plastocor®, inc.

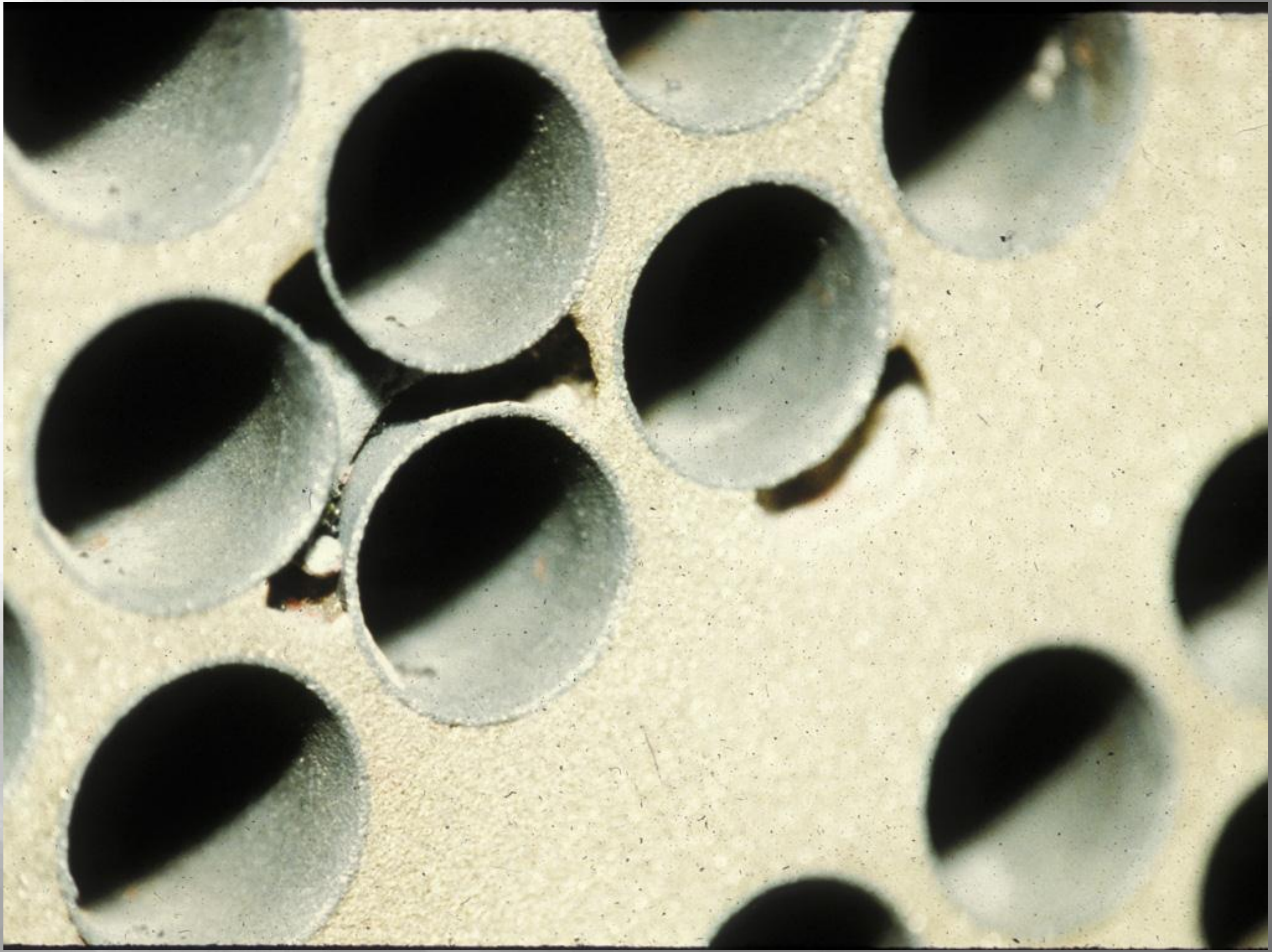
Western Regional Boiler Association

Specific Heat Exchanger/Condenser Applications

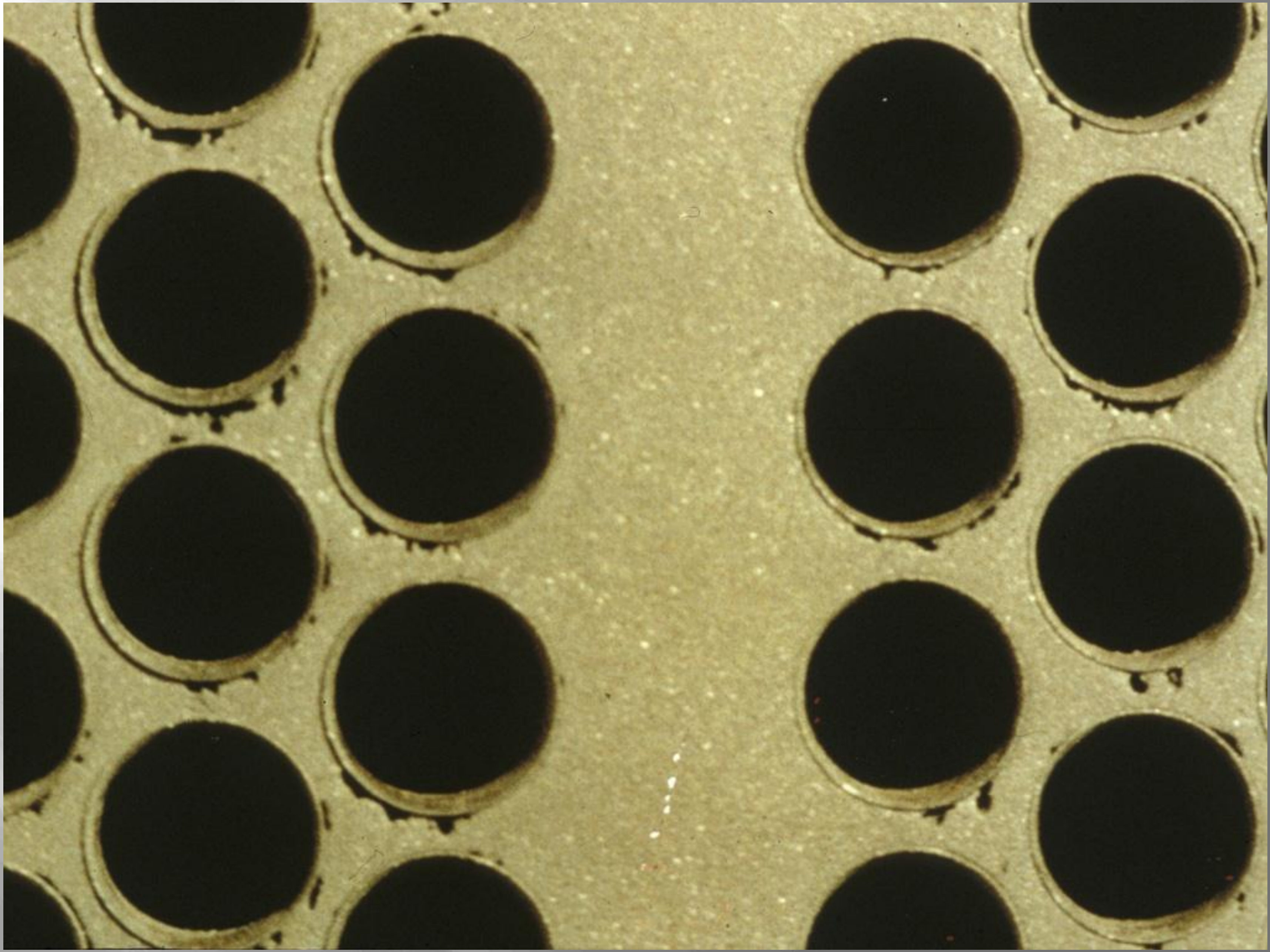
- Tubesheet coating
- Tube-end ID coating
- Full-length tube coating
- Channel Head/Waterbox coating
- Flange sealing
- Coating Service And Circulating Water Piping

Tubesheet Problems

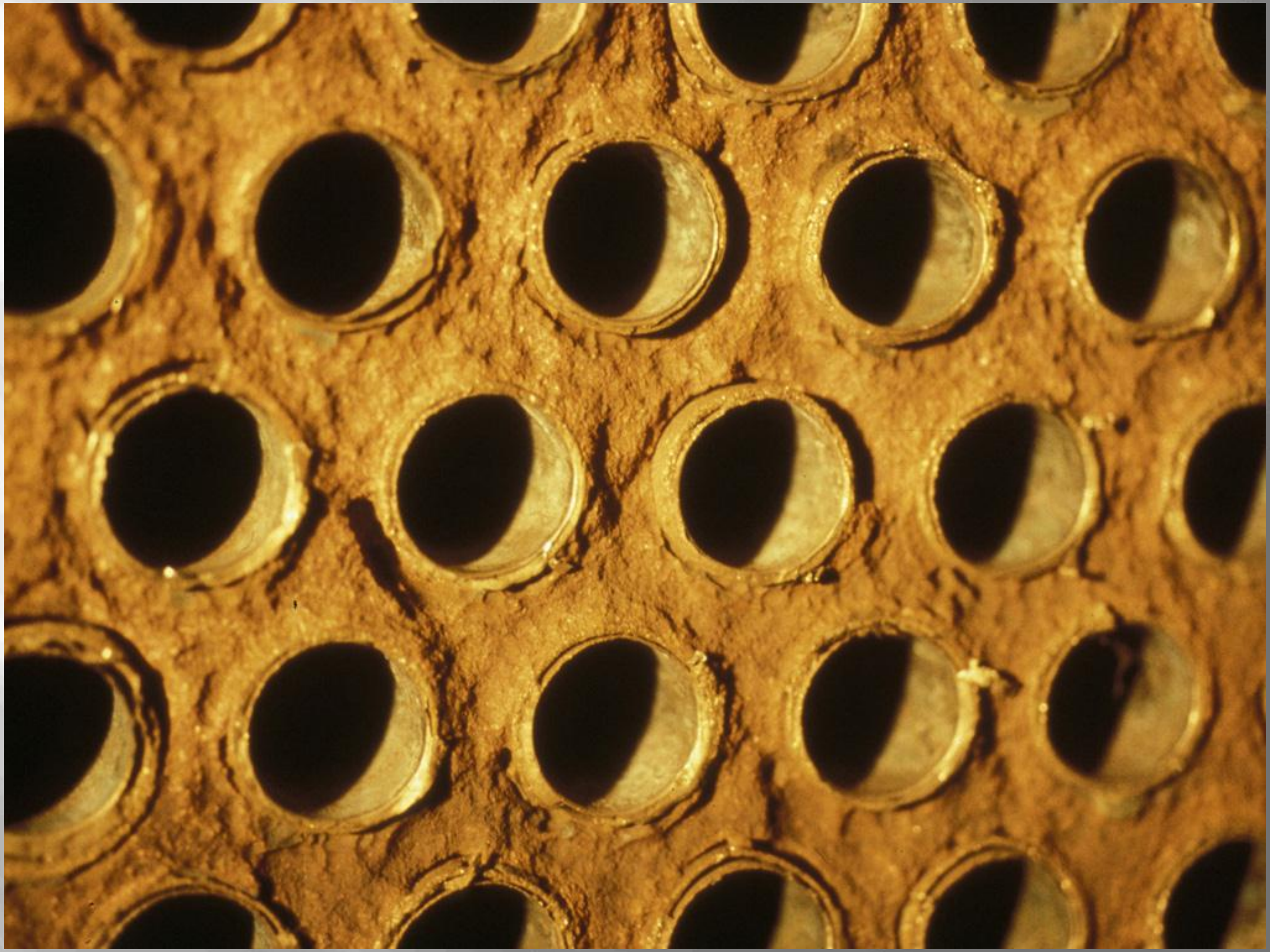
- Mechanical stress – may break the rolled tube joint
- Erosion/Corrosion – lost tubesheet metal
- Galvanic corrosion
- Dealloying
- MIC – (Microbiological Influenced Corrosion)



