HDPE Pipe Fittings Standardization

Use of HDPE for
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THE NEED

- Virtually all other pipe materials have standardized fittings dimensions….. Steel, Ductile-Iron, Concrete, etc.
- Engineering Firms need standardized dimensions so that fitting components can be modeled and placed into 3-D models for spacial location, constructability, fit and interference fit.
- All fittings need a consistent design-basis for pressure.
- Fittings Manufacturers need to be able to build to standardized dimensions and pressure ratings to provide a safe and consistent product meeting user specifications and expectations.

Standardization

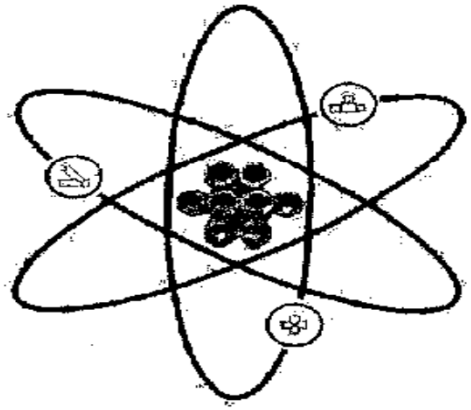
- Because many polyethylene pipe fittings fabricators do not have professional engineers on staff to design, test, and validate fittings designs to accommodate combined primary, secondary and tertiary loads, as well as local stress intensification from geometry effects, it is essential that the industry gather its talented members with the required skill-sets, to create pre-designed fully pressure rated fittings with service-life as long as the pipeline to which it is attached.

Fittings For Nuclear Power Plants

NEW
International Symbol

For

ASME Class 3 HDPE Pipe and Fittings



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Molded Versus Fabricated

- Injection Molded HDPE pipe fittings have been produced and sold for decades up through 12-inch IPS DR 11.
- Molded fittings need to be codified and dimensionally standardized over time, so that they may be used interchangeably between manufacturers.

- Fabricated Fittings are pressure vessel components requiring FEA visco-elastic analysis & modeling, or design by formulae, like pipe.
- Fitting dimensions fabricated from pipe segments are some-what limited by the equipment used to fuse the segments together.
- Custom Fitting Fabricators need pressure vessel design experience to assure the long term pressure capacity equal to the pipe-main.

HDPE FITTINGS FABRICATION PROCESSES

- Pressure Injection Molding
- Pressure Compression Molding
- Pressure Heat Fusion Joining TR-33 & 41
- Pressure Thermoforming

- Non-Pressure Fabrication processes like hot gas joining, hot extrusion-gun joining, and hot lamination processes are typically not pressure vessel rated fab. methods.

HDPE Flange Adapters

- ASTM F2880
- Injection Molded
- Compression Molded
- Machined from Heavy-Wall ASTM F714 solid-wall Pipe
- Sufficiently long NECK for Electro-fusion couplers
- Sufficiently long NECK for clamping in same-size fusion machine. (may need pipe added for larger machines)
- Hub = same diameter as steel flange raised face dia.
- Hub Thickness = 1.25 x Neck DR min wall thickness.
- FA's are as strong as pipe in pressure, tension, shear.

HDPE FABRICATED ELBOWS

- The "wedge" removed from pipe to make the directional change, weakens the pipe, so extra mass must be applied to the pipe elbow's "gore" segments to reinforce the elbow and raise the elbow pressure rating to become equal to that of the pipe-main to which it is joined.
- The elbow's pressure rating is affected by: the angle of the miter-cut, the ratio of the radius-of-curvature to pipe diameter, the thickness of the pipe from which the "gore" segments are made, the closeness of the joints.
- The most significant effect comes from the mass of material removed from straight pipe: the miter angle.

HDPE FABRICATED ELBOWS

- The formulae for elbows have been derived from first principles, using HDPE plastic physical properties.
- The three formulae required for HDPE elbow pressure design are analogous to the equations found in ASME B31.3 Section 304, paragraph 304.2.3. The pressure design is based on geometrical effects and material properties. A fab. elbow is 1/4th of a segmented torus, a "hoop within a hoop".
- Elbows are subjected to primary, secondary, tertiary loads imposed by: radial pressure, pressure elongation "opening", burial ring-deflection, axial bending from expansion / contraction, out-of-plane bending, thrust loads from impact of water changing its direction, impact from water hammer pressure-waves at end of pipe-run.
- Elbows must be engineered to endure complex combinations of loads and combined stresses that straight cylindrical pipes never see.

