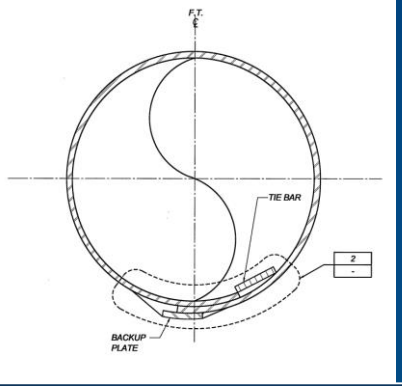


COLLAPSED-CAN STEEL LINERS-DESIGN

Stephen F. Shumaker, P.E | Senior Civil Engineer, CDM Smith
Carlsbad, CA | shumakersf@cdmsmith.com

CDM Smith®

Water Research Foundation Large Pressure Pipe Structural Rehabilitation Conference

Jan 20, 2016

at MWD-Los Angeles, CA

Water Research Foundation℠

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Presentation Topics

- Principle of Collapsed-Can Liner
- Steel Liner Design
- Layout and Access Pits
- Installing in Place
- Grouting and Mortar Lining

PRINCIPLE OF COLLAPSED-CAN LINER

Collapsible Steel Liner

- Collapsed can provides maximum installed diameter for minimum hydraulic loss

- Collapsed configuration, allows for:
  - Transport and maneuvering
  - Negotiation of small bends

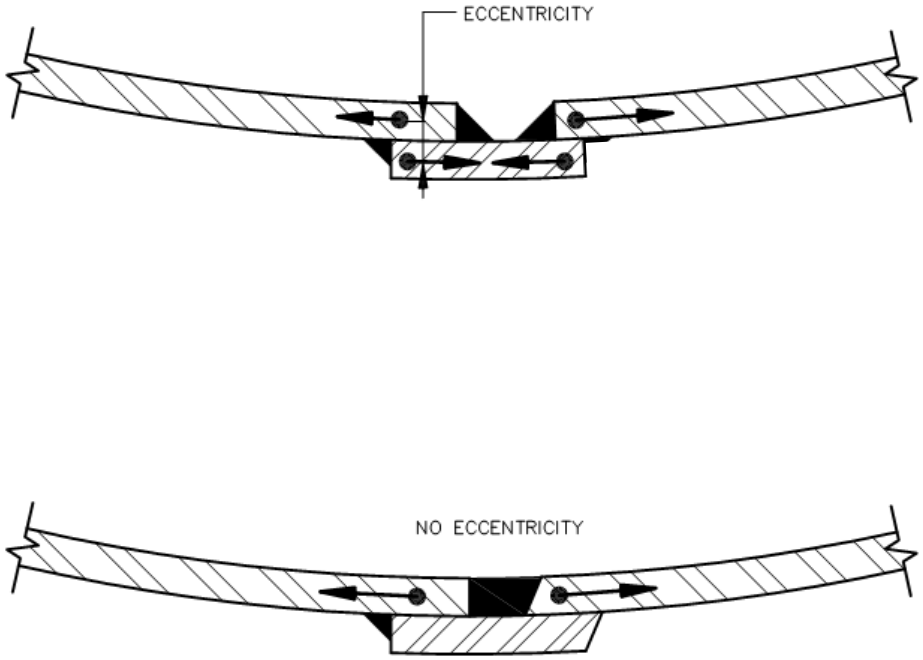
Collapsible Steel Liner

- Fabricated from rolled steel plate with one unwelded longitudinal seam
- Held in collapsed configuration with external steel bands and internal tie-bars