Aluminum bronze tubesheet with titanium tubes



Crevice Corrosion and MIC on Stainless Steel

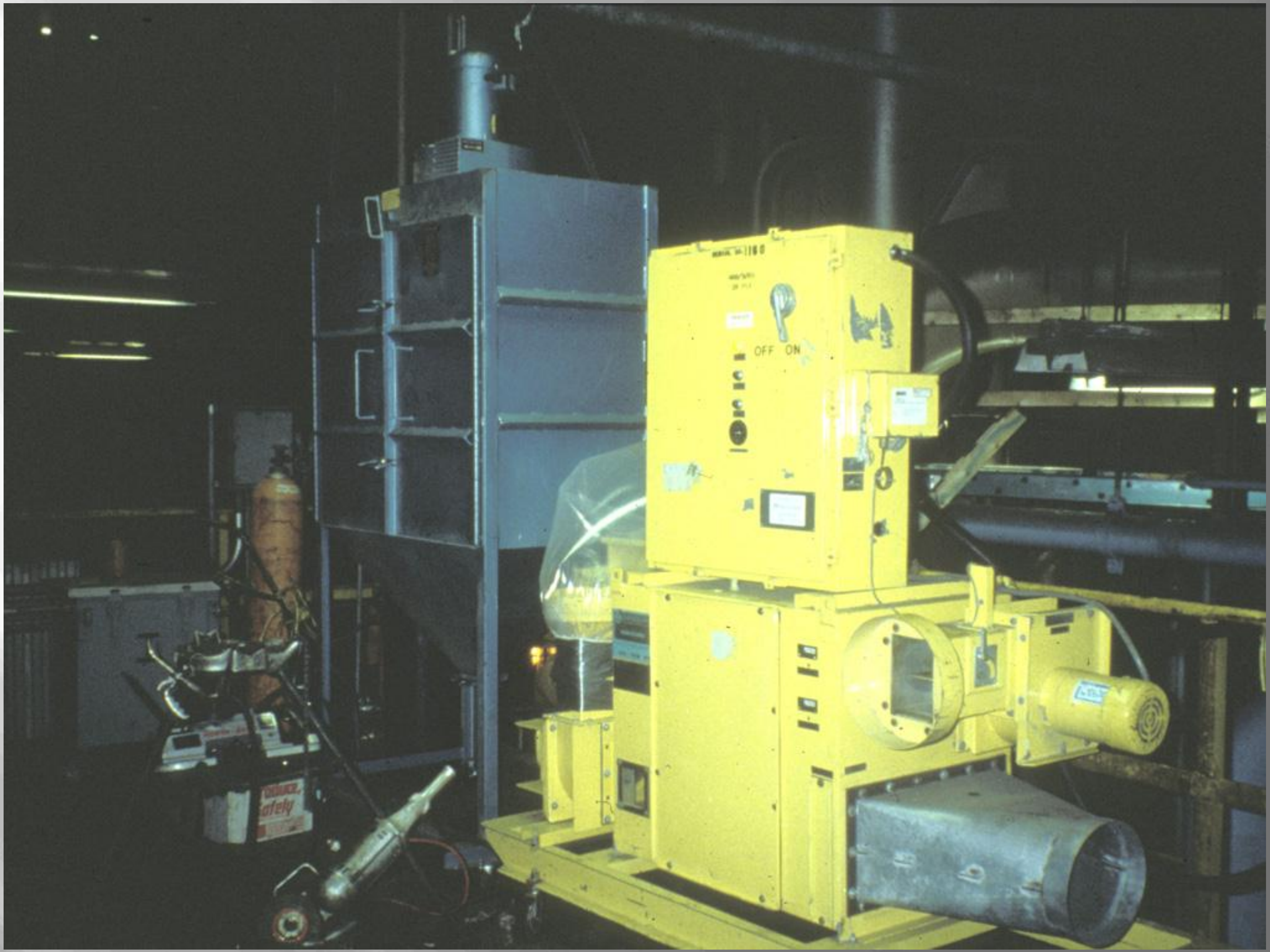


Galvanic attack and erosion of Muntz Metal Tubesheet

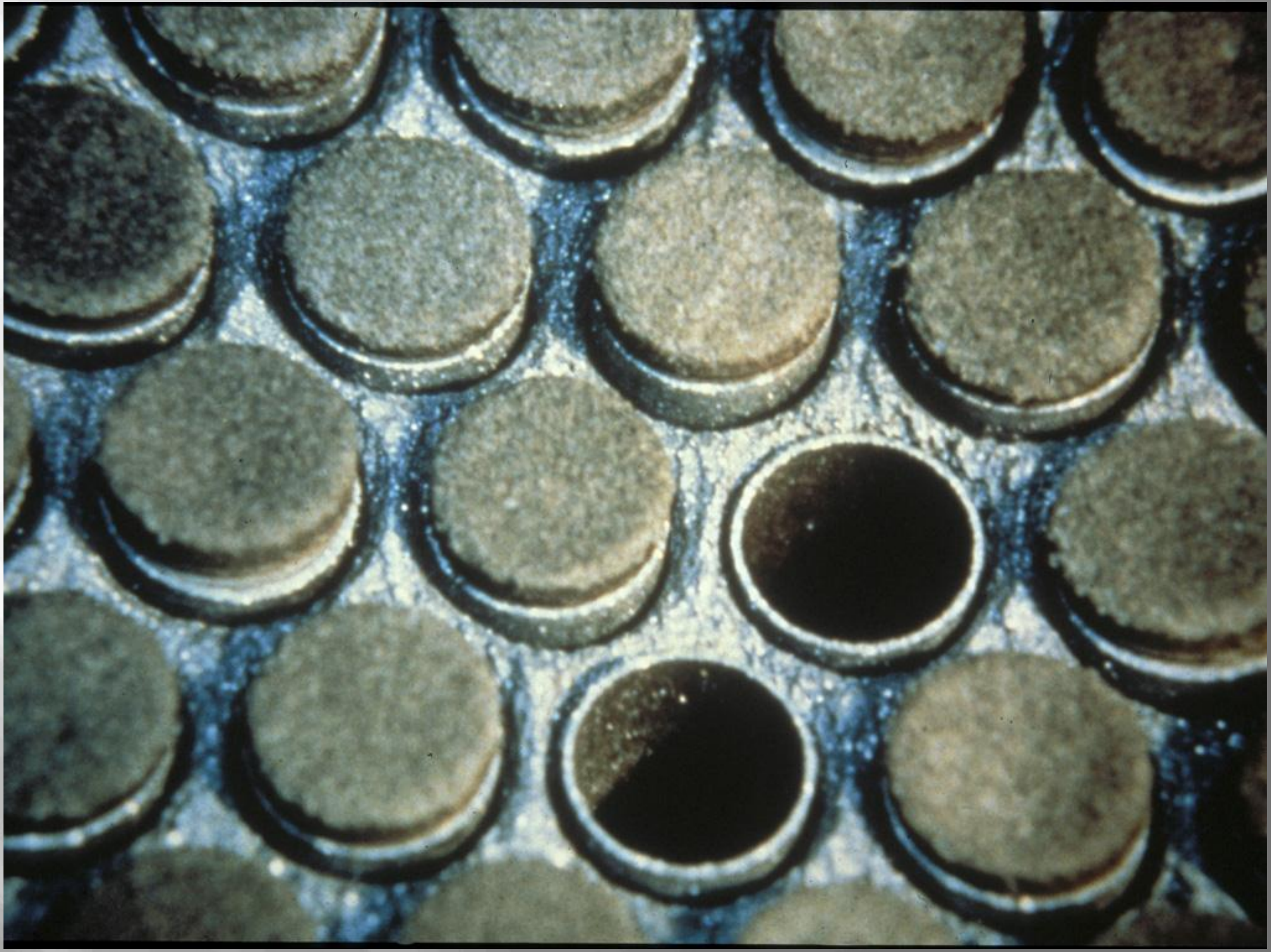
Galvanic Attack – Stainless Tubes with Carbon Steel Tubesheet

ultra high pressure cleaning to remove coatings and decontaminate surface

Crevice Corrosion and MIC on Stainless Steel



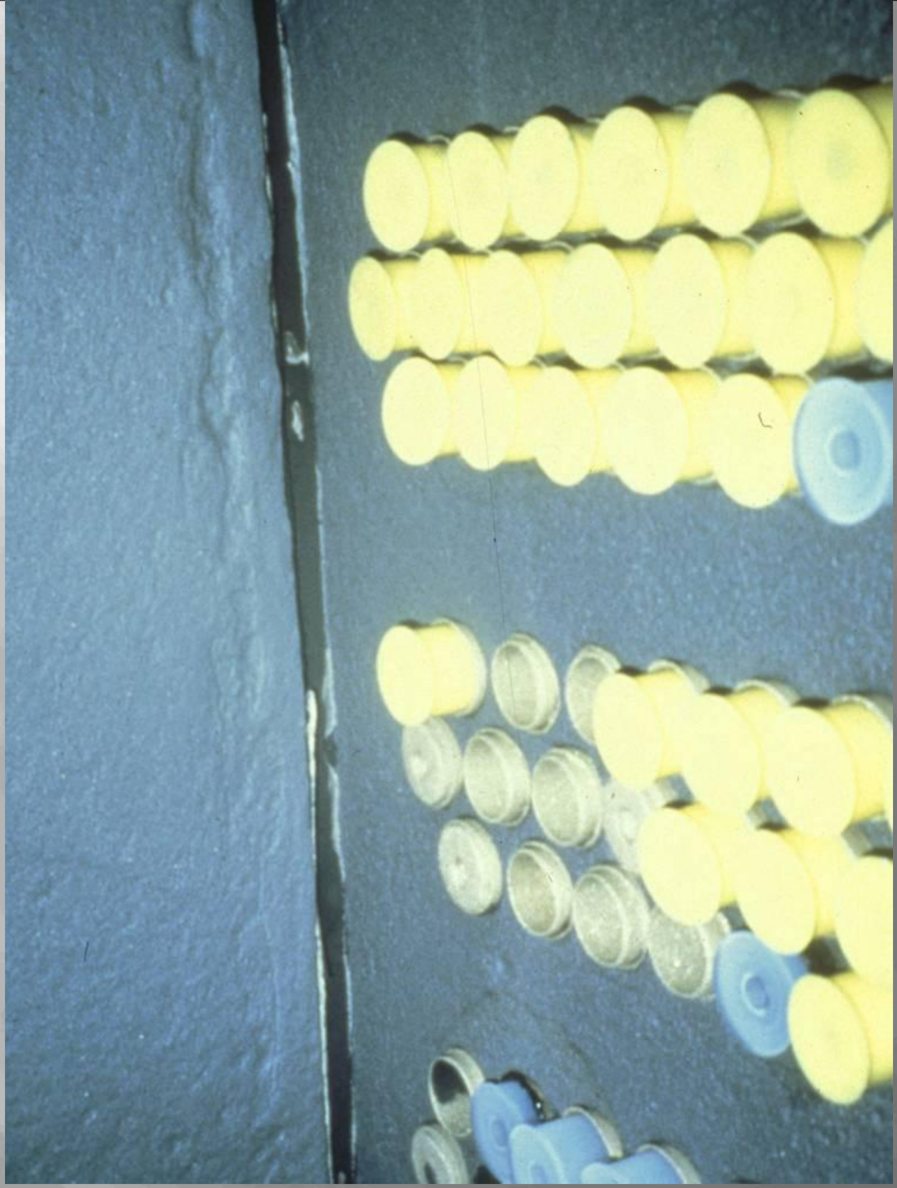
Environmental Control Equipment
- dehumidification, and dust collection -



