard industry practice expressed in this paragraph requires that purchaser-imposed examinations and the acceptance standards accepted by the fabricator or contractor before the job starts.
* Similar paragraphs are found in B31.3, B31.5, B31.9, ASME Sections I and VIII and AWS D1.1 through D1.8,
* D1 handles it best: it makes the owner responsible for all repairs discovered by unspecified NDE except in the case of **gross negligence.**

Gross Negligence???




Gross Negligence???

Recall the Horror Stories. . . .

Don't sign up for the likes of:

> "Welding performed under these specifications shall be subject to special tests and inspections by the Owner or his agent, including rigid Ultra Sonic Testing (UT) and radiographic inspection at random. . . ."

Acceptance Criteria

- The Codes permit certain imperfections for all examination methods. Radiographs, for example, do not have to be free of any indications of discontinuities (flaws).
- Discontinuity ≈ Flaw ≠ Defect (rejectable by definition)

Acceptance Criteria

- Those who perform nondestructive examination have a vested interest in finding rejectable indications.
- Worthwhile to have an independent reviewer look at any radiographs to be sure that they are being interpreted to the correct requirements, not arbitrarily stringently -- or just as bad – too loosely!

Responsibility. . . .

* The extent of nondestructive examination and the acceptance criteria required are clearly understood by all parties and documented in writing.
* If radiographer works for the Owner, the Contractor is still responsible for being sure that radiographs are acceptable.
* A contractor who had a maintenance contract with a major oil company. . . .

Responsibility. . . .

* This extends to film quality (i.e., it the film exposed in such a manner that small indications can be seen)
* The film needs to be adequately exposed (if you hold it up to fluorescent lights in the office, you should not be able to see anything except identification marks)
* It needs to be adequately sensitive (the 4t hole should be visible on the penetrameter.)

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Subcontracted Work

- Impose the same code and contract requirements on the fabricator who is doing subassembly work for you, preferably the same code that you are obligated to use.
- Impose one on the sub even if you are not obligated to use one.
- Do it by contract.

Liability issues

- Codes and contract law make contractor responsible for the quality of welding and brazing his welders provide.
- At NY Cranes, a shop hand had part of a tower crane turret repaired at a local welding shop – no WPSs, no welder qualifications. The weld failed, the crane fell 20 stories killing the operator. The owner of NY Cranes is facing manslaughter charges.
- He has no Standard Industry Practice to fall back on because he didn't follow it.

Liability issues

- While leaking hot or chilled water may just cause property damage and just jack up your insurance rates,
- Consider the consequences of a refrigerant or oxygen leak at a hospital or old folks home.
- The contractor responsible for the quality of welding and brazing his craft produce.

Hydrostatic Testing

- The B31 Code Sections require either hydrostatic or pneumatic testing of completed piping systems. Hydrostatic testing of piping subassemblies is neither required by Code nor is it customary. *Typical testing pressures is 1-1/2 times the design pressure*

- Although the Code permits pneumatic testing, the contractor should remember that compressed gas is a very good device for storing energy, and its release can be exceedingly destructive in the event of catastrophic pressure boundary failure. Do not do pneumatic testing except as a last resort, and even then with extreme care.

- Contractor was installing B31.9 piping in an office building. As portions of the system were installed, they did pneumatic testing at 125 PSI on each segment as they completed it.
- Due to the presence of some check valves in the system, a segment remained pressurized over a weekend.
- Young welder was killed by an end cap attached with a Victaulic coupling.


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Summary

- The Owner has to choose and specify the appropriate Code for his piping systems
- Engineer has to follow the Code in his design, utilize his engineering expertise and experience and ensure that the appropriate requirements are incorporated into the specifications and drawings.

Summary

- **The Contractor needs to:**
  - Understand what is in the Code and specifications
  - Pass that information on to craft supervision in terms they can understand.
  - Be sure that the work is done in accordance with the applicable Code and Specifications and Drawings
  - Get changes in writing from competent responsible representatives of the owner.

The Test

- What is the first thing you should look for when reviewing contract documents and specifications

The Test

- What is the first thing you should look for when reviewing contract documents and specifications
- Answer: Be sure that the B31 construction code section that applies to the work is clearly defined. If not, quote to the one that you will follow (B31.9, B31.3, etc.)

The Test

- What should you look for in the contract and specification regarding the **extent** and type of examinations that the Owner may perform?

The Test

- What should you look for in the contract and specification regarding the **extent** and type of examinations that the Owner may perform?
- Answer: Death clauses. Any provision that says that the owner or his representative may perform radiography or ultrasonic examinations exceeding those specified in the spec or contract.

The Test

- What should the contractor do to ensure that his welders make decent welds?

The Test

- What should the contractor do to ensure that his welders make decent welds?
- Have someone other than the welder perform fit-up inspection; remember:

Welders weld to meet the level of inspection imposed on them. . .


Ooooo... This not be cheap.