STEEL LINER DESIGN

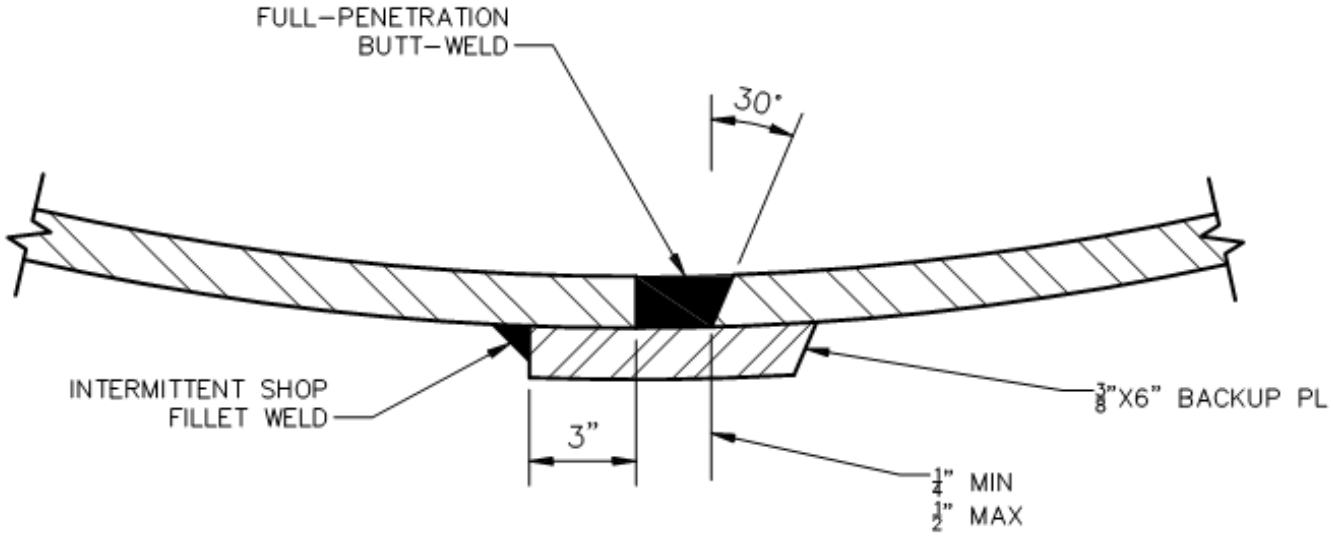
Longitudinal Field Weld

- Some past designs utilized field fillet welds
  - Backer bar was structural
  - Eccentricity induced bending moment
  - Overlapping heat-affected zones decreased ductility
  - Positions of max bending moment and decreased ductility coincided



