

Continuous Digester Rapid Thinning

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Topics

- Where does it occur?
- What is the cause?
- How to visually identify the damage
- Inspection approach, results evaluation and frequency
- Mitigation methods
- Other considerations for digester thinning

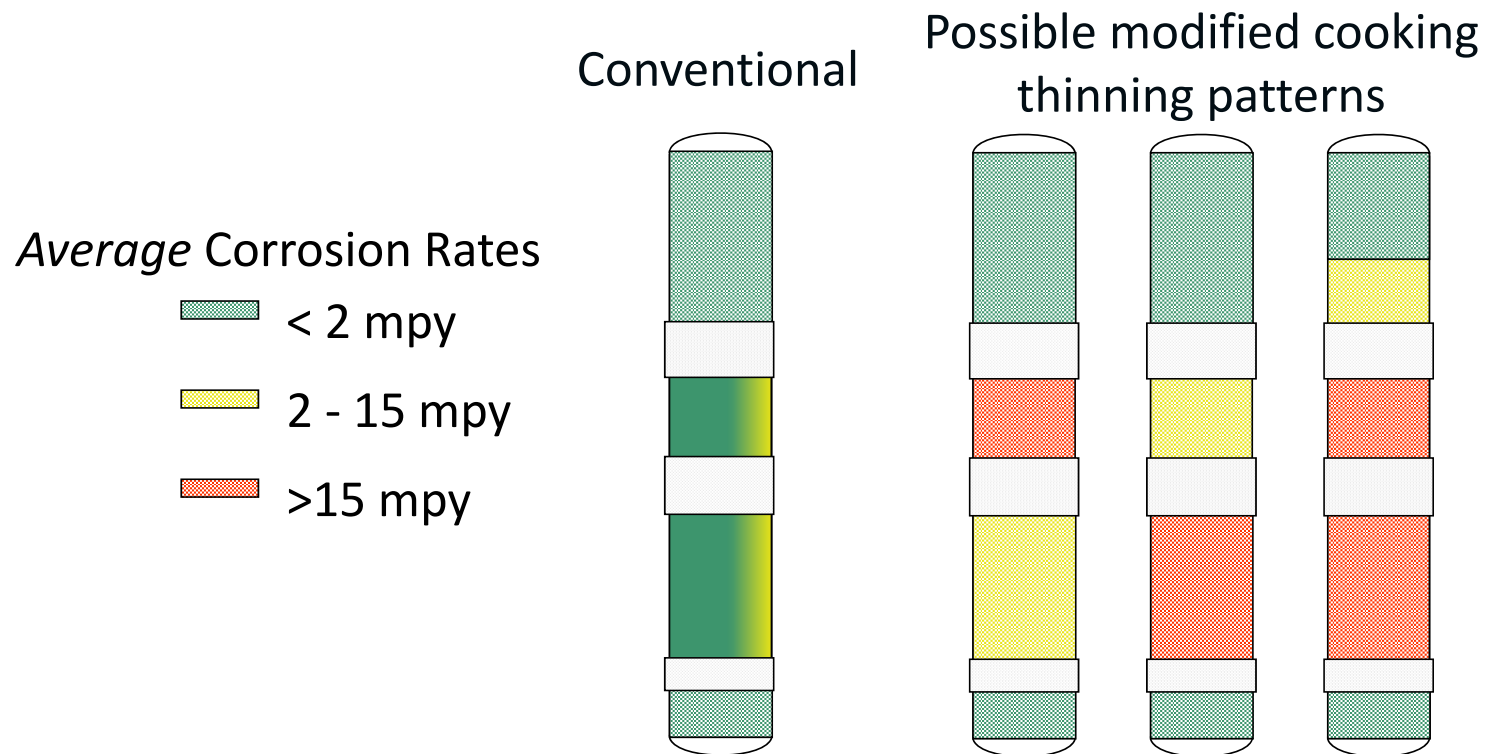


Where Does it Occur?

- The exposed steel shell in the mid section of the digester between the top and bottom screens
 - Carbon steel blank and header plates can also corrode
- It mainly occurs in modified cooking digesters
 - MCC, EMCC, Lo-Solids, ITC etc.
 - Digesters built after 1980 are typically fully stress relieved, so thinning may be a greater concern than cracking
- Maximum average corrosion rate is about 40 mils/yr
 - TAPPI defines rapid thinning as > 20 mils/yr



Typical Corrosion Patterns



What is the Cause?