Protective plugs installed – tubesheet abrasive blasted

Protective plugs removed

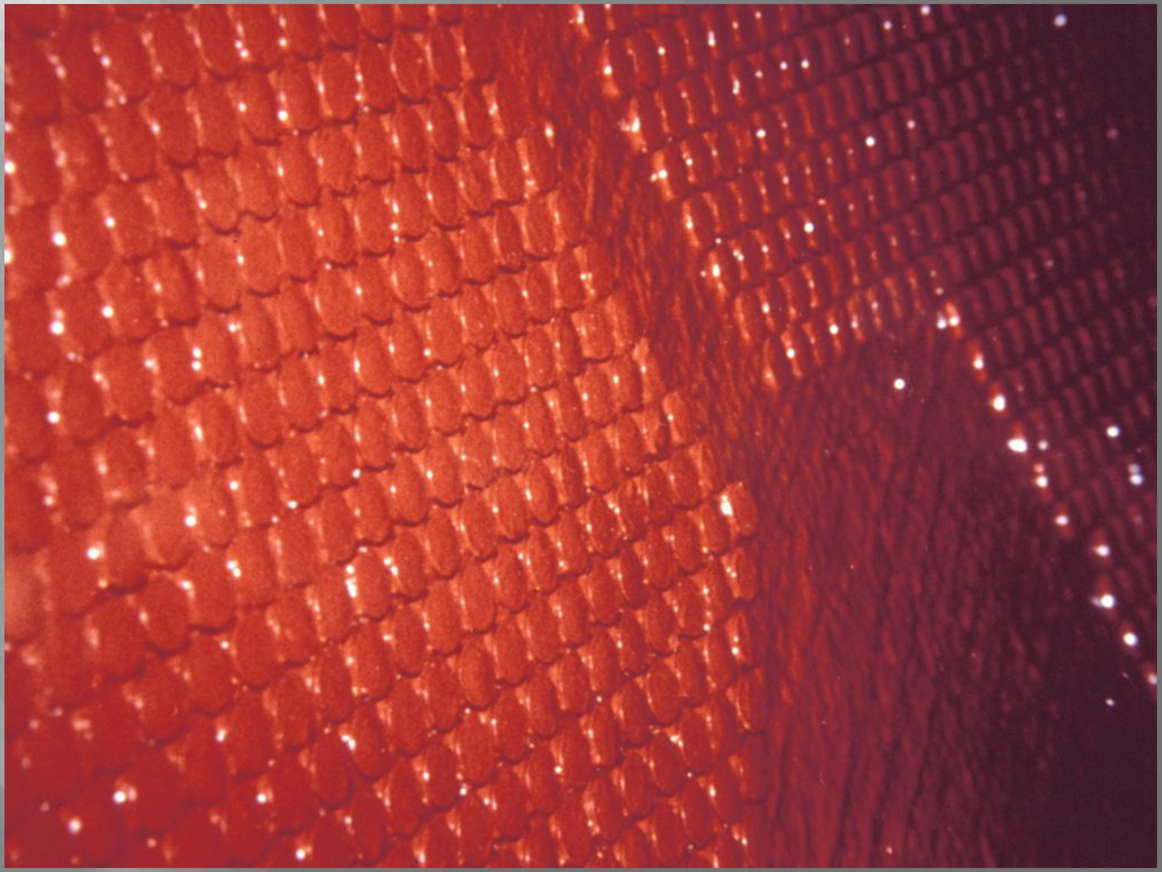
Coating plugs installed

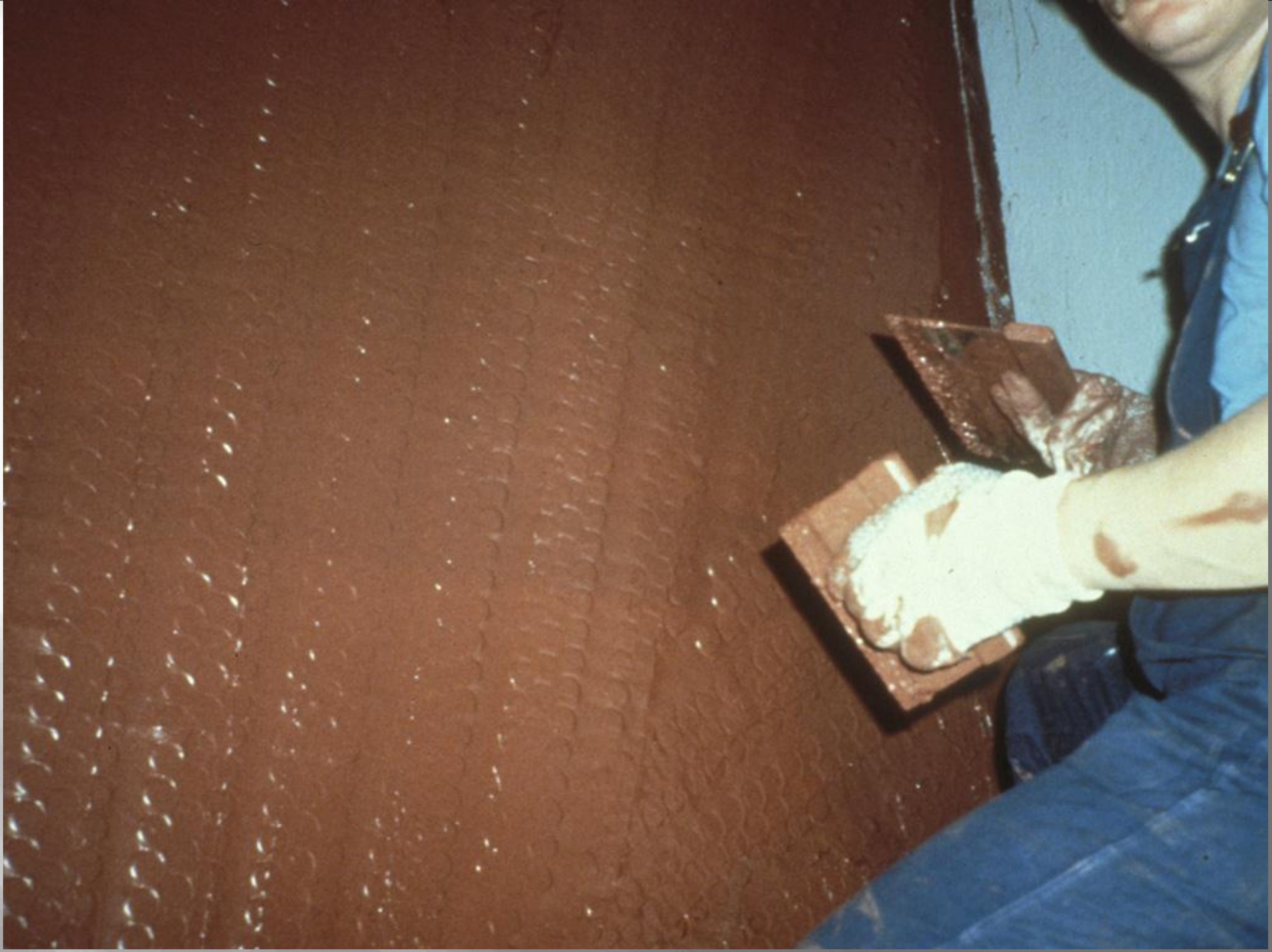


Many different sizes of plugs often required

Coating plug tops are leveled off – this determines
The thickness of the coating

First coat applied

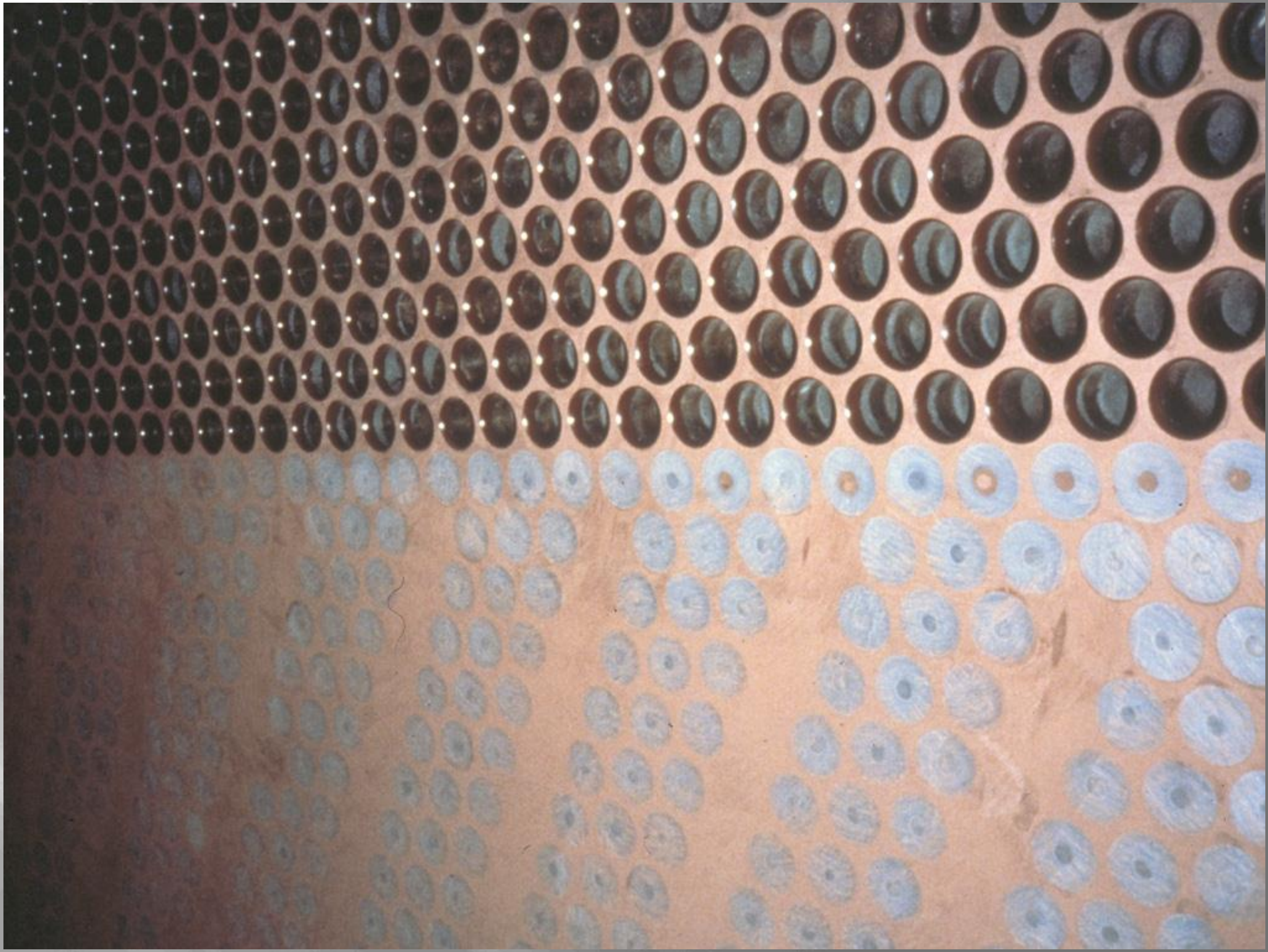


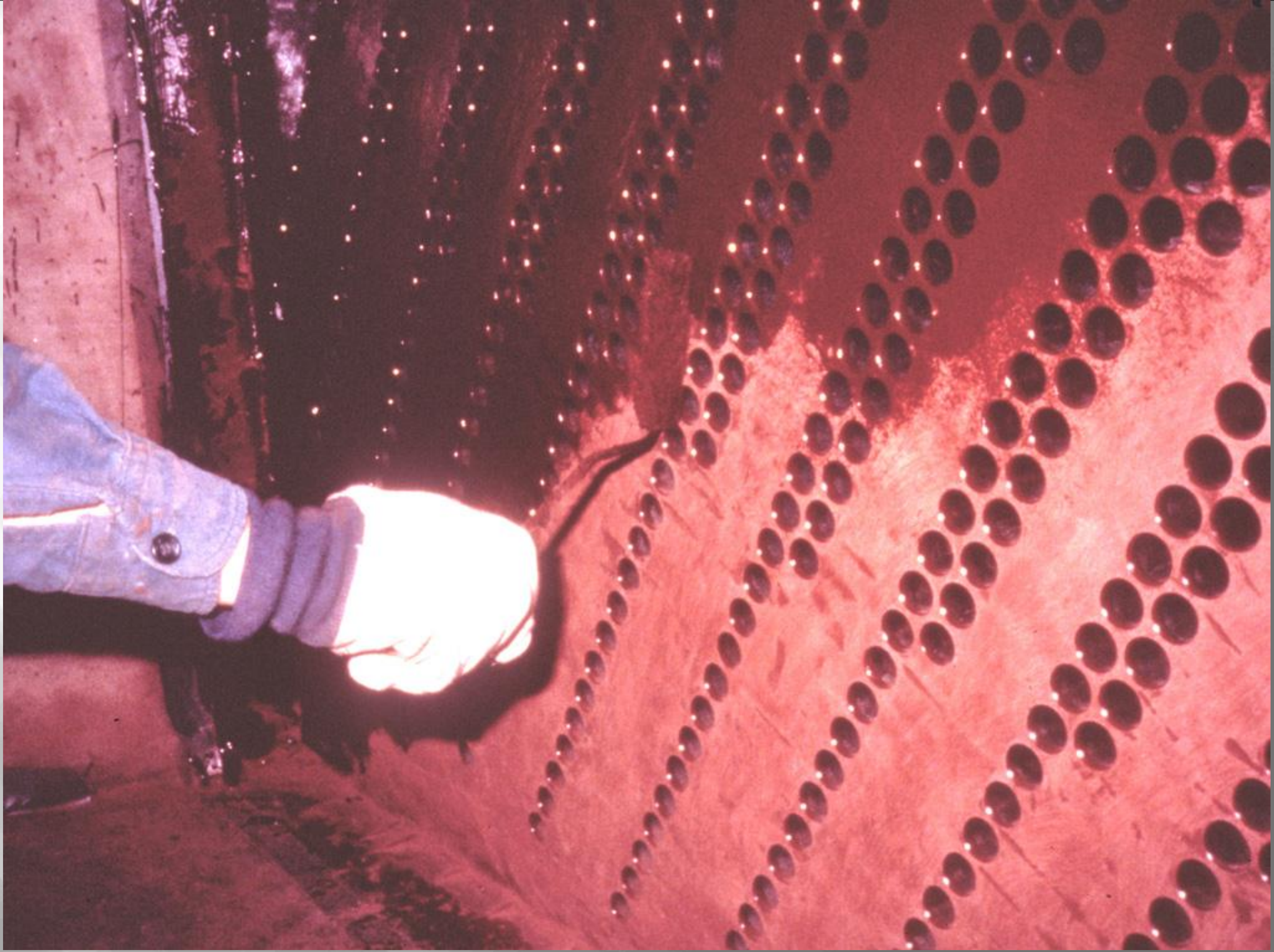


