



# **“Reinforced wall thickness” determined for API 15HR, by ASTM D3567**

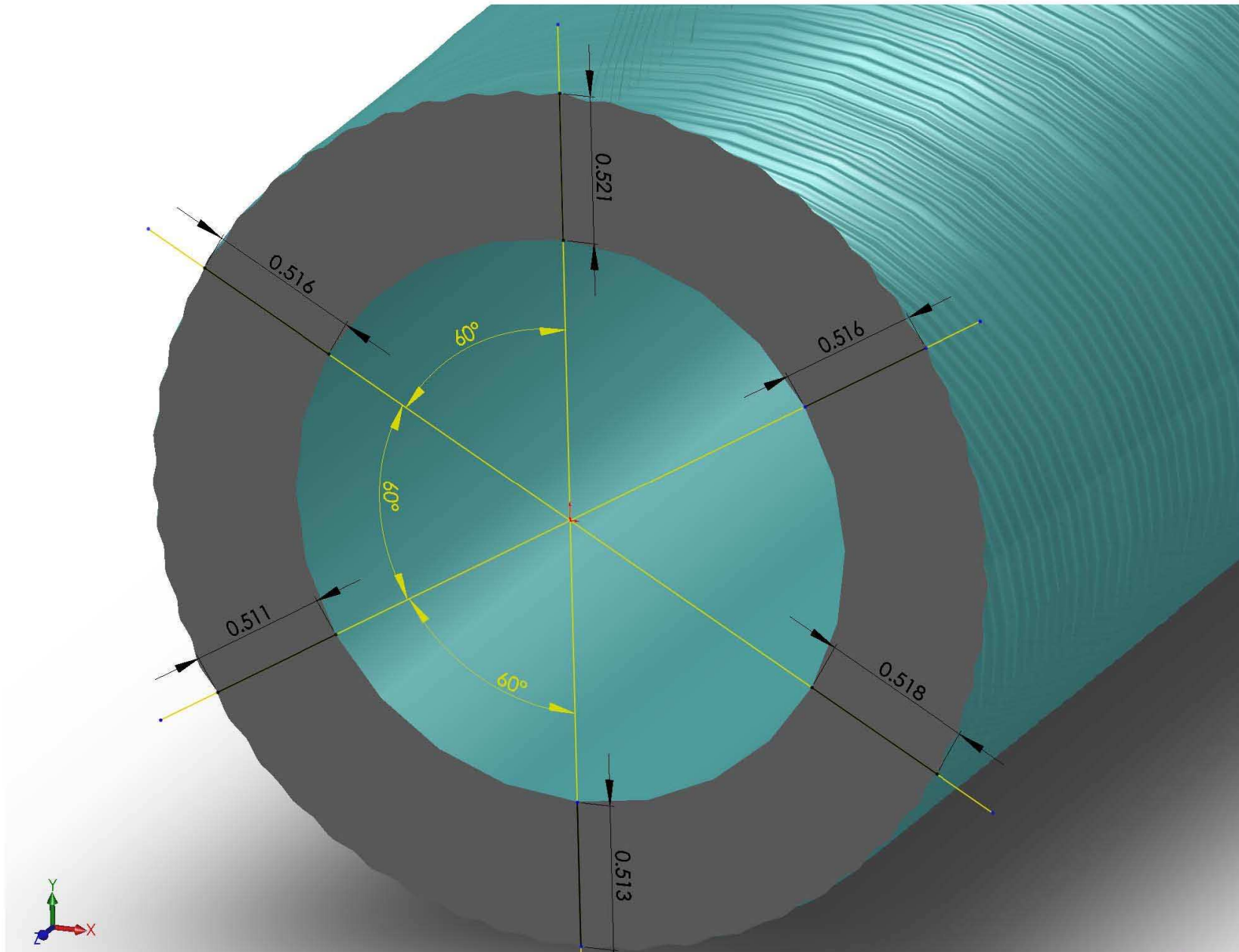
Disparity between terms used in API 15HR and ASTM D3567