- The damage mechanism is erosion corrosion in pulp mill equipment
- Softwood pulping
 - Softwood is more corrosive than hardwood
 - Temperature probably plays a role
- No or unknown correlation with REA, residual hydroxide
 - 1998 Gorog, mill liquor testing, 8.9 g/L NaOH minimum in softwood
 - 2002 Pawel, ORNL Report, correlation only with softwood
 - 2019 Tunncliffe, TAPPI PEERS, correlation with REA inconclusive

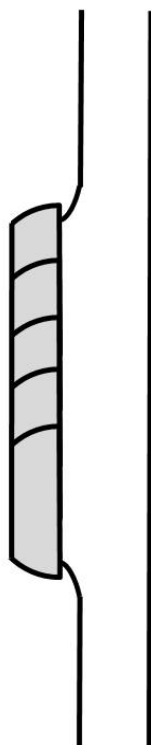


Visual Identification

- Preferential corrosion
 - Welds, heat affected zones
 - Grinding, scratches
 - Disruption of mill scale
- “Ocean-Island”
- “Polishing” that produces a pit-free surface



The Shell has Receded from the Stainless Nozzle



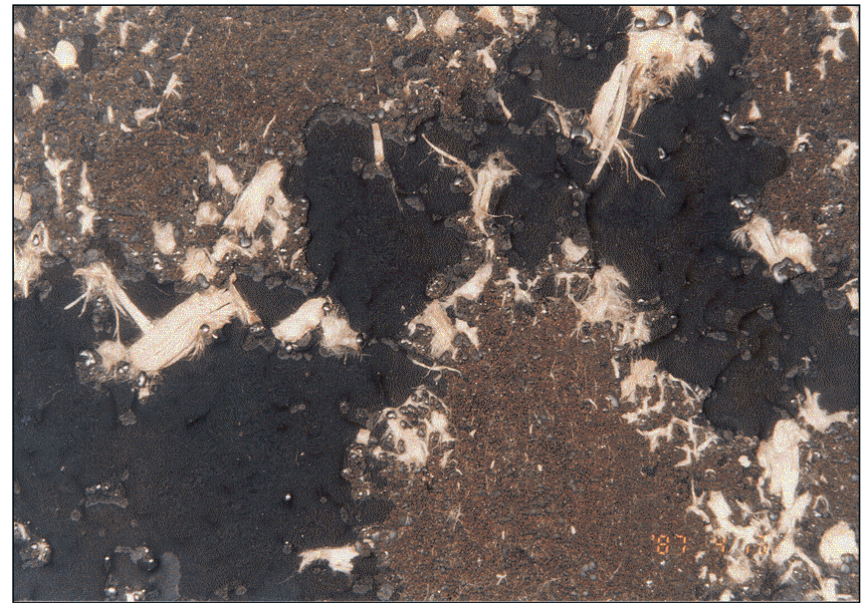
Preferential Weld Corrosion



“Ocean-Island” Corrosion



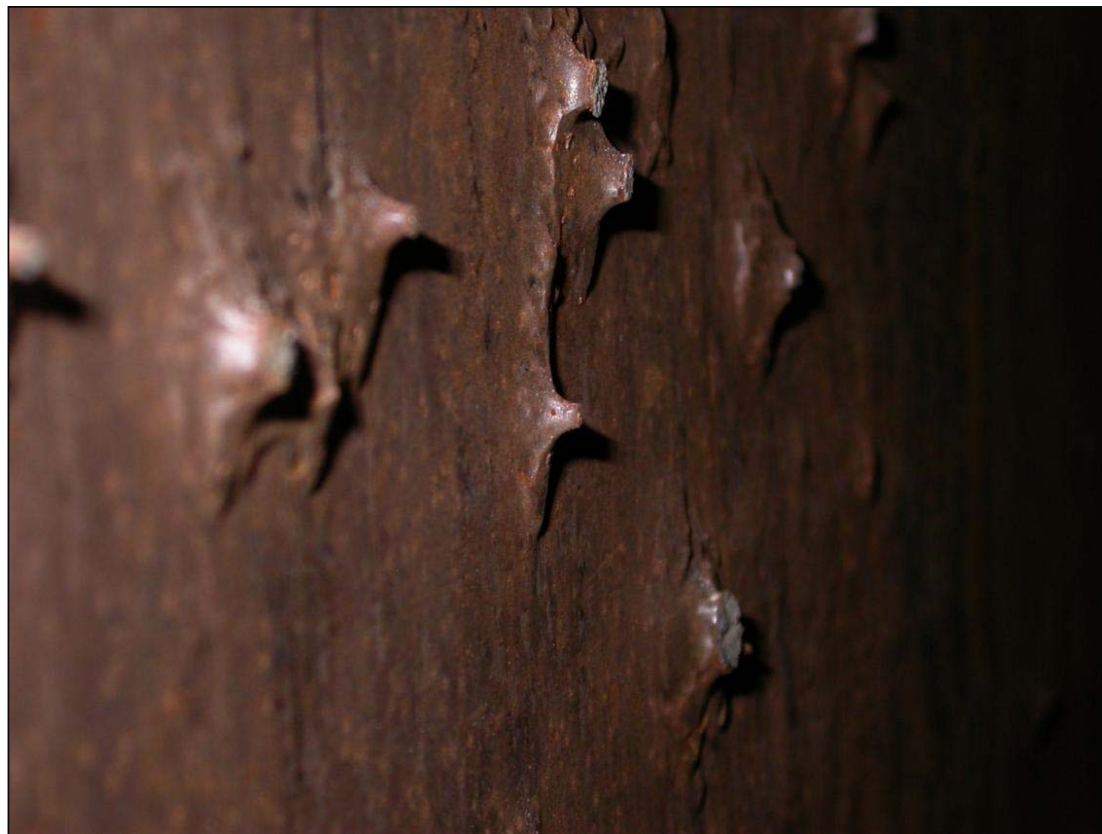
More Ocean-Island Corrosion