Second, “build coat” applied

Excess build coat sanded off to tops of coating plugs

Coating plugs are removed





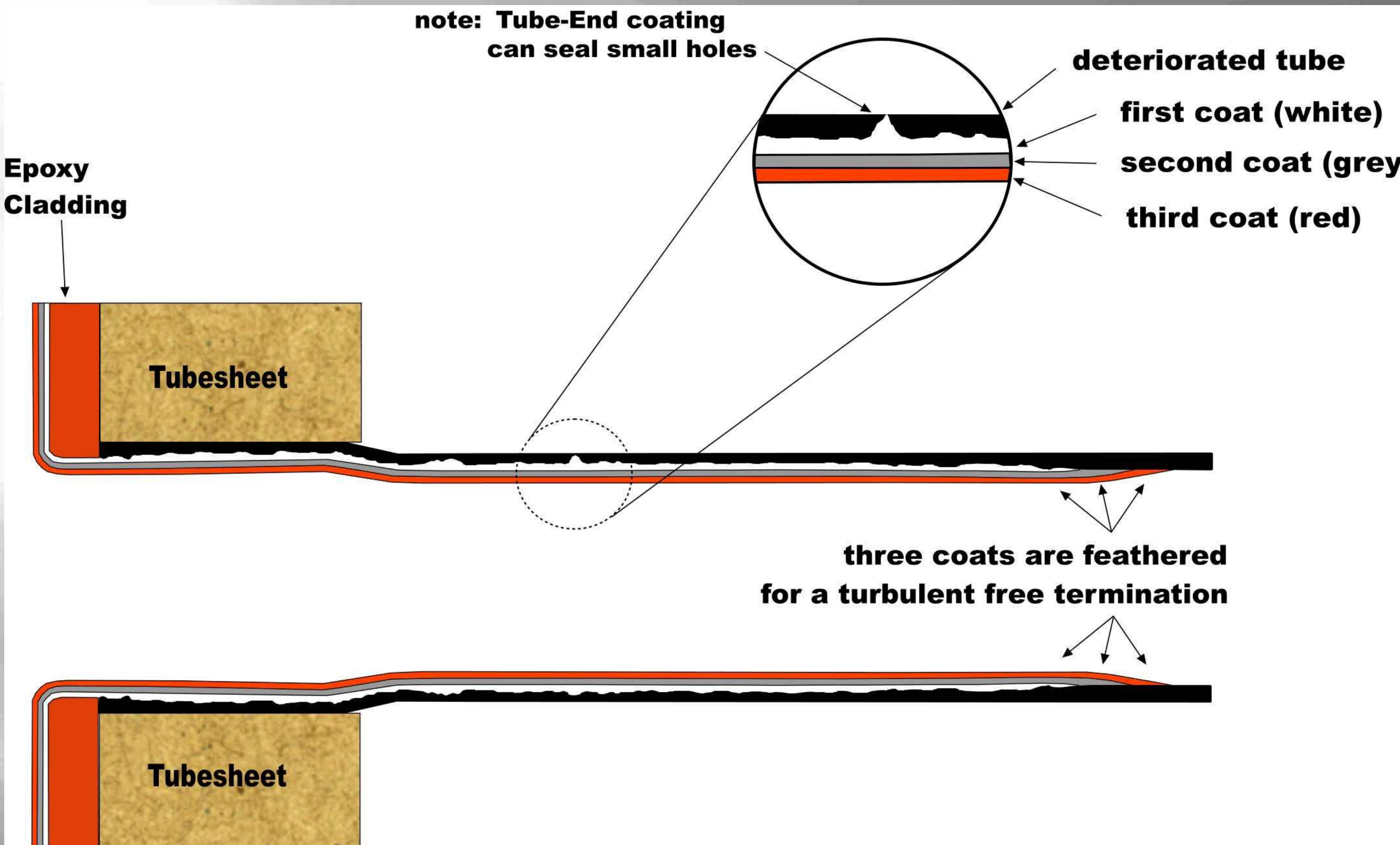
Top coat applied to fill in sanding marks

Tube-end Problems

- Erosion/Corrosion – lost tube metal
- Cathodic protection malfunction
- MIC – (Microbiological Influenced Corrosion)

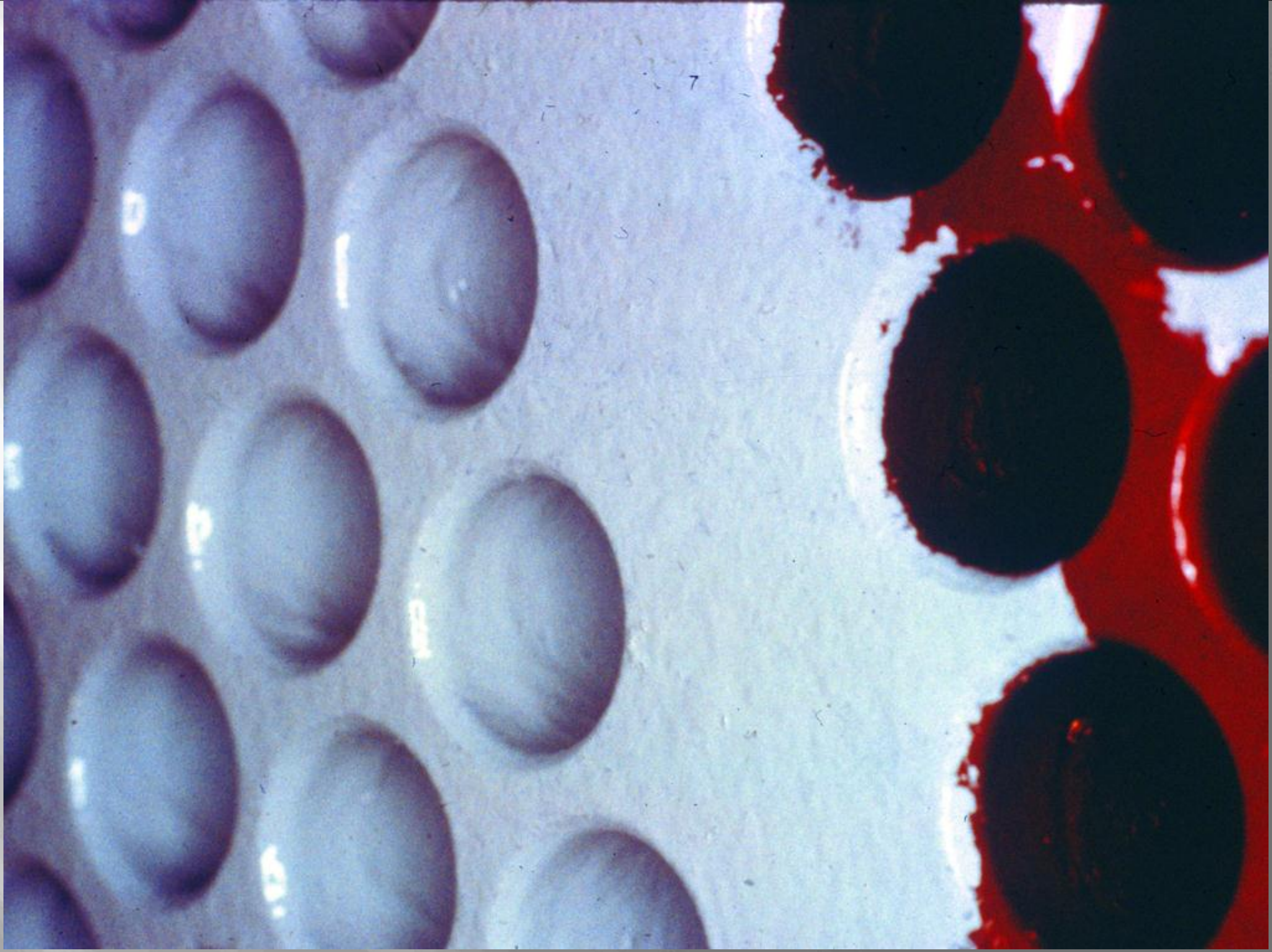
Inlet tube erosion on copper alloy tubes