This leads to confusion and potential miss use

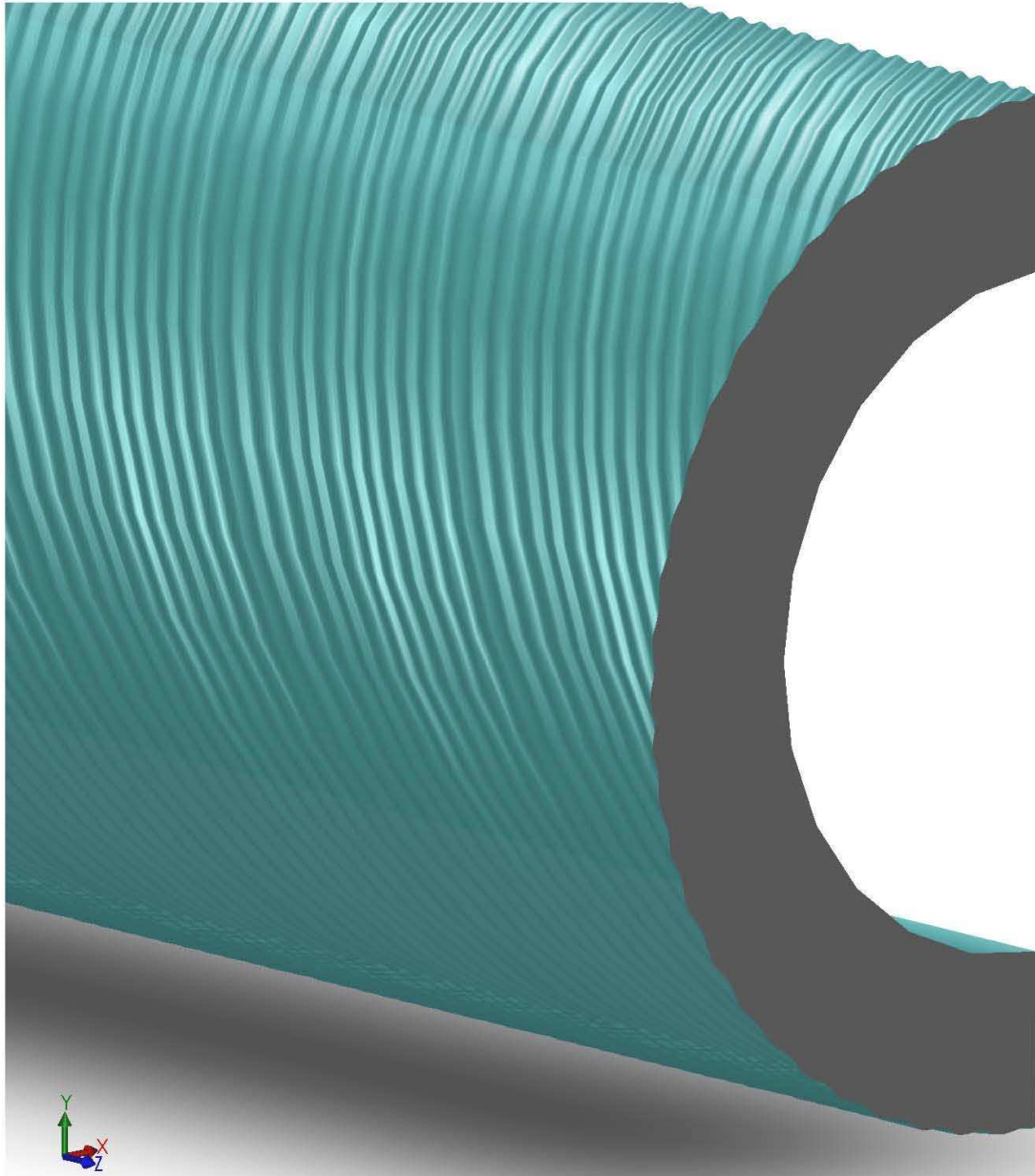
Action - 15HR should define the terms to clarify the intent

Following example is for “Unlined pipe” - Unreinforced liners, and non reinforced thicknesses shall simply be subtracted