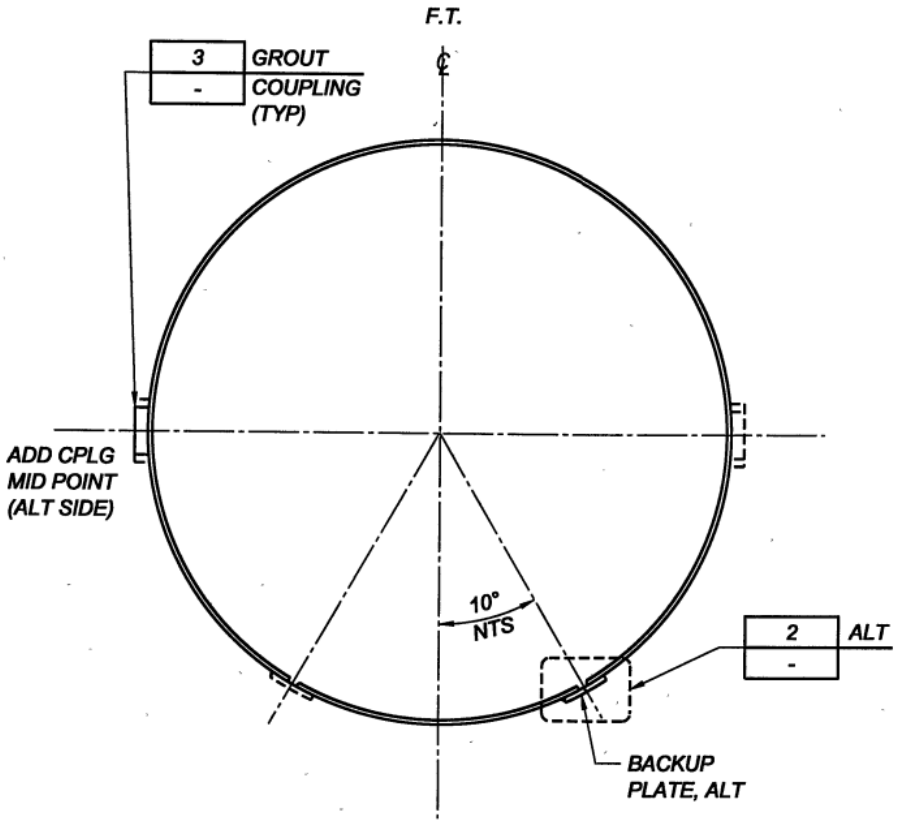
Longitudinal Field Weld

- Longitudinal back up bar
  - Non-structural
  - Acts as backer plate for full penetration weld
  - Avoids moment-inducing eccentricity
  - Radius matches pipe
  - Fabricated from rolled plate or cut from completed steel pipe



Longitudinal Field Weld

- Alternate position of weld prevents propagation of potential failure



Steel Liner Material

- Mild steel; typically 36 to 42 ksi yield
- Ductility important:
  - Charpy V-notch test
  - Elongation of tensile test specimen 22% min
  - Fully killed, fine-grained, continuous cast
- Initial design for internal pressure, typically:
  - Maximum 50% of yield at working pressure
  - Maximum 75% of yield at max transient pressure
- Also check for handling and grout pressure

LAYOUT AND ACCESS PITS

Layout and Access Pits

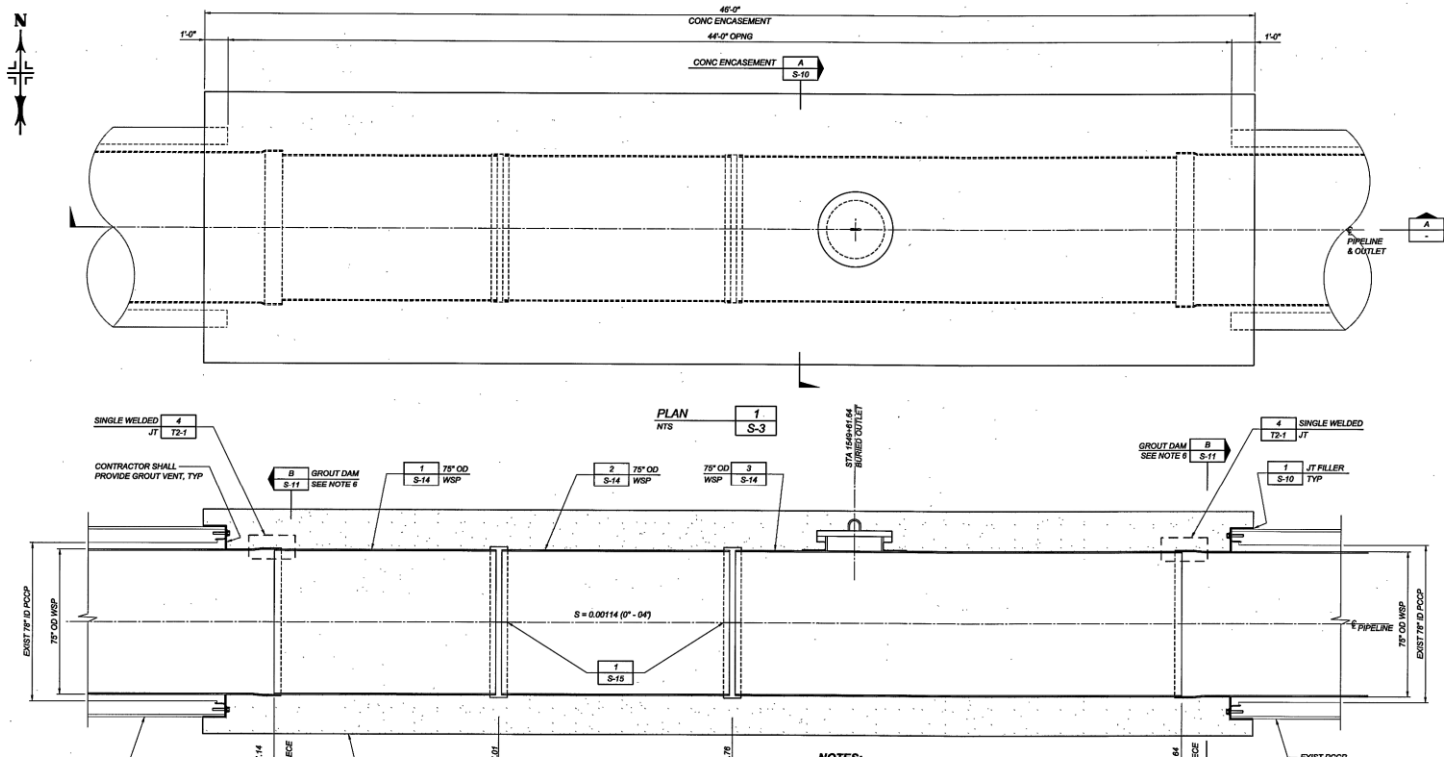
- Bends generally require cut-and-cover excavation and replacement of host pipe with standard fabricated steel pipe bends
- Access pits required to insert liner
- Co-location of pits at bends reduce total number
- Liner pieces transported from pits with specialized mechanized carts