Crevice Corrosion and MIC on Stainless Steel

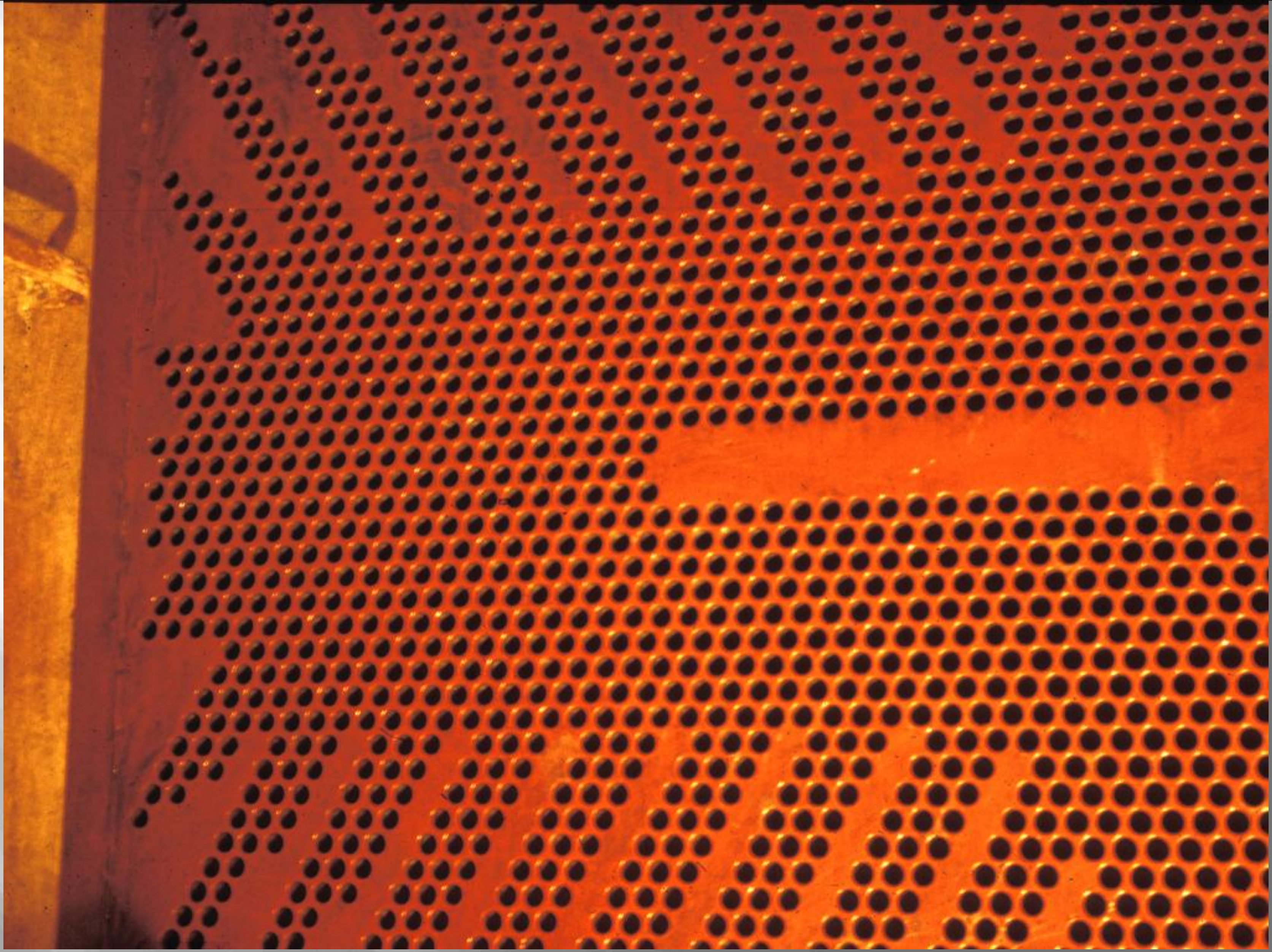


note: Tube-End coating
can seal small holes
deteriorated tube
first coat (white)
second coat (grey)
third coat (red)
Epoxy
Cladding
Tubesheet
three coats are feathered
for a turbulent free termination
Tubesheet

If required, tube-end coating is applied

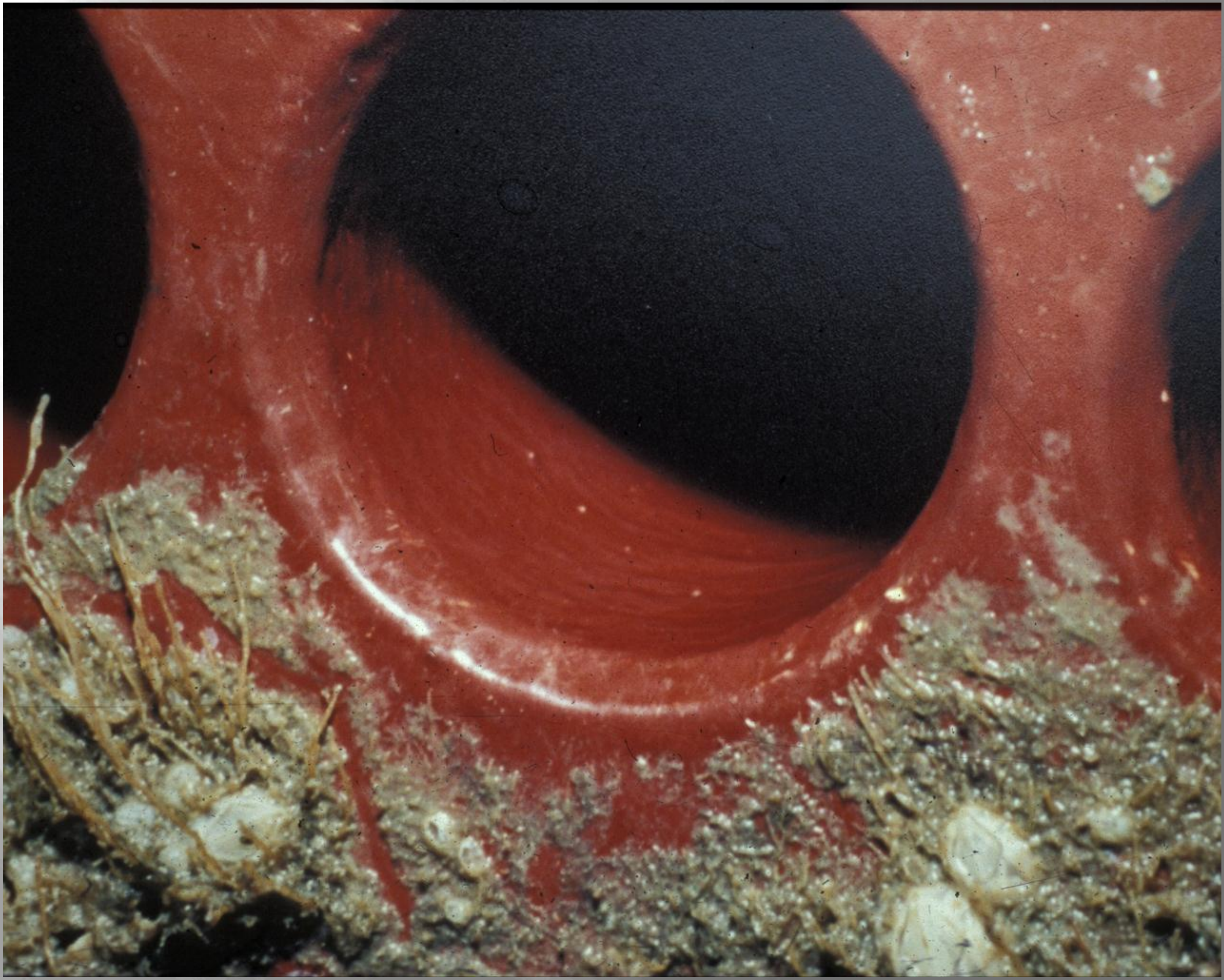


Second tube-end coat applied



Final Product

Microbiological Corrosion (MIC) on Stainless



Full-Length Tube Problems

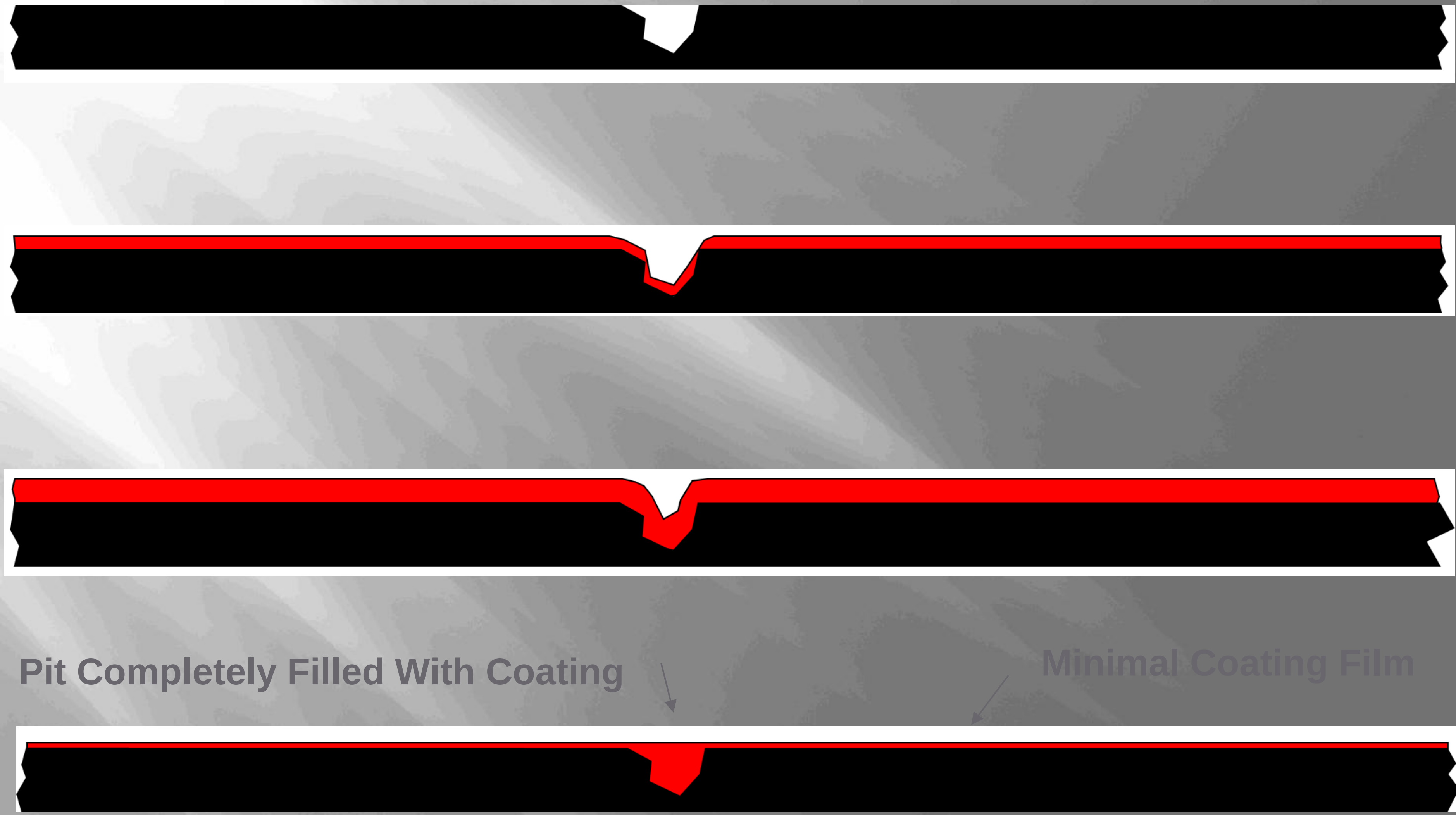
- General thinning
- Pitting
  - Under deposit corrosion
  - Crevice corrosion
  - MIC