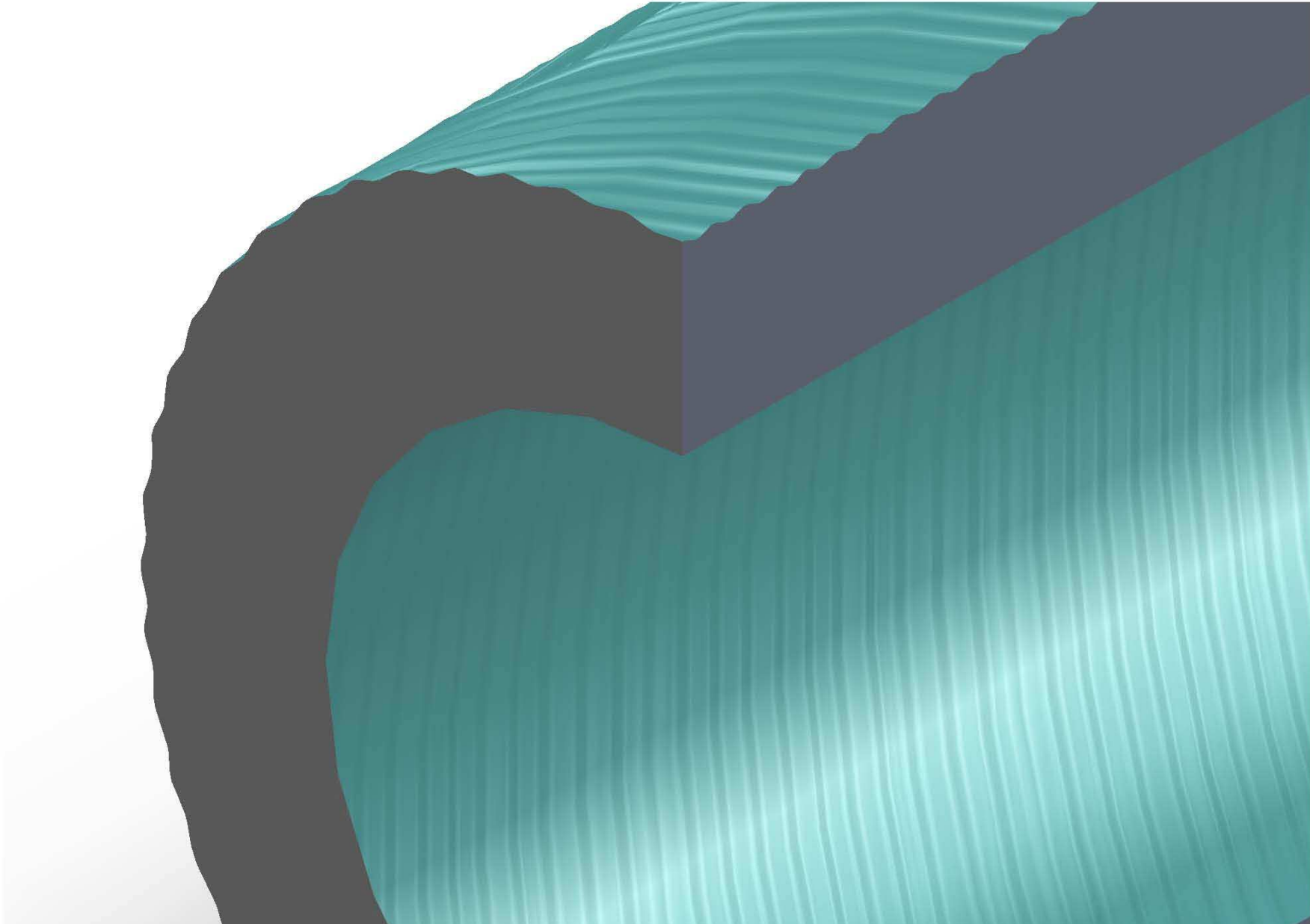
ASTM D3567 – 7 , 6 measurements evenly spaced



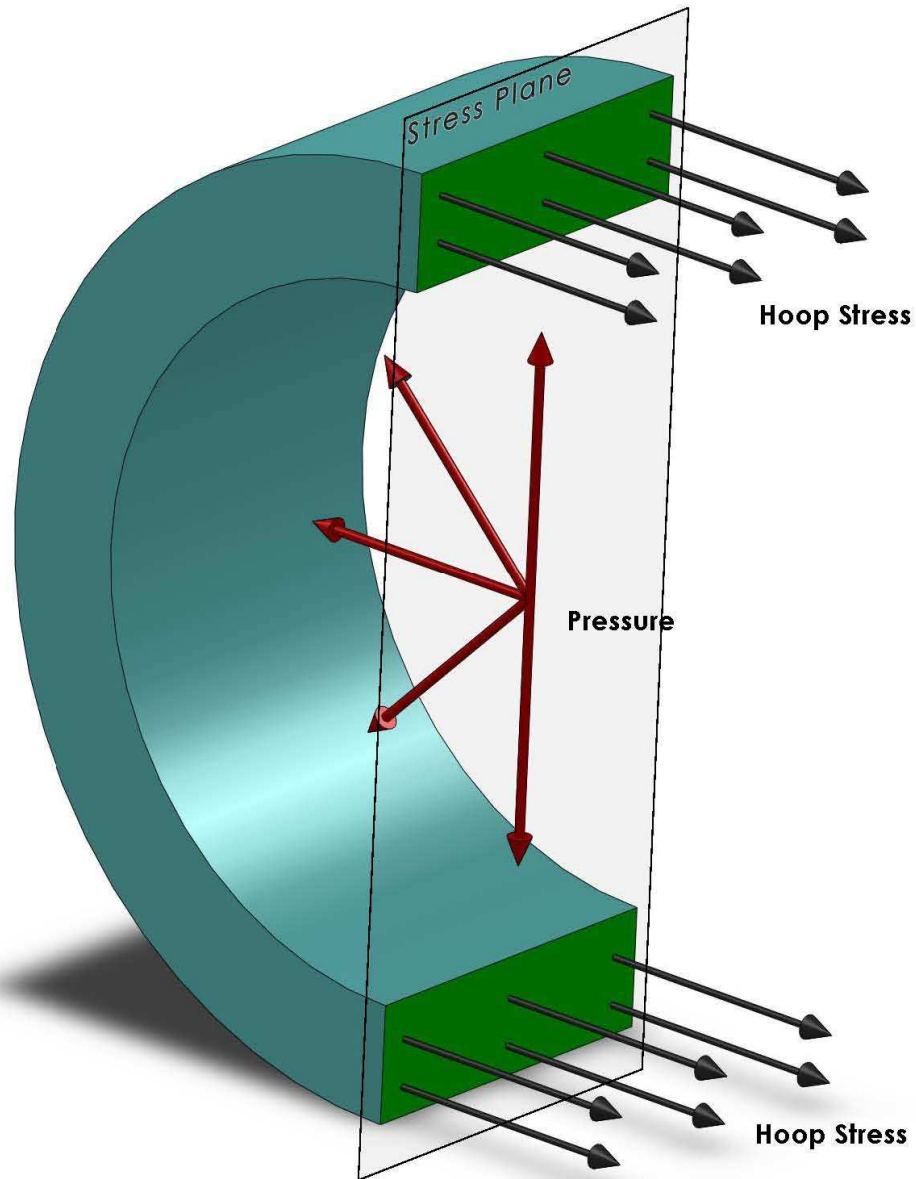
Wound Pipe (no liner), irregular exterior follows wind angle