HDPE FABRICATED ELBOWS

- The following three formulae consider all the above elements and integrate them into a robust design which will endure combined loads with longevity equal to that of the pipe main to which it is joined.
- The equations are:
- **P = (HDS W T / r) [(R- r) / (R- 0.5r)]**
- **P = (HDS W T/ r) [1 / (1 + ((0.622 r tan θ) / (rT)0.5))]**
- **M** = 2.5 (r Ts)0.5 or **M** = tan θ (R –r)

- A complete explanation of the equations and derivation can be obtained by e-mail from: hsvetlik@indpipe.net

HDPE FABRICATED ELBOWS

- The Equations Translated>>> For DR 11, AND
- For R / D ratios of 1.0 , 1.5 , and 2.0, AND,
- A miter angle of 11.25-deg (a 22.5-deg. directional change), the elbow GORE pipe segment wall needs to be over 125% of the pipe main wall thickness.
- A miter angle of 15.0-deg. (a 30-deg. directional change), the elbow GORE-pipe segment wall needs to be over 137% of the pipe-main minimum wall thickness.
- A miter angle of 22.5-deg, (a 45-deg. directional change), the elbow GORE-pipe segment wall needs to be over 157% of the pipe-main minimum wall thickness.

HDPE FABRICATED ELBOWS

- The elbow gore-pipe segments, need to be thicker.
- The thicker reinforcement can be placed on the pipe OD, as is done with injection molded elbows (externally reinforced)
- The thicker reinforcement can be placed on the pipe ID. (internally reinforced)
- Each case is individual, but internally reinforced elbow ID flow area constriction can reduce flow area down to about 85% of that of the pipe-main. Examine each case.
- Externally reinforced elbows preserve full flow area and provide full pressure rating, and durability to handle combined loads.

HDPE PIPE ELBOWS

- Externally Reinforced HDPE Pipe Elbow

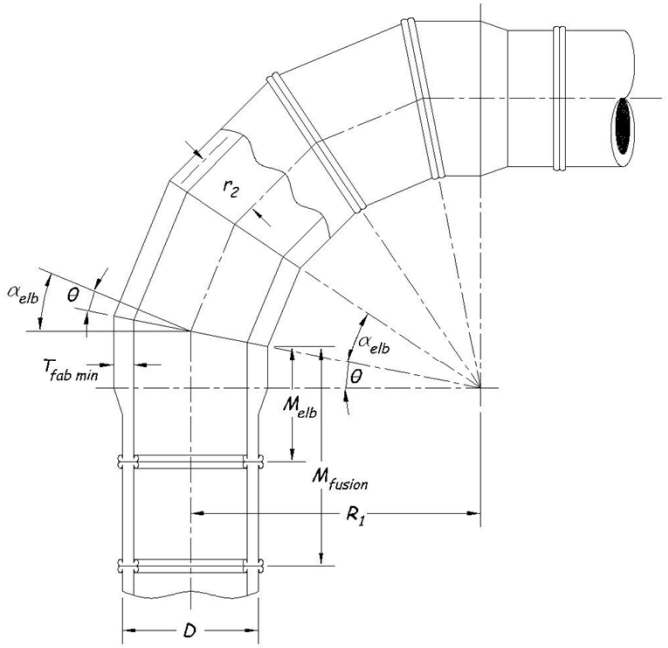


Figure - 3123-1b: Nomenclature for Constant ID, 5-Segment, Reinforced, 90 Degree Elbow

HDPE FABRICATED ELBOWS

- ASME CC N-755 Elbows are made from conventionally extruded solid wall ASTM F714 standard dimension, or custom OD & Wall, PE4710 pipe, using HDPE made by the source material (resin) manufacturer possessing its PPI T-4 Independent Listing, and extruded by the polyethylene material (pipe) manufacturer possessing its PPI TR-4 Dependent Listing.