Objectives for Tube Coatings

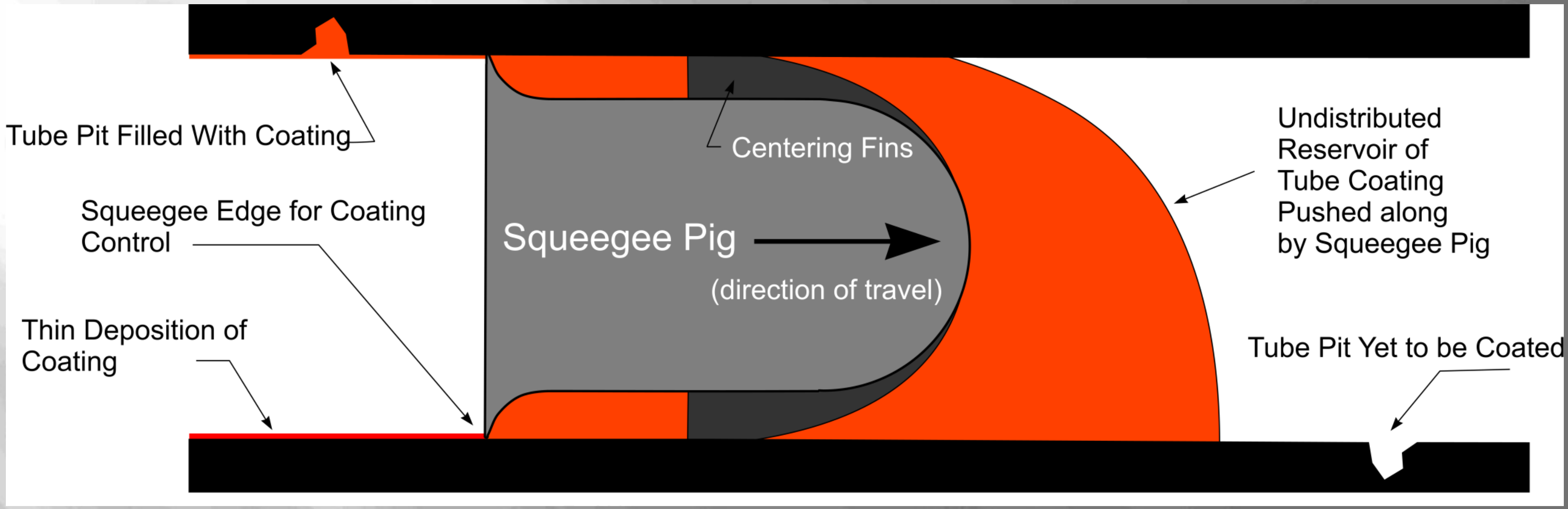
- Apply a protective film in ONE coat (although additional coats can be applied)

  Have that protective film (coating) be of sufficient thickness to protect the full length/whole tube interior (ID)

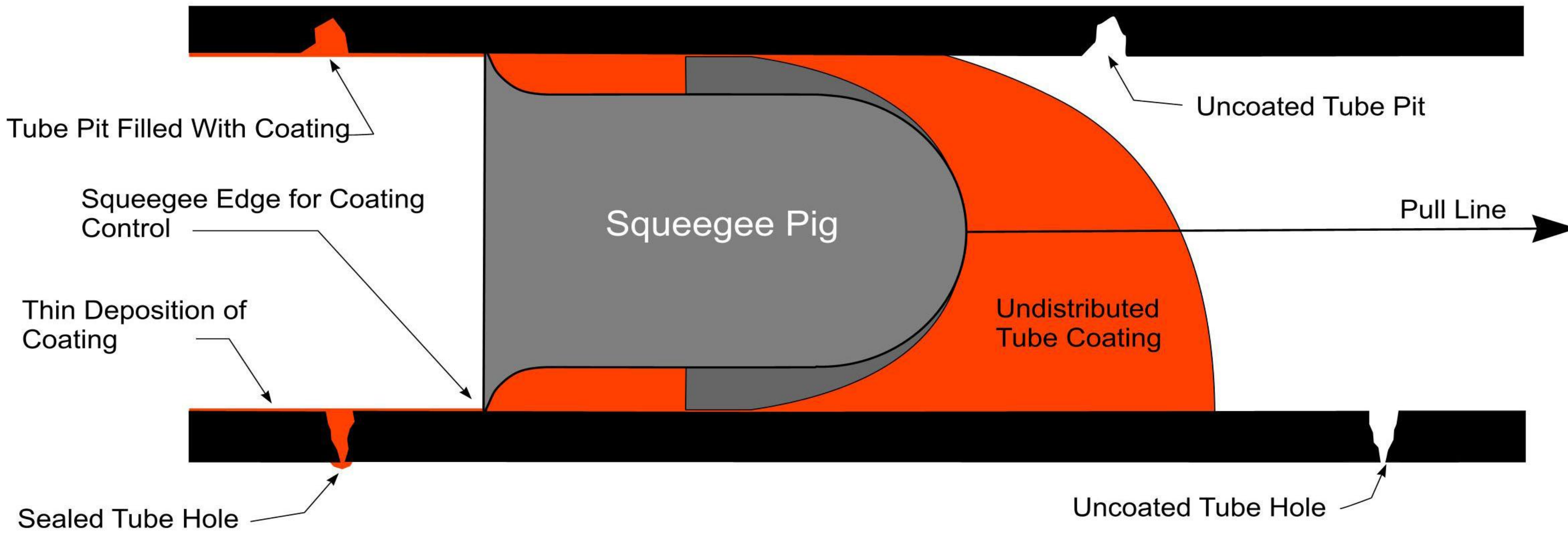
- While being applied at a minimal coating thickness of .25 mils to tube ID's so as to limit heat transfer loss in areas of no tube metal loss


Pit Completely Filled With Coating
Minimal Coating Film

Sealing pits



Sealing Holes



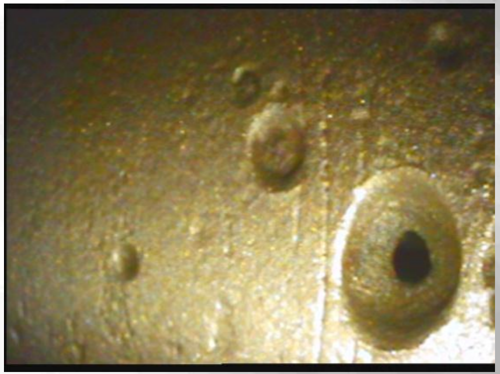
Tube Coating Specifics

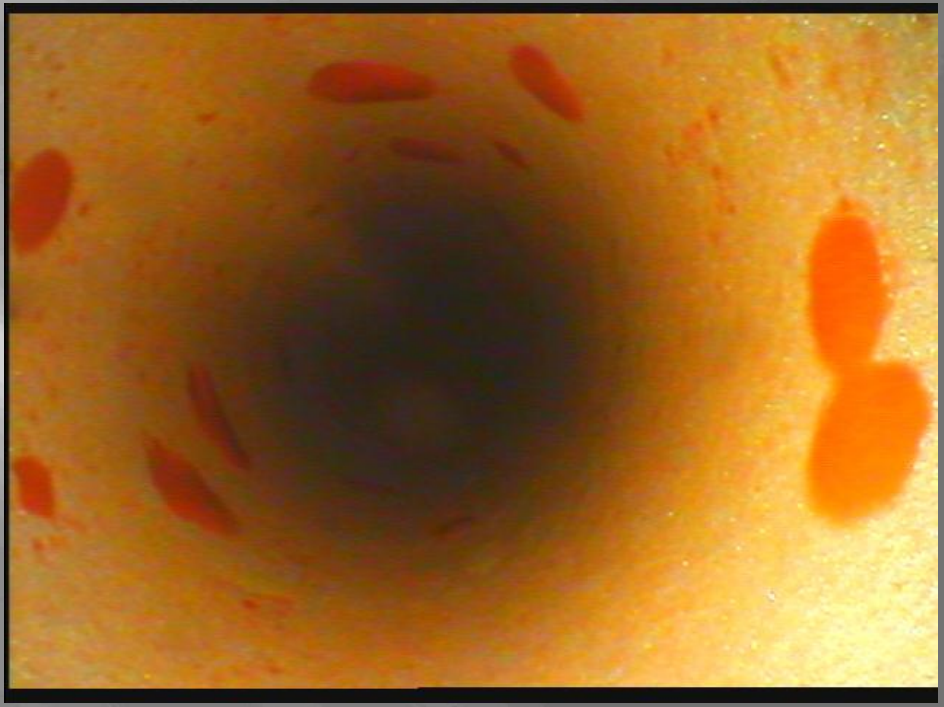
- Cleaning the tube
  - Rough cleaning
  - Decontamination
  - Final cleaning

- Coating the tube
  - Patented "squeegee pig"
  - Pits completely filled
  - Coating thickness < 1 mil