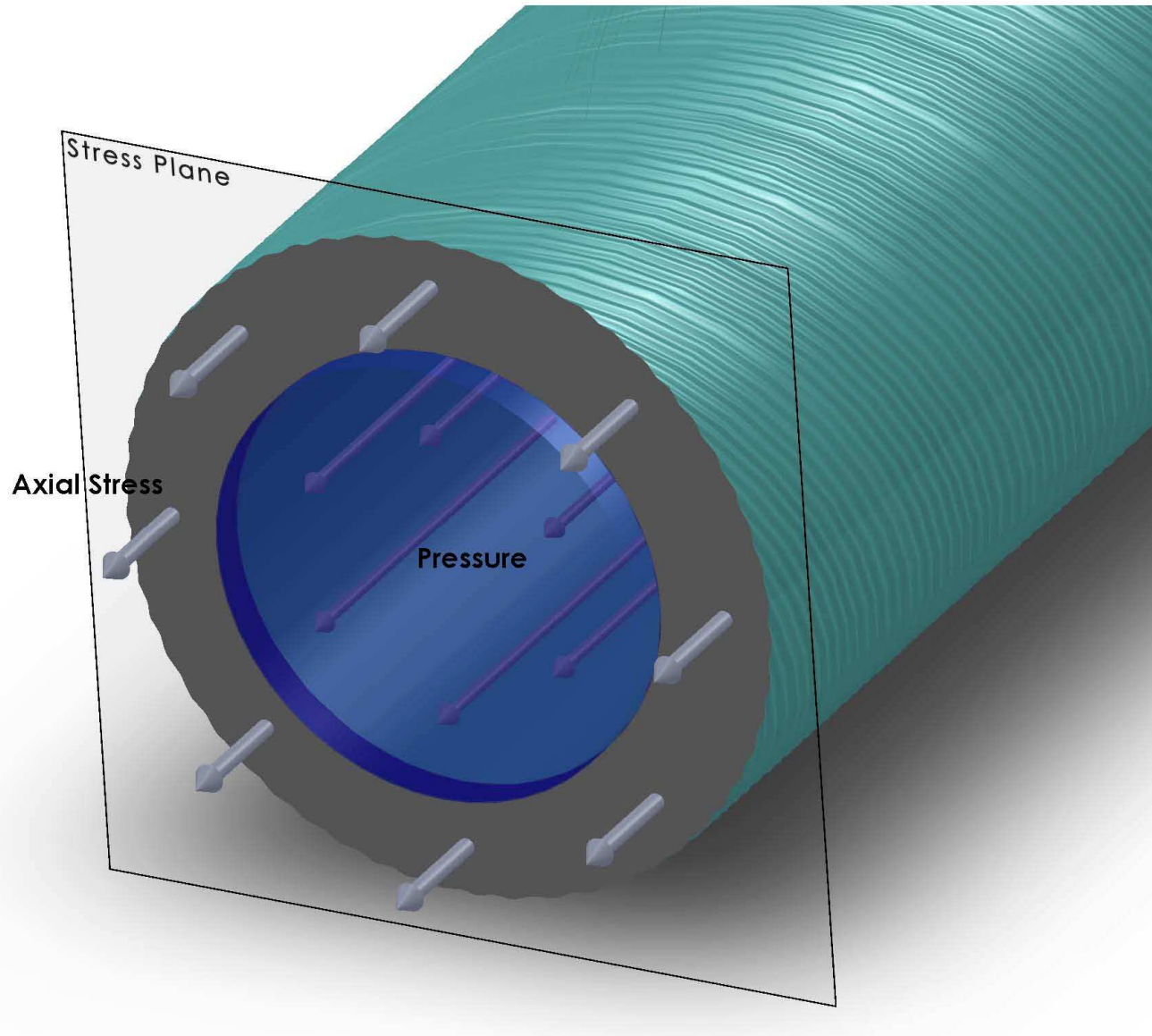
Wound Pipe (no liner) magnify wall sections of interest