Layout and Access Pits

- On gently sloping pipe, liners can be delivered each direction from pits
  - e.g. 1,200’ pit spacing = 600’ max transport length
- Access pits typically require removing 2 lengths of host pipe
- Alternatively, can cut and remove top half of host pipe at pit

Closing Access Pits

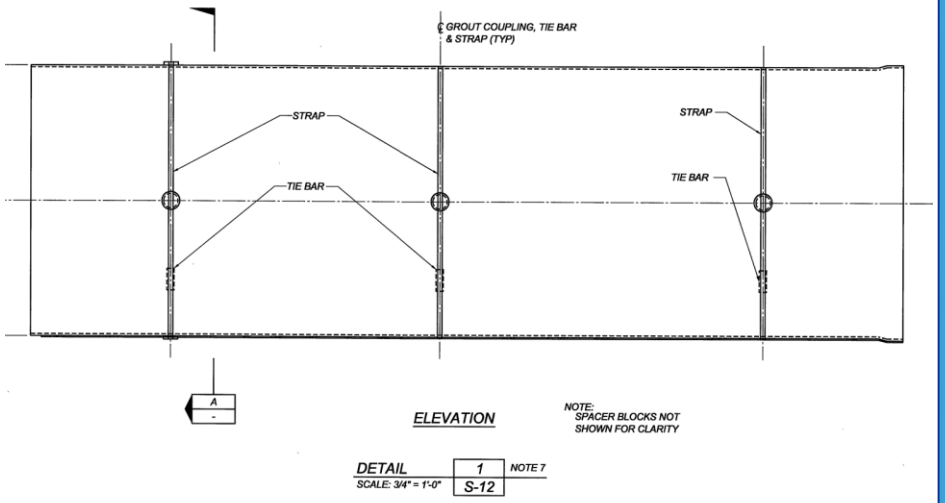
- Pipe at pits replaced by standard fabricated steel pipe
- Replaced pipe at pits generally encased in reinforced concrete

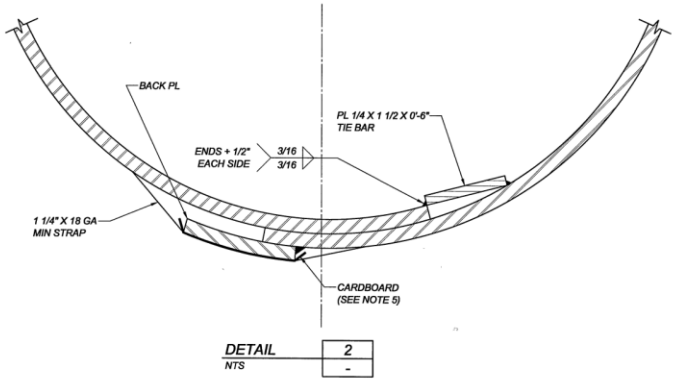


INSTALLING IN PLACE

Liner Preparation

- Liner “collapsed” to tighter radius
  - Compression of can must be limited so bending stresses don’t exceed yield stress
  - Thin wall helps
- Tack welded in collapsed configuration with temporary tie bars
- Banded with steel straps lined-up with grout ports