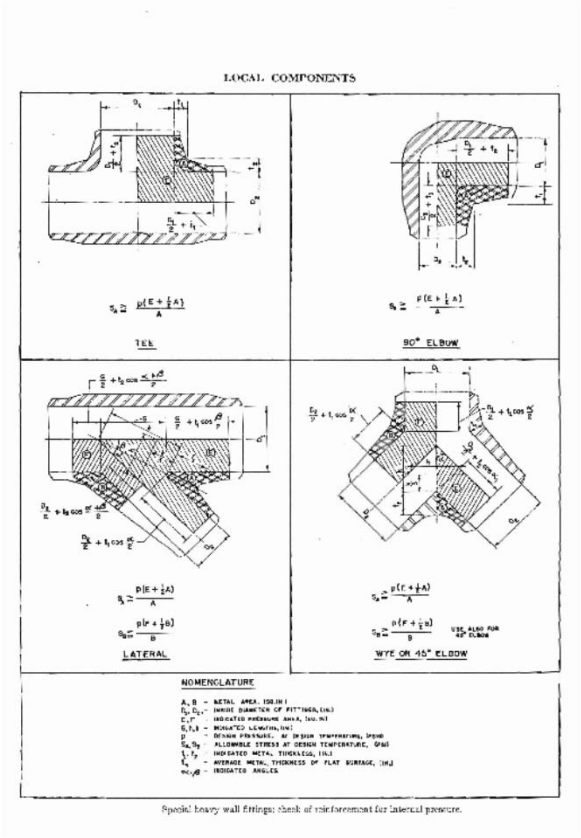
Branch Outlets (TEE & WYE)

- The fundamental situation with a branch outlet from a pipe main, is how to reinforce the hole cut into the wall of the pipe main. The un-supported pressure area must be must be constrained, typically with a reinforcement mass, so as to preserve the pressure capacity of the pipeline, while allowing flow through the outlet hole.
- Tees are one case of the branch outlet, in which the branch is at 90º (perpendicular) to the axis of the main, having a circular hole through the pipe-main.
- Lateral Wyes are a second case of a branch outlet, usually inclined at 60º or 45º to the main, with a longer and elliptical hole through the pipe-main.
- Equal Wyes are a special case where-in the pipe-main divides into two equal outlets (like a fork-in-the-road).

Branch Outlets

- Research and testing during the 1930's, 1940's, and 1950's lead to the development of design and evaluation methods for Tees and Wyes. Significant progress occurred during this time period.
- Fundamental Researchers such as J.S. Blair, H.S. Swanson, USBR EM-32 & EM-03, W.M. Kellog, Markl, F.L. Everett, and others, contributed significantly and quickly to pressure vessel tee and wye design methods in graphical, mathematical, and empirical forms.
- They developed crotch plates, wrappers, collars, branch saddles, and thickened wall reinforcement methods.