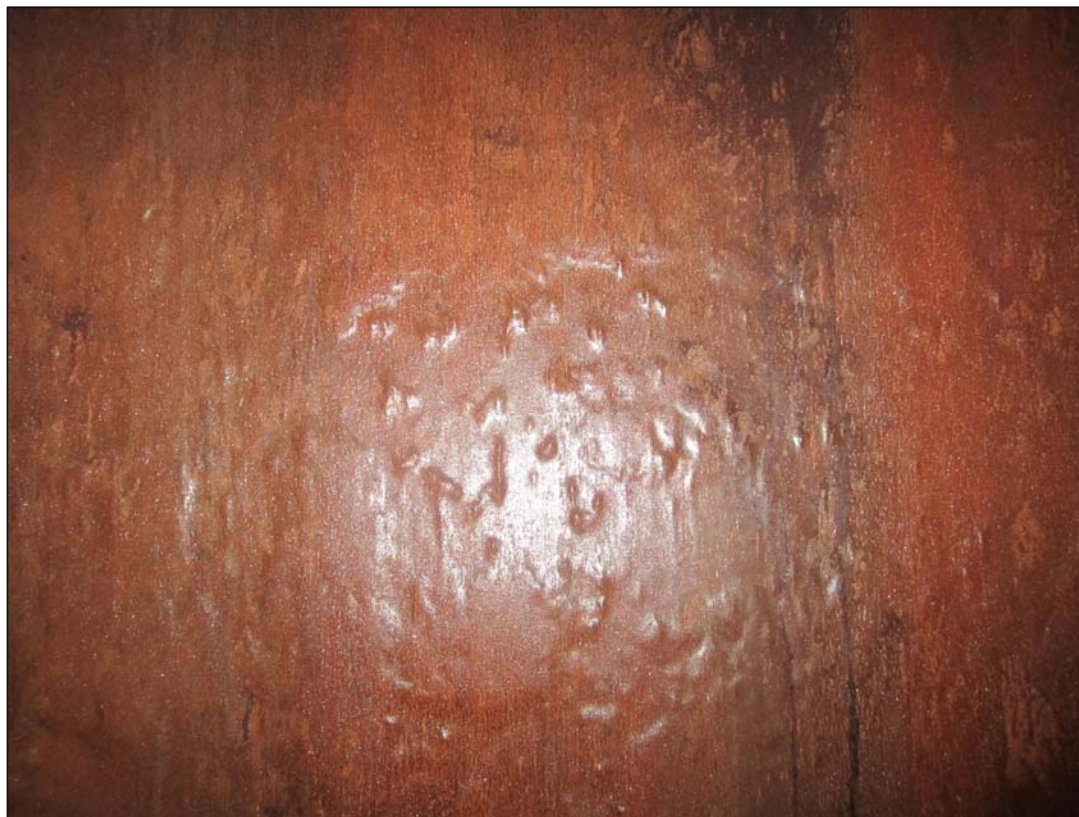
Same Ring 8 Years Later



Side View Showing Steel Spikes



After Another 5 Years



Grooving, Smoothing and Weld Washout



Weld Close-Up Shows Polishing Effect



Contrast With Upper Digester Pitting



Shallow, round, dispersed pits, rough surface



Inspect for Shell Thinning

- A minimum of twelve UT thickness measurement locations in each fully exposed shell course
- Use an evenly spaced grid pattern such as 3 horizontal by 4 vertical locations
 - Corrosion is not uniform around the circumference
- The grid should be adjusted to match the corrosion rate and can change from inspection to inspection

128	109	130	123	106	218	157	123	135	130	179	186	182	168	202	154	190	200	146	134	140	185	152	101	81	120		36	71	43	16	1	60	42	80	28	47	58	62	130	100	137	145	113