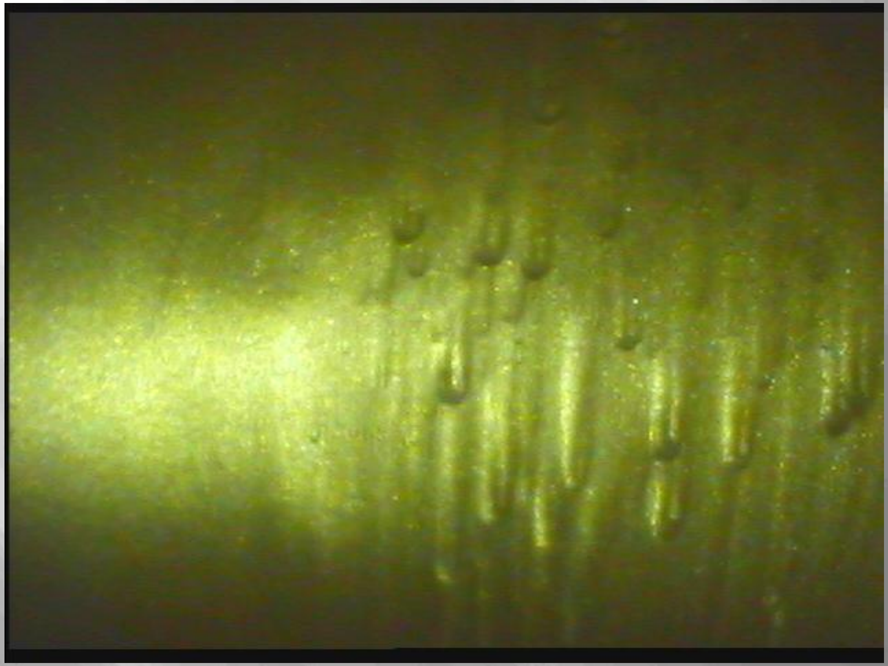
Before and After

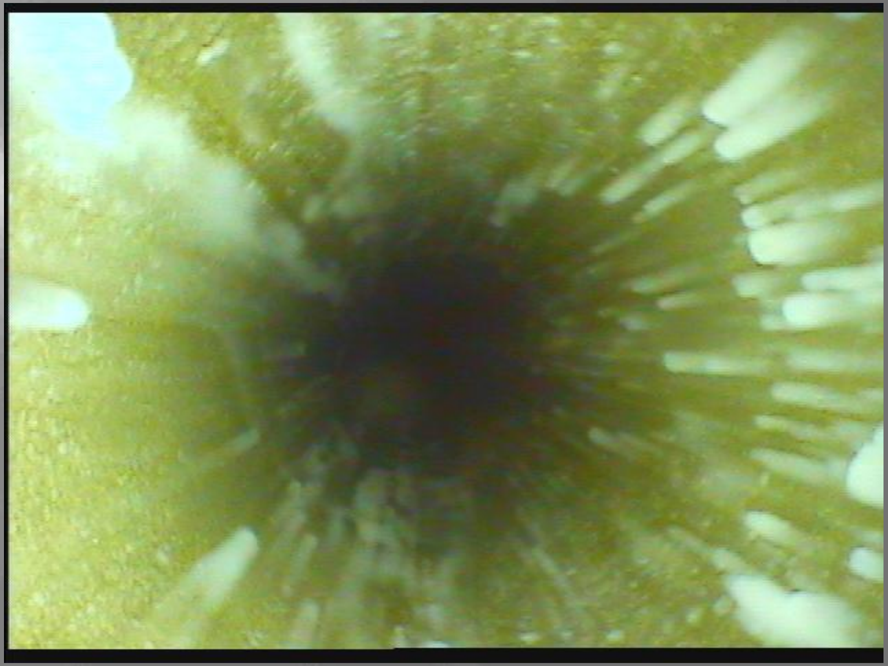
Hydrogen Cooler holes and pits





Before and After





Characteristics of the Tube Coating

- 100% solids
- Low viscosity
- Durable
- Thermal Conductivity
- Anti-fouling

Recent Case Studies

A Bridge to a Retube

Copper Stopper

Do or Die

Case 1: A Bridge to a Retube

- Spring 2006 - 620 Mw Unit - Brackish Water
- 11,000, 316 SS tubes – 1″ OD 22 BWG (1972)
- Rapidly accelerating tube failure rate
  - Manganese scale, chloride pitting and MIC
- 18% of tubes were plugged
- Load reductions
- Increased polishing
- Leak sealing media in cooling water

Initial Response

- 100% eddy current testing
- Preventative plugging

Results:

- 11 % leaking
- 11 % Marginal

- End result would have been:
  - 40% of the Tubes Plugged

Action Taken

- Pulled 3 tubes thru manway and coated
- Applied one coat to 4,800 -- 60′ tubes
- Approximately 2,000 known to have holes
- Performed a condenser hydro 37 Coated tubes found to be leaking and were plugged

Results

- Unit operated successfully for the 2006 Summer Run
  - Operated above bogey backpressure due to previously plugged tubes
  - This was acceptable as no forced derates or outages were experienced.
- Unit continued to operate successfully until a scheduled outage in Spring 2007

Case 2: Copper Stopper

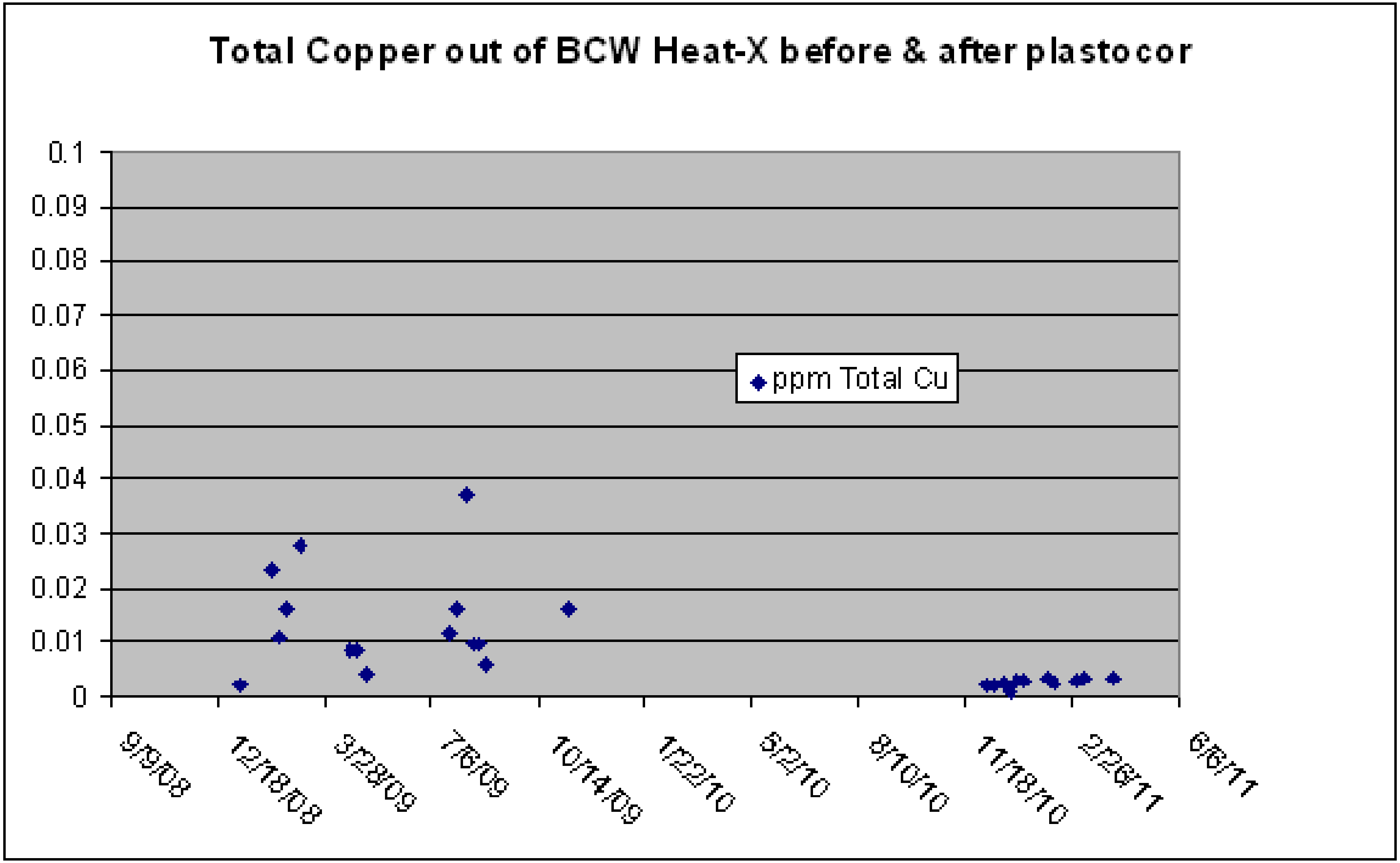
- 500 Mw unit on Lake Michigan
- Admiralty tubes
- In 2006 future NPDES permitting mandated a reduction in copper discharge from 100 ppm to 12 ppm by 2011

Actions Taken

- Retubed the condenser with 304 SS
- Still had not met goal of 12 ppm
- Coated the tubes of two Bearing Cooling Water Heat Exchangers
  - 1,600 Admiralty tubes, 20′ long

Results

(graph courtesy of NIPSCO)



Case 3: Do or Die

- 177 Mw – natural gas fired plant
- Commissioned in 1958
- 10, 264 tubes – retubed in ‘70s
  - 7,288 x 18 BWG Admiralty
  - 2,976 x 22 BWG SS
  - 7/8” OD x 30’ long

Case 3: Do or Die

- Around 2002 with natural gas prices deemed uncompetitive
- Decision made to allow plant to “Run to Fail”
- Condenser Tubes Deteriorated
- Boiler Tubes Deteriorated

Case 3: Do or Die

- Fast Forward to 2011
- Gas prices hit historic lows
- Decision made to reverse course
  - began boiler repair program
  - condenser condition uncertain
  - limited budget

Case 3: Do or Die

- Spring 2012
- Pressurized the condenser shell
- Dislodged fouling and corrosion products from tube holes
- 28% of the tubes plugged
- Condition of remaining tubes uncertain
- Successful 2012 summer run doubtful

Case 3: Do or Die

- Retire Unit ?

- Re-tube condenser ?

  June 4, 2012 – Unit off-line

  July 4, 2012 – Unit on-line

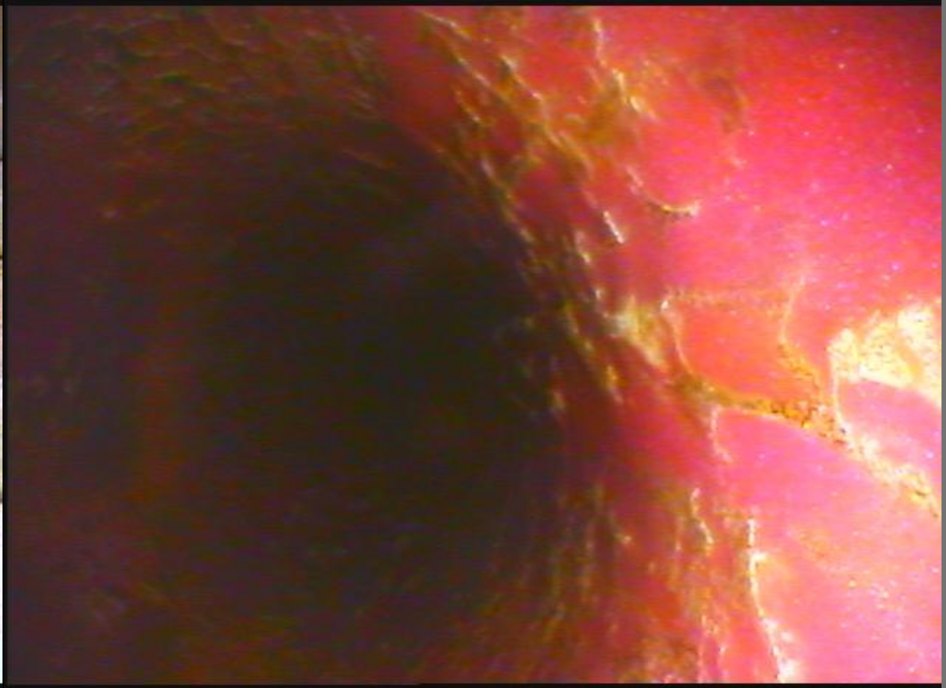
- Coat / recover tubes ?