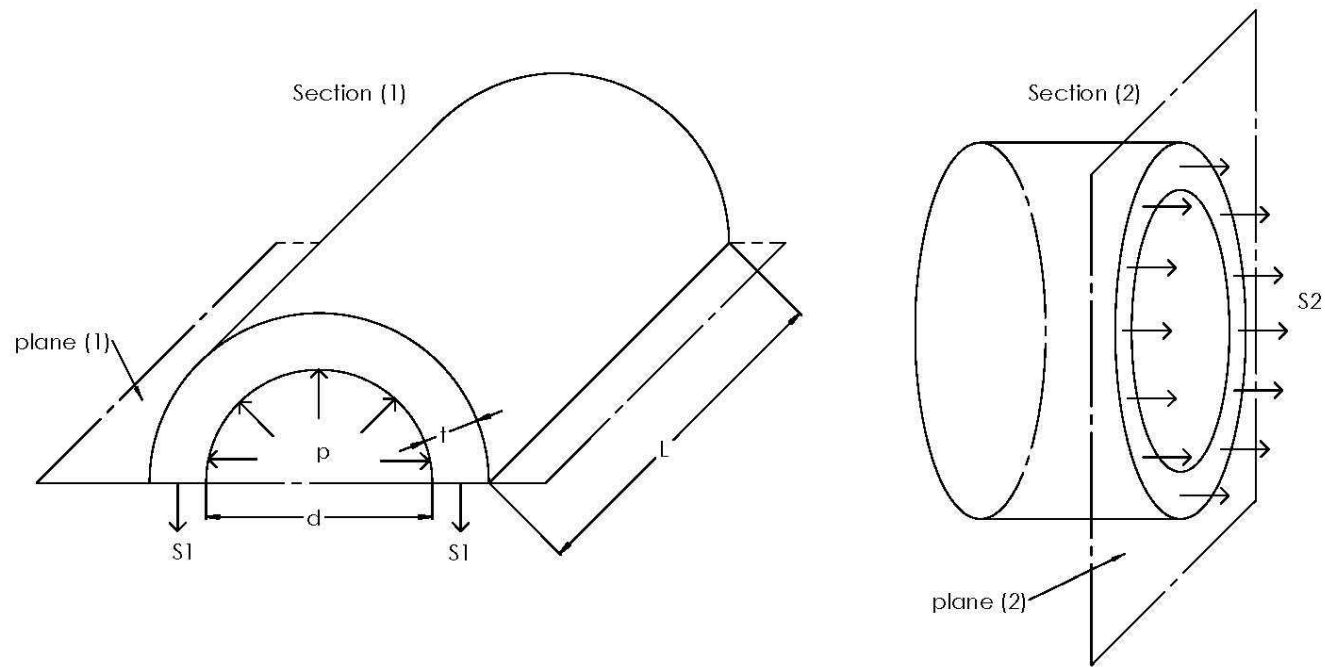


Primary 15HR - Hoop tensile stress – (Area resisting load)



# Secondary 15HR- Longitudinal Axial stress (Area - resisting load)





#### Section (1)

Hoop stress ( $S_1$ ) develops as a function of internal pressure ( $p$ ) acting on plane 1 across distance ( $d$ ) and the cross sectional area of pipe dissected in plane 1.

- forces > (pressure)  $p \cdot (\text{area}) d \cdot L$
  - reactions > (stress)  $S_1 \cdot (\text{area}) 2 \cdot t \cdot L$
- following equality:  $p \cdot d \cdot l = S_1 \cdot 2 \cdot t \cdot L$

simplified: (hoop stress)  $S_1 = pd/2t$

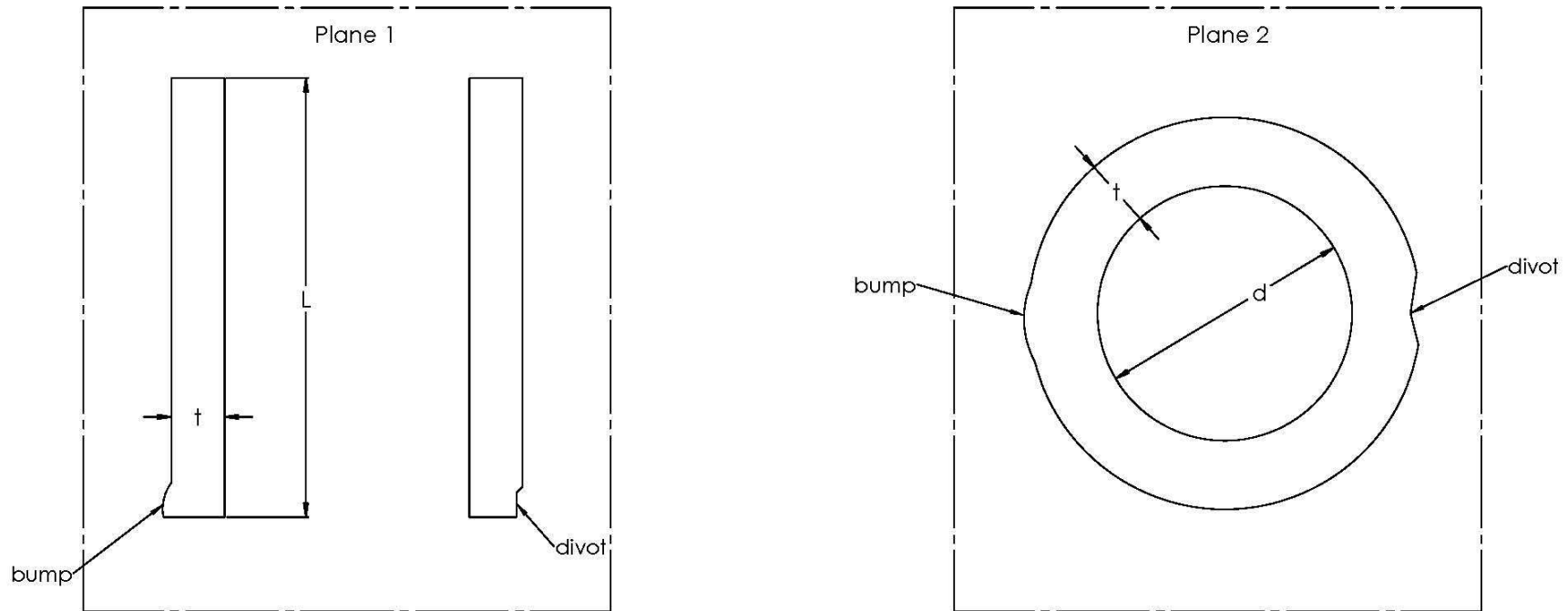
#### Section (2)