Tees and Wyes

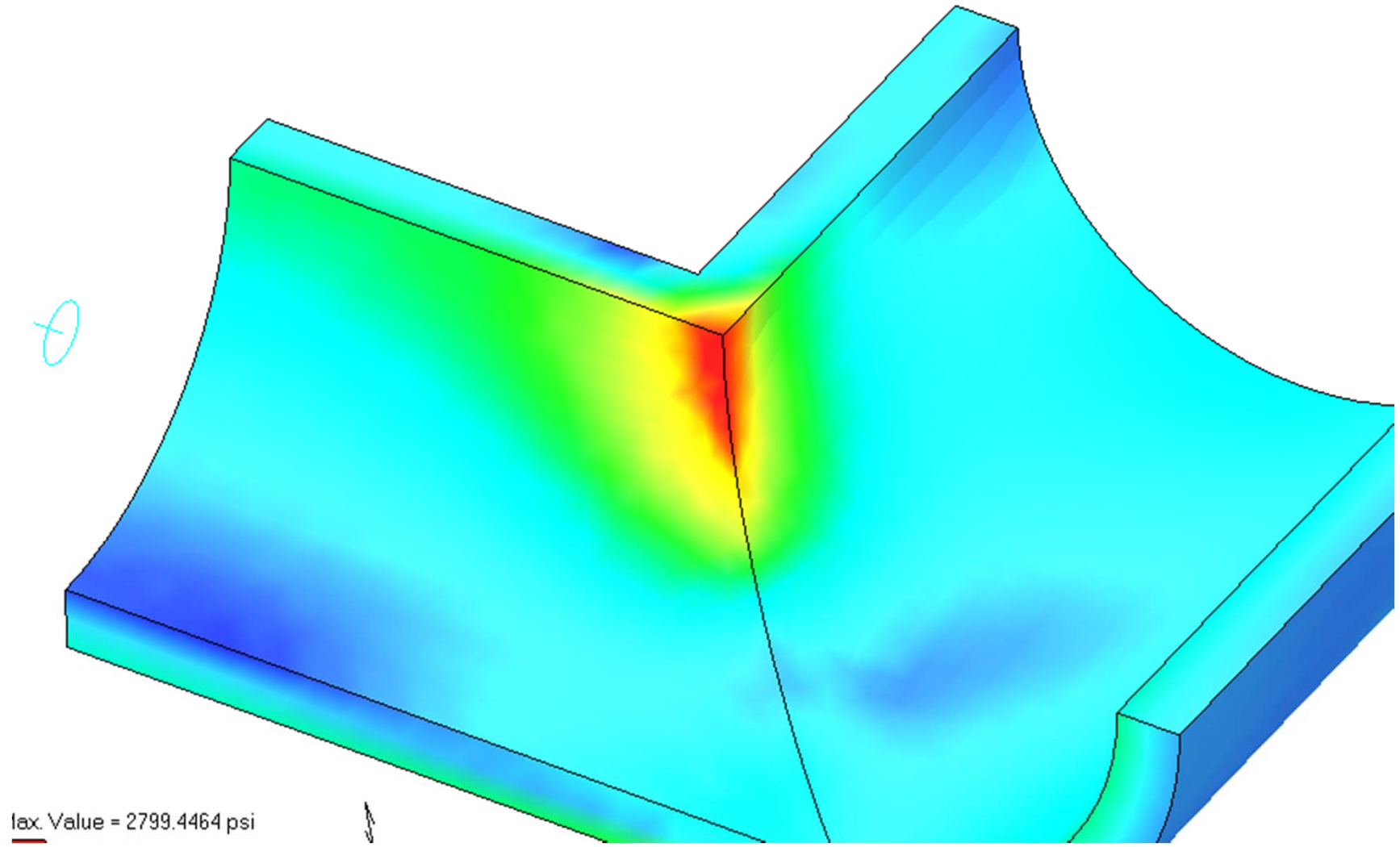


Special heavy wall fittings; check of reinforcement for internal pressure.

Tees and Wyes

- The point of highest stress concentration is on the ID at the intersection of the outlet to the centerline of the pipe main, where there is no supported "hoop", and the fitting tries to bulge as a sphere, which adds secondary bending stresses to primary hoop-stresses. The local stress intensification may become the site of slow-crack growth, fatigue cracking, or pressure rupture, unless the local stress is reduced near to or below acceptable stress values. Reinforcement is essential, especially when considering burial loads, pipe ring deflection, outlet bending from pipe-main thermal contraction, etc…

Tee Local Stress Intensification without



The Point

- The point is: The HDPE pipe industry and the committee on polyethylene pipe fittings standardization needs to generate fittings with common dimensions … as well as …. integrate the documented design basis for each fitting style.
- In this way the user, the public, the manufacturer, and the pressure pipeline itself are protected into future generations.
- And, an engineering heritage is preserved for future customization of fittings, using a known baseline model.

Who Needs This Standardization

- ASME for CC N-755
- NIST
- DOT for Natural Gas Distribution ASTM D2513
- AWWA for AWWA C906
- ASTM fittings to match F 714 & D 3035
- API fittings for Oil-Patch Line Pipe
- **YOU !**

The Standardization Path Forward

- Flange adapters are done : F2880 + TN-38
- Elbows are in-process for 2011
- In Progress: MJ adapters, massive base branch saddles, reducers in 2011
- 2012: Equal Outlet Tees; Reducing Outlet Tees.

- Each style fitting must have a documented design basis, modeled by equations and confirmed by FEA.
- Each style fitting must have consensus dimensions without compromising pressure integrity.
- If you want to contribute: hsvetlik@indpipe.net