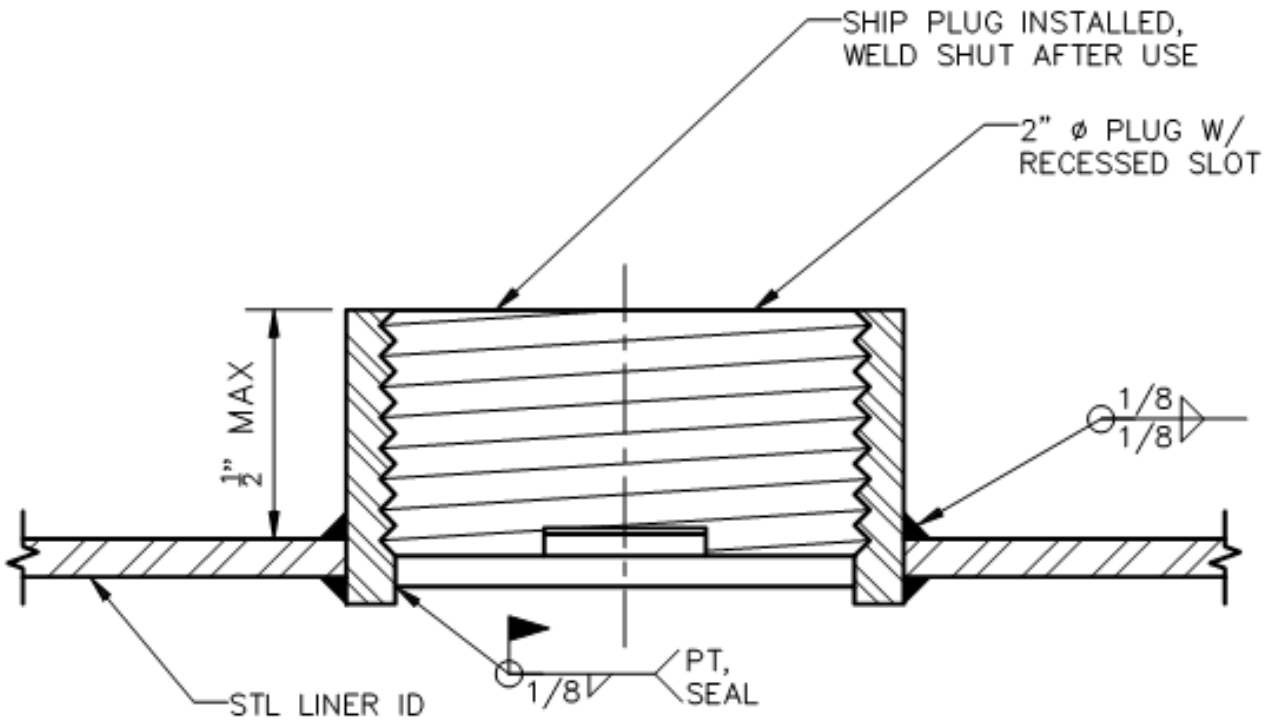
Liner Delivery

- Liner transported from access pit with mechanized delivery system or “cart”
- Temporary tie bars removed and bands cut through grout ports
- “Cart” has mechanized controls which orient and push the liner into proper position