Axial stress ( $S_2$ ) develops as a function of internal pressure ( $p$ ) acting on the end of pipe area and the cross sectional area of pipe dissected in plane 2

- forces > (pressure)  $p \cdot (\text{area of end of pipe}) \pi \cdot d^2 / 4$
  - reactions > (stress)  $S_2 \cdot (\text{area}) \pi \cdot d \cdot t$
- following equality:  $p \cdot \pi \cdot d^2 / 4 = S_2 \cdot \pi \cdot d \cdot t$

simplified: (axial stress)  $S_2 = pd/4t$

## ? Wall thickness to calculate accurate Area for Stress

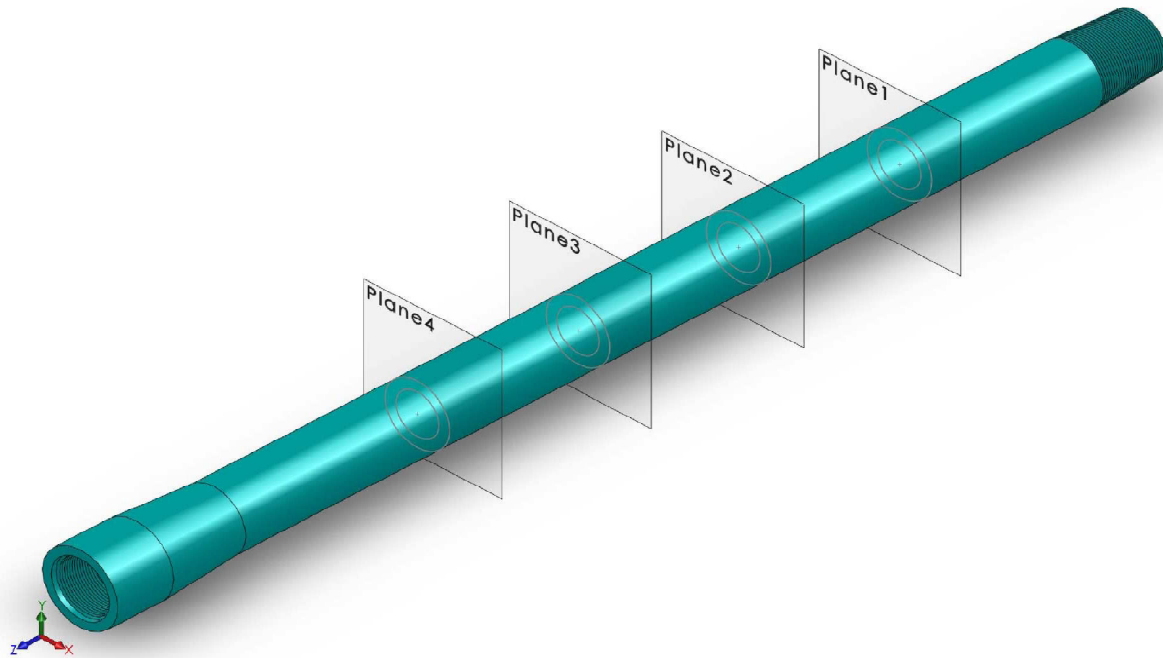


Measurement of pipe thickness from multiple points at one cross section will most likely show there are imperfections or some large measurements and some small measurements. These local imperfections will only effect stress if they are large enough to skew the calculated stress area. Small thickness measurements will be offset by larger measurements.