141	146	143	132	158	188	188	141	148	192	172	214	236	228	236	199	228	174	186	168	155	171	148	123	102	90	124	81	93	59	58	31	38	97	77	95	90	97	132	127	127	145	154	152
166	167	145	145	172	199	166	153	198	192	221	238	229	246	229	189		196	200	130	133	162	188	165	130	133	90	72	81	48	56	49	74	85	123	92	99	123	166	156	163	162	135	145

Example 2' x 2' grid with remaining corrosion allowance displayed

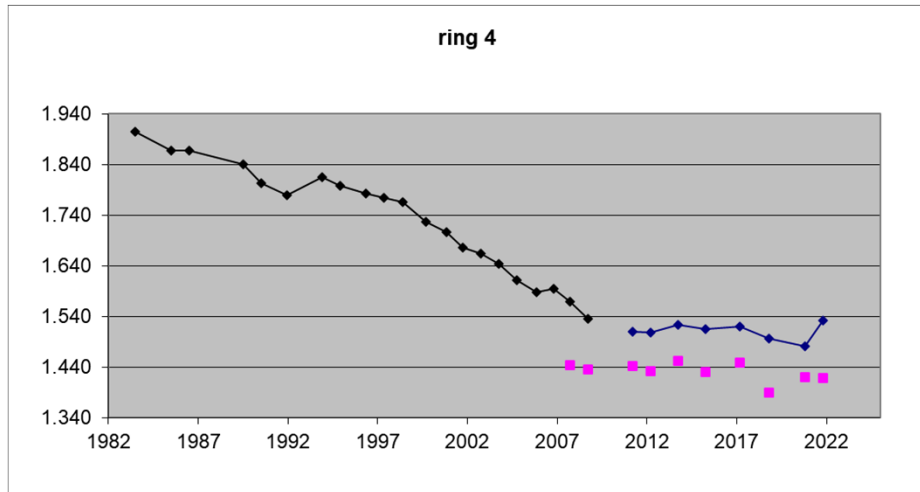


Data Analysis

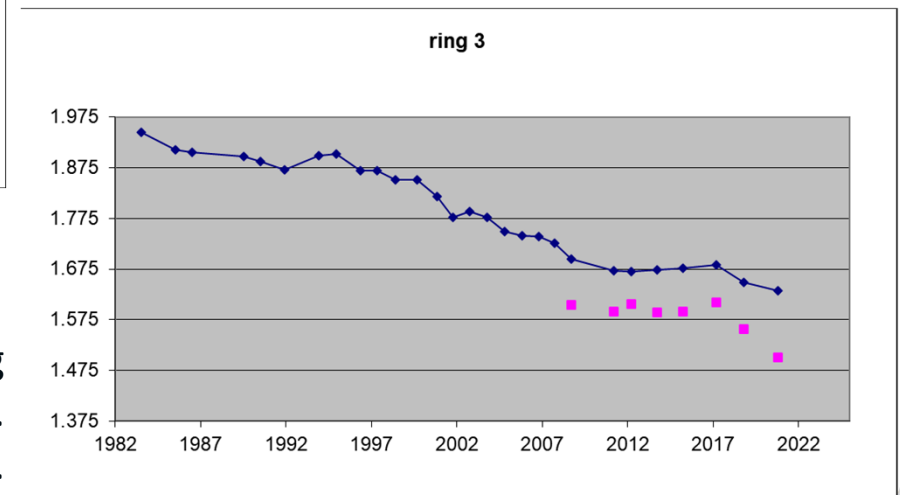
- Don't base the corrosion rate on a single location or inspection
- Record minimum thickness and remaining corrosion allowance
- Calculate average thickness and remaining corrosion allowance
- Trend average thickness
- Analyze results every time data is collected
- Use Fitness for Service to
 - Evaluate pitting, localized and general metal loss
 - Plan repairs
- TAPPI TIP 0402-27, API 510 and NBIC accept API 579 ASME FFS-1