  Waterboxes On (not removed)

Case 3: Do or Die

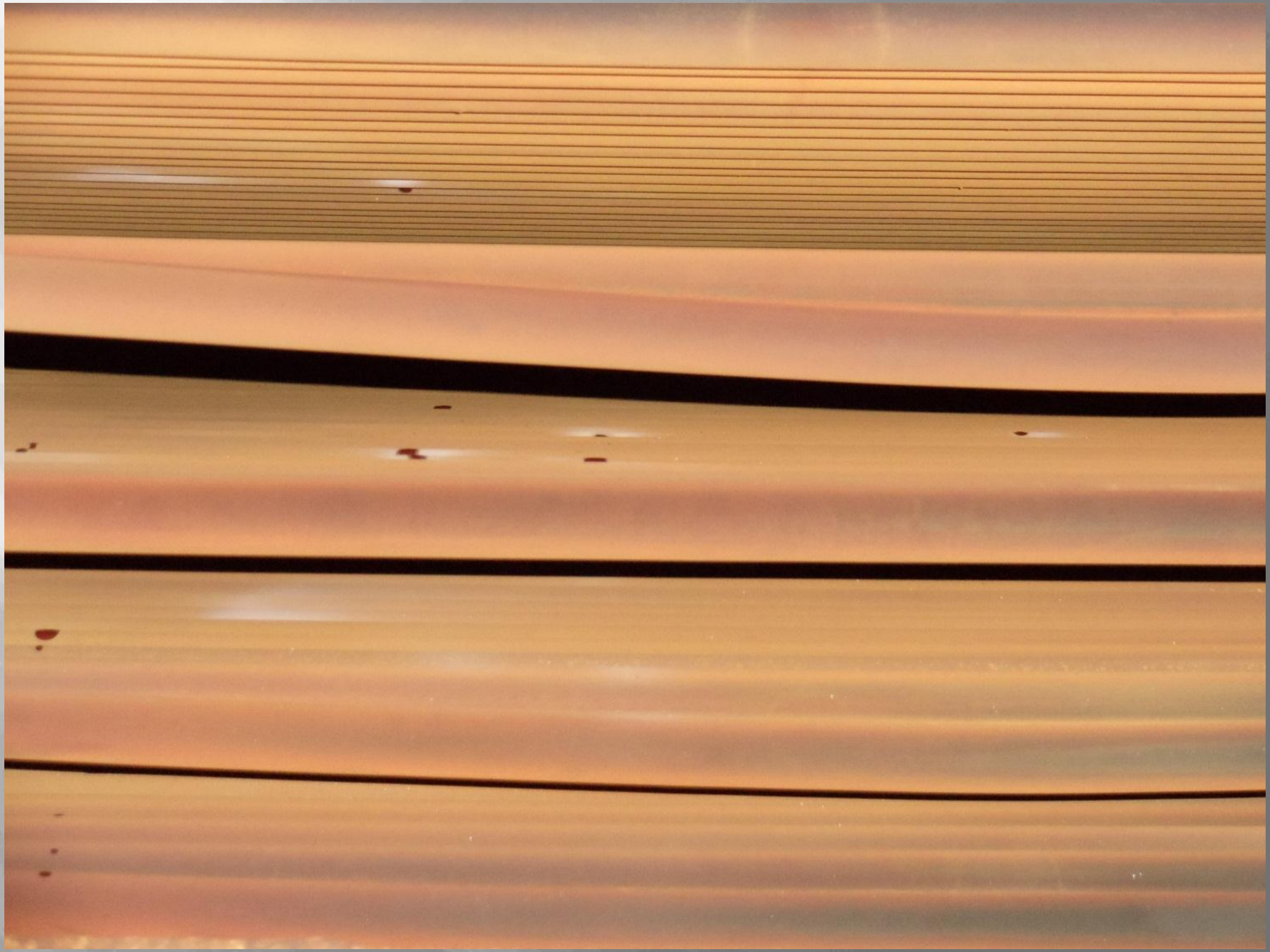
- Un-Plugged 1,150 brass tubes
- Coated 5,564 brass tubes
- 10 day project duration
- Hydro -- 55 brass tubes still leaking and were re-plugged
- Unit has run reliably with NO heat rate issues

Case 3 – Do or Die



Case 3 – Do or Die

epoxy “dots” on tube OD showing repaired holes



Elements of Quality

- challenges to a consistent outcome -

- Coating application is a sequential process
- Due DILIGENCE each step
- More similar to a manufacturing process than construction process
- Bring shop level conditions to the field

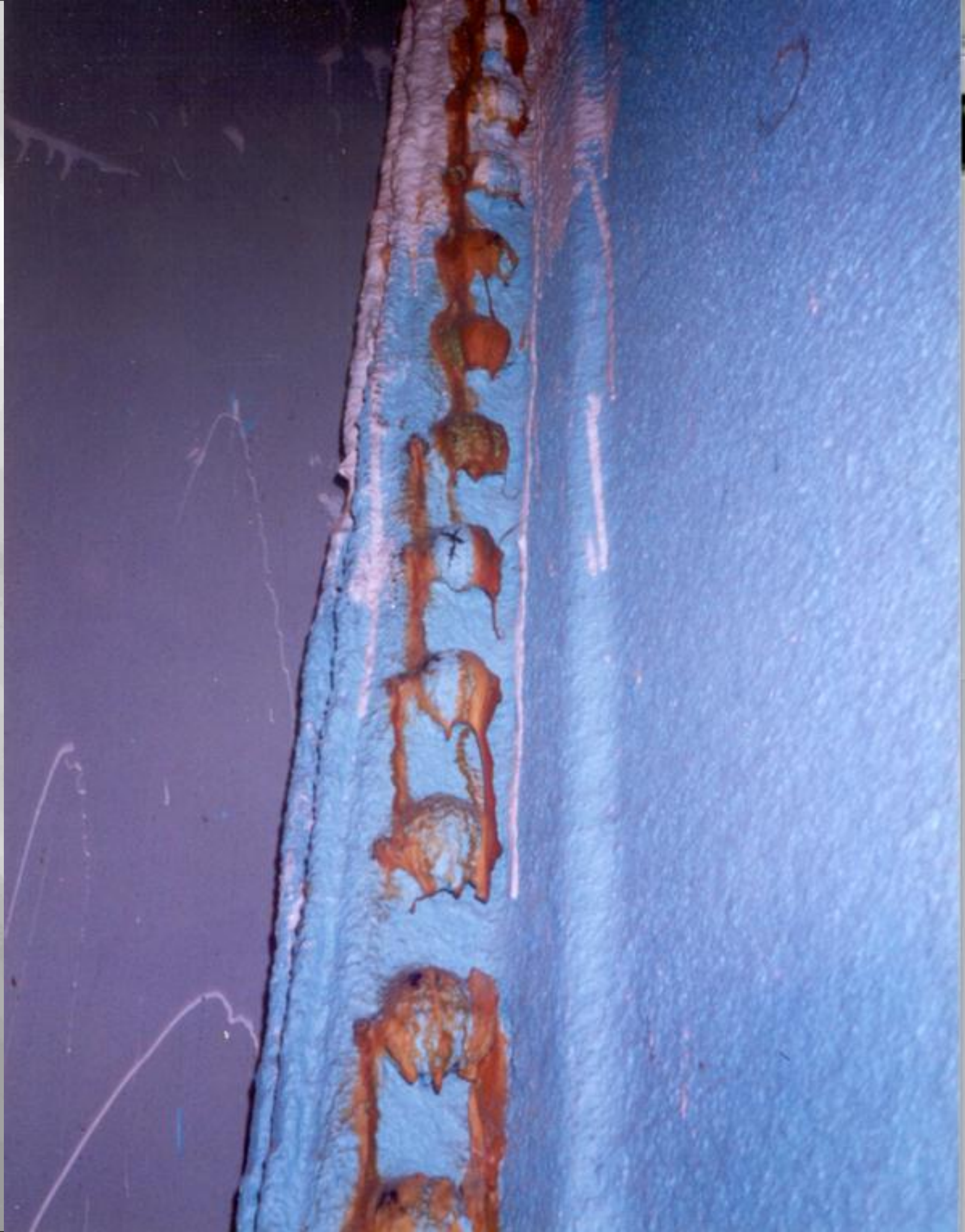
- MATERIALS + METHODS + MANPOWER = SUCCESS

Waterbox and Channel Heads

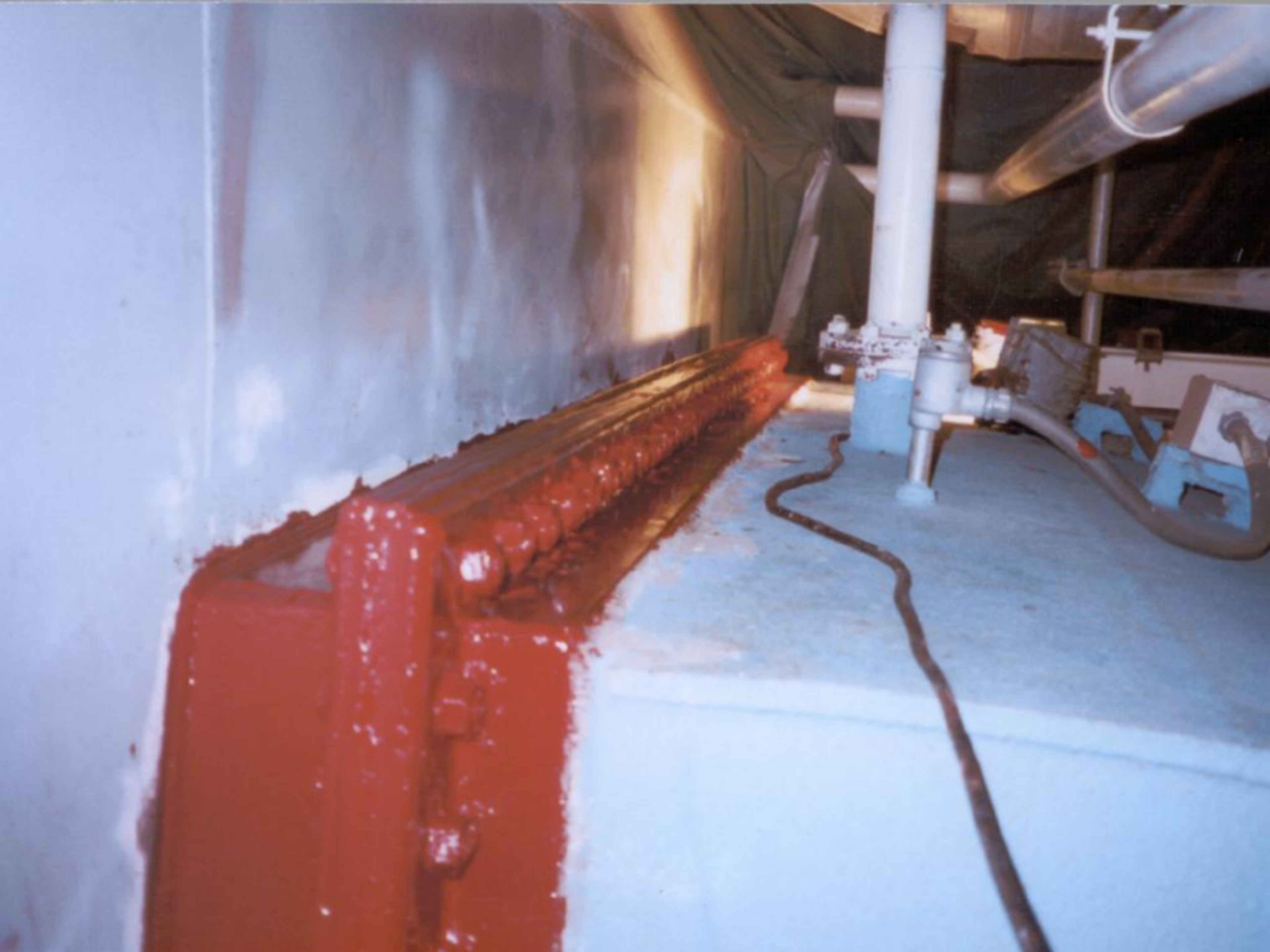
- Coatings protect surfaces and can help with fouling control
- Thickness of coating determines longevity and ability to withstand abuse

Flange Sealing

- Stops Air Inleakage
- Stops raw water Inleakage around bolts and gaskets




3B



Equipment Package

UPS