GROUTING

Grout Ports

- Threaded plug; seal weld in place after grouting

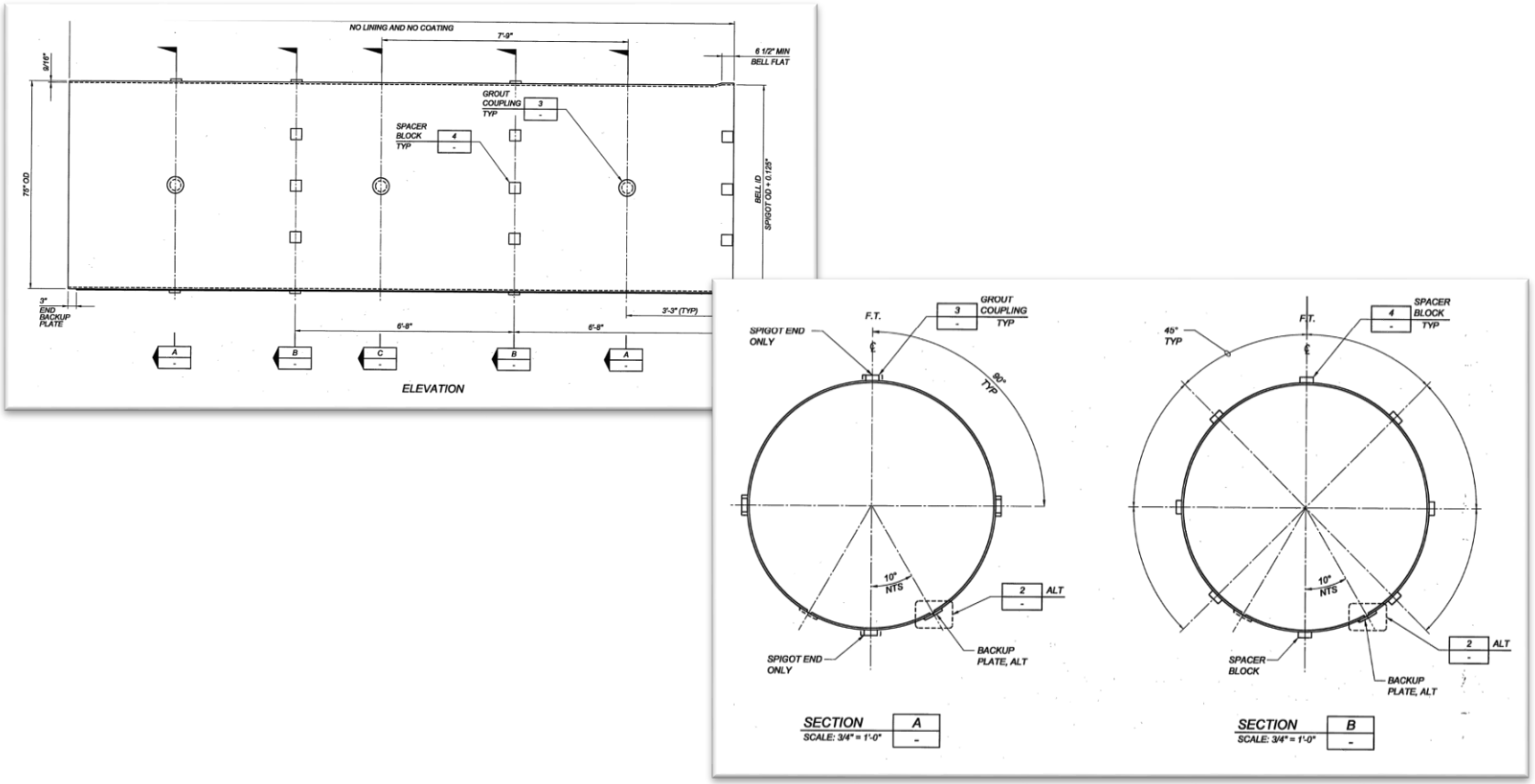


Spacers

- Keep liner centered in pipe during installation and grouting
- Height, “H” as required to center liner in host pipe