Average Thickness Trend Example



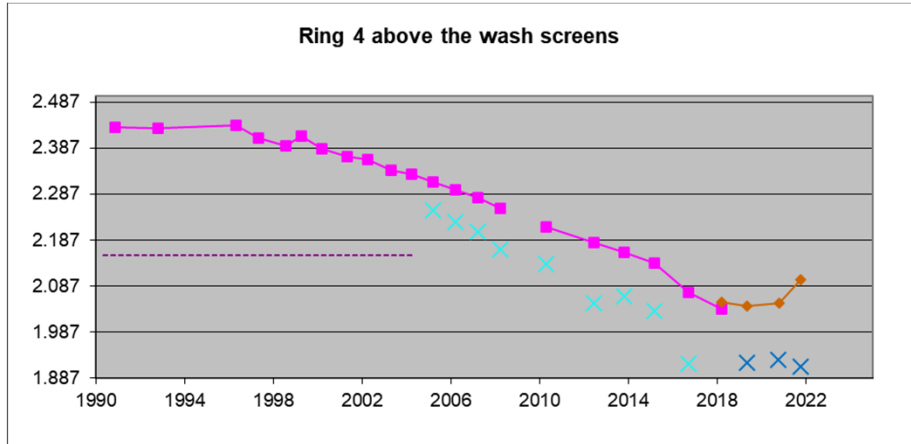
After a process change the average ring corrosion rate increased from 9 to 21 mpy. After overlay, the remaining exposed shell stopped corroding



After a process change the average ring corrosion rate increased from 4 to 15 mpy. The ring has not been overlaid.

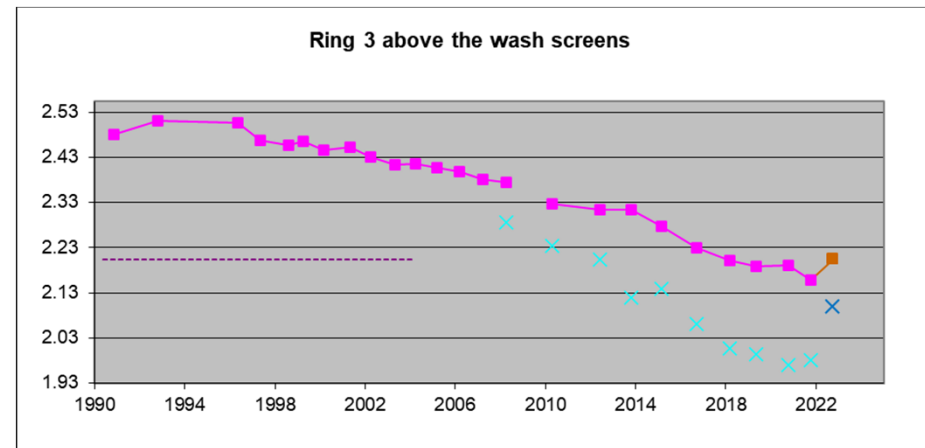


Another Example



20 mpy
33 mpy max
Partial overlay 2018
Full overlay 2021

10 mpy
25 mpy max
Partial overlay in 2021



Interval between thickness testing

- TIP 0402-27 Continuous Digester Inspection
 - Inspect carbon steel annually until corrosion patterns are established
 - The interval may be expanded based on sound evaluation of all data
- 18- and 24-month intervals can be managed, even with corroding digesters
 - Reassess after every inspection
 - Coordinate with scheduling of repairs
- The interval does not have to match other NDT going on in the digester
- Suggest that non-corroding sections with plenty of corrosion allowance be thickness tested on a 4-to-6-year frequency