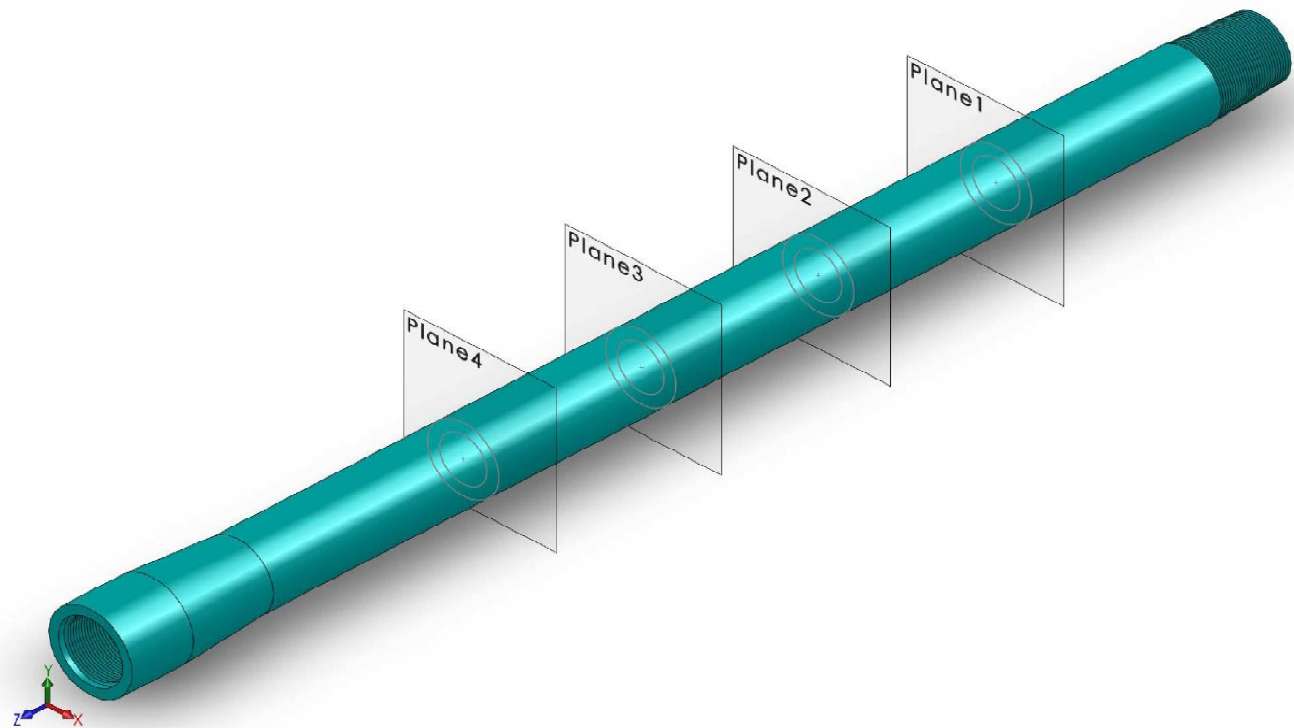


“Average reinforced wall thickness” per ASTM D3567 is required to predict accurate - hoop and axial stress

ASTM D3567 is performed at a “single” cross section and yields the “reinforced wall” at that section only.



API 15HR “intent” of “minimum reinforced wall thickness”  
- Manufacturer guarantees that **No** cross section will yield a  
“reinforced wall thickness” less than the guaranteed Minimum  
when ASTM D3567 – 7 is performed - measurement at any  
Plane (cross section) shall yield results  $> tr_{min}$