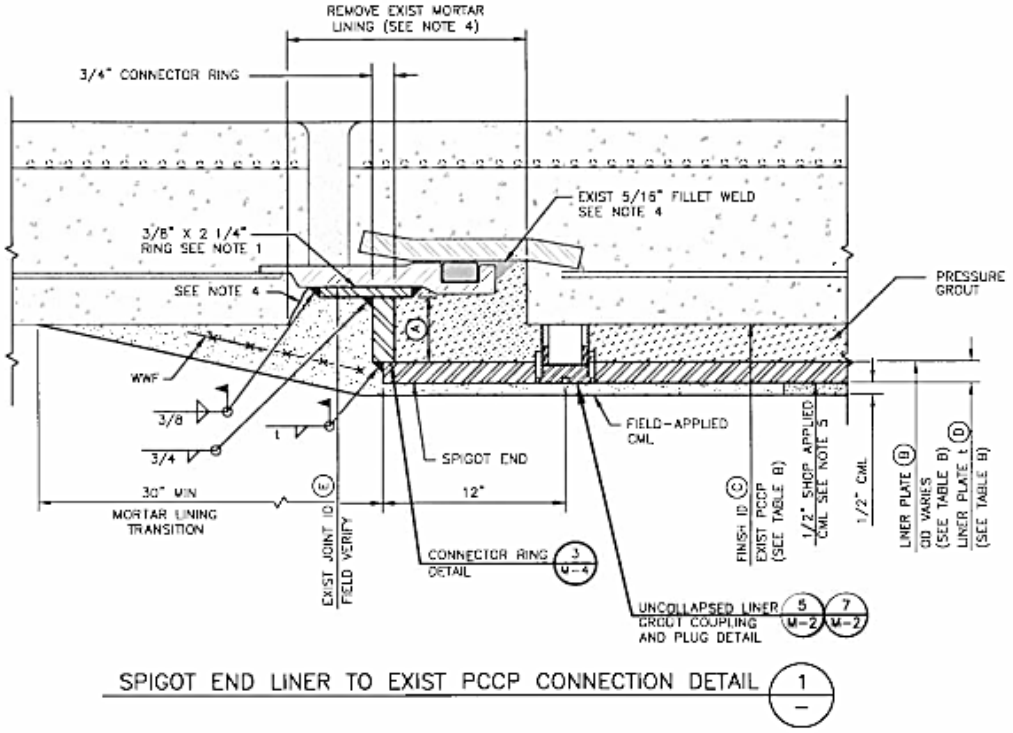
Grout Port and Spacer Spacing

- Goal: reduce grout flow resistance



Grout Rings or “Dams”

- Confine grout flow
- Required at transitions
- Continuous grouting operation between rings
- Grout port required at top to release air



Grout Pressure

- Calculating collapse pressure, Pc
  - $Pc = \frac{2Es}{1-vs2}\left(\frac{ts}{dn}\right)3$ AWWA M11 4th ed. Eqn 4-2
  - Where,
  - Es = modulus of elasticity of steel cylinder
  - ts = thickness of steel cylinder
  - vs = Poission's ratio for steel cylinder
  - dn = diameter to neutral axis of steel cylinder
  - Substituting for Es and vs,
  - $Pc = 66{,}666{,}667\left(\frac{ts}{dn}\right)3$ AWWA M11 4th ed. Eqn 4-3

Grout Pressure

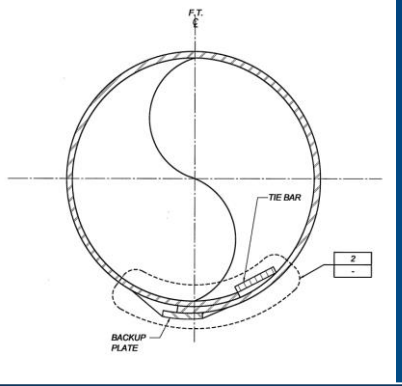
- External collapse pressures calculated per the AWWA equations assume uniform external pressure on the steel cylinder
- For 84” ID, ½” thick steel liner, uniform collapse pressure is 13.8 psi – Grouting near this pressure will collapse the pipe!
  - Actual grouting conditions must account for dynamic friction of grout flow, distance between grout ports, differing static pressure between top and bottom of the pipe, etc., which result in non-uniform external pressure distribution
  - Typical grouting pressures run about 3 to 5 psi
- Spacing of grout ports is critical!

Field Mortar Lining

- Collapsed-can liner requires mortar lining in the field.
- Per AWWA C602
- Standard (non-collapsed) closure sections and fittings can be shop-lined with joints hand-mortared in the field.