Corrosion Protection – Weld Overlay

- Use TAPPI TIP 0402-03 for guidance
 - Consider applying overlay when the average remaining corrosion allowance is around 100 mils
- 309L with 18% chromium has enough corrosion resistance
- 312L duplex stainless steel, is not required, but its strength may be used if the shell is below ASME Tmin
- Establish quality requirements to prevent hot cracking i.e., control ferrite in stainless steel
- Vertical or horizontal overlay
- May require an extended shutdown
- Long lasting with little maintenance



Vertical Down



309L Overlay After 15 Years



Corrosion Protection – Thermal Spray

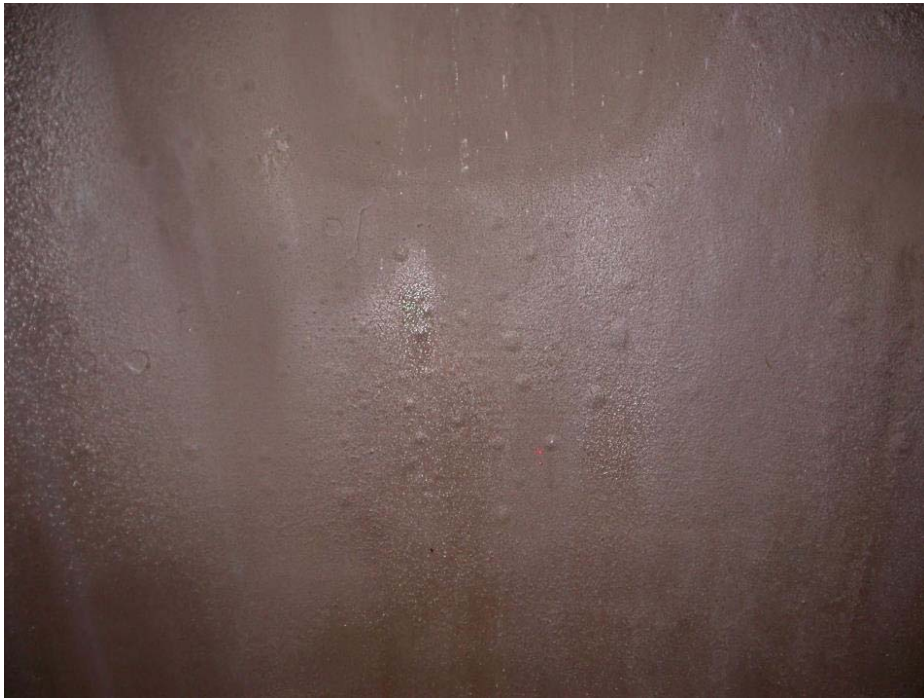
- Use TAPPI TIP 0402-32 for guidance
- No heat affected zone
- May require an extended shutdown
- Limited access while the coating is applied
- Denser, thinner coatings are more likely to blister and spall
- For large areas, thermal spray requires more maintenance than weld overlay



Protecting welds from Stress Corrosion Cracking



Blistering and Spalling in a Flash Tank



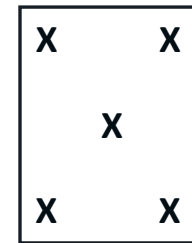
Corrosion Protection – Sheet Lining

- Use AMPP SP0292-2018-SG Installation of Thin Metallic Wallpaper Lining in Air Pollution Control and Other Process Equipment for guidance
- Limited experience though successfully used in the bleach plant
- Less welding
- Possible seam and plug weld cracking
- Use duplex stainless steel



Inspecting Behind Screens and Plates

- Blank plates do not require UT unless indicated by visual examination
- The shell behind screens and plates corrode at much lower rates than on open surfaces
- If corrosion rates are low, it is not necessary to check thickness behind every screen or plate that is open
- UT behind screens and blank plates when the opportunity arises. Take a condition-based approach to developing the scope.
- A 5-point UT grid is commonly used



Other Locations that Experience Thinning

- Internal header (2014 Busby, TAPPI PEERS)
- Doghouse
- Outlet device cone (stainless steel)
- Outlet device rake arm
- IV bottom head (stainless steel cladding/overlay)
- Flash tank



References

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