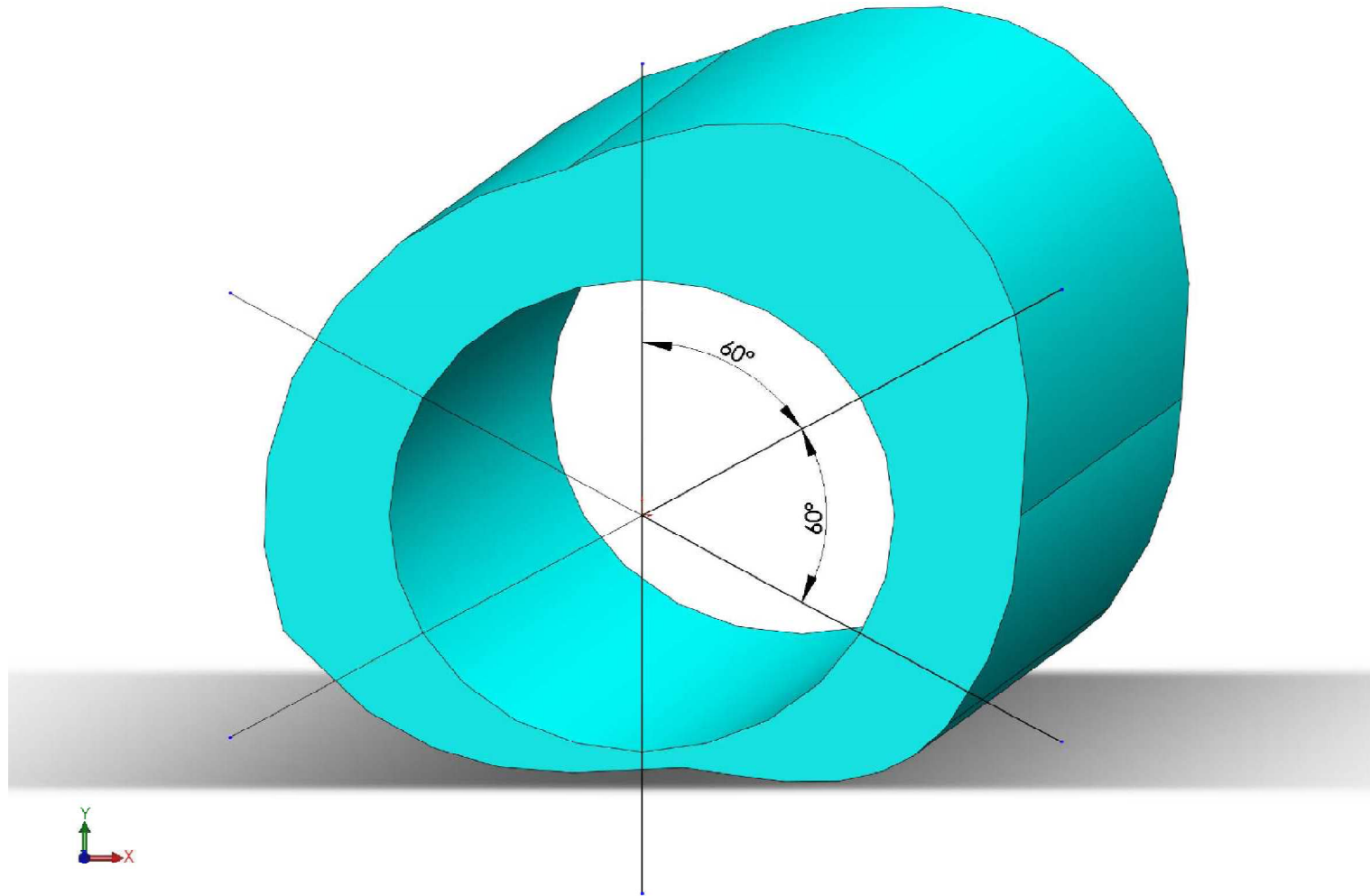
Suggested 15HR clarifications to Define Reinforced and Minimum reinforced Wall thickness: (unlined reinforced pipe)

- A. “Reinforced wall thickness” is determined by the result reported by ASTM D3567 , 7.5.2 “Average reinforced wall thickness”
  
- B. The “Minimum reinforced wall thickness” is a manufacturer guarantee that - NO “reinforced wall thickness” as reported by method ASTM D3567 – 7.5.2 will be found less than this value at any section measures along the pipe length or component.

*The “minimum reinforced wall thickness” is the smallest acceptable “average reinforced wall thickness” determined by ASTM D3567 7 and reported per 7.5.2*

How to protect against extreme Variations?

Define: The Maximum acceptable variations



## Suggest: Acceptable variations and limitations to reinforced wall thickness measurements per ASTM D3567 - 7

1. The (6) reinforced wall thickness measurements per ASTM D3567 – 7 shall produce an average result which exceeds the manufacturers stated minimum reinforced wall thickness ( $t_{r\min}$ ).
2. It is allowed to search for and select the smallest observation to begin the procedure ASTM D3567 - 7, however the remaining (5) observations are evenly spaced at 60 degrees based on the first observation selected.
3. No more than (2) of the (6) observations may be found less than the stated “minimum reinforced wall thickness”
4. None of the (6) observations may be less than  $(0.95 \times t_{r\min})$ .
5. Where any single observation is found below  $t_{r\min}$ , the maximum observation may not exceed  $1.225 \times t_{r\min}$ . Ref. 15HR – 5.2.2 table 1

(support text with example)

## Example: reinforced wall thickness per 15HR by ASTM D3567

$t_{rmin} := 0.100"$  = Guaranteed "minimum reinforced wall thickness"

$o_{min} := 0.95 \times t_{rmin} = 0.095"$  = Minimum acceptable observation

$o_{max} := 1.225 \times t_{rmin} = 0.1225"$  = Maximum acceptable observation (applies only when an observation is found lower than  $t_{rmin}$ )

$o1 := 0.095"$  Smallest observation  $> o_{min}$ , meets requirements

$o2 := 0.110"$  observation 2

$o3 := 0.105"$  observation 3

$o4 := 0.097"$  observation 4,  $<$  than  $t_{rmin}$ ,  $>$   $o_{min}$ , meets requirements

$o5 := 0.120"$  Largest observation  $<$   $o_{max}$ , meets requirements

$o6 := 0.108"$  observation 6

$(o1 + o2 + o3 + o4 + o5 + o6) / 6 = 0.106"$  Average reinforced wall exceeds  $t_{rmin}$

No more than 2 observations found  $<$   $t_{rmin}$ , ( $o1$ ,  $o4$ )

Measurement meets the requirements for Minimum reinforced wall thickness



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Discussion, modification, agreement