General Observations

- Contractor experience requirements written into specifications
- Full time certified weld inspection
- Full time installation inspection including field mortar lining.



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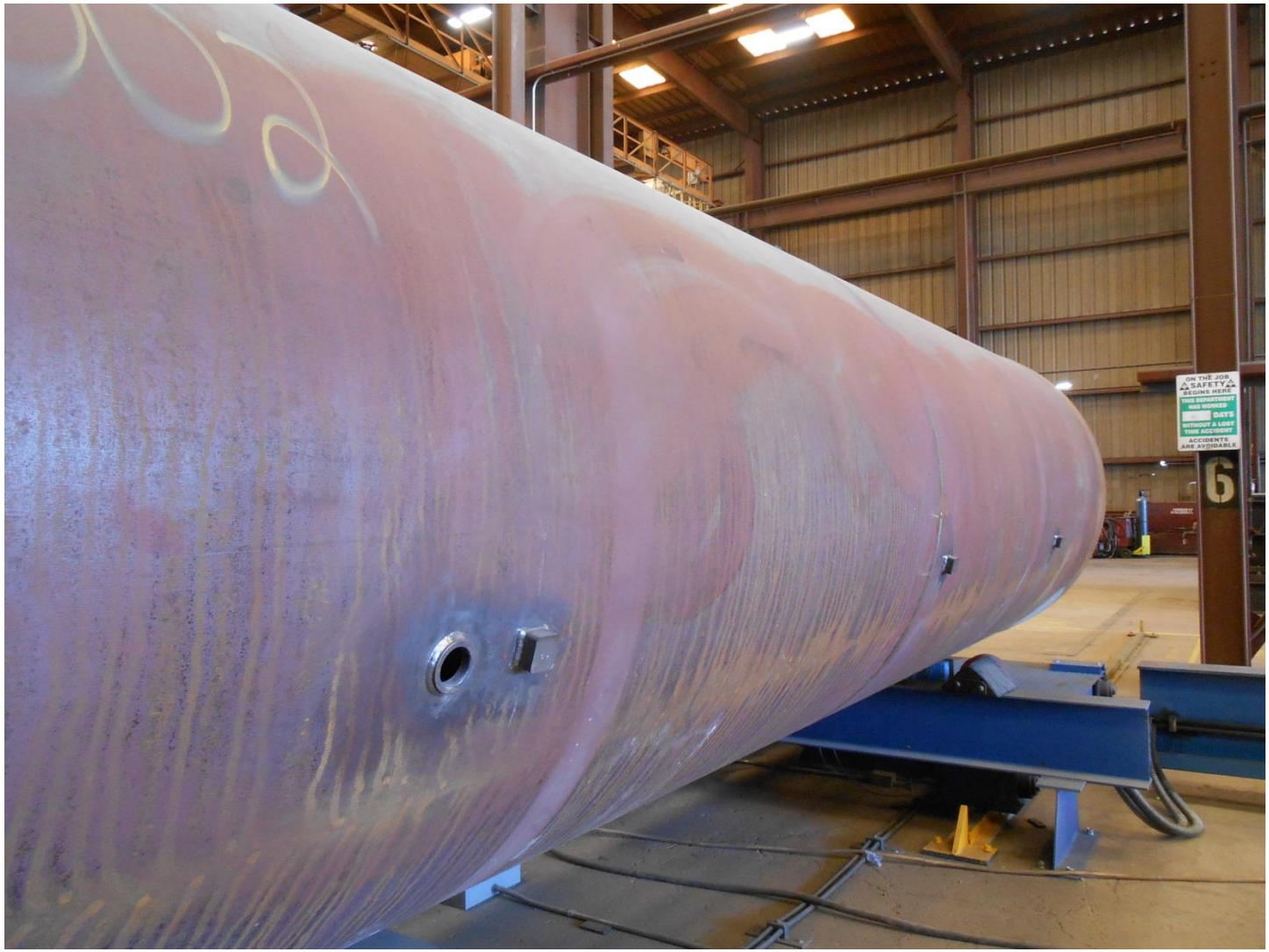
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