



# Exchanger Diaphragm Retrofit Welding and Inspection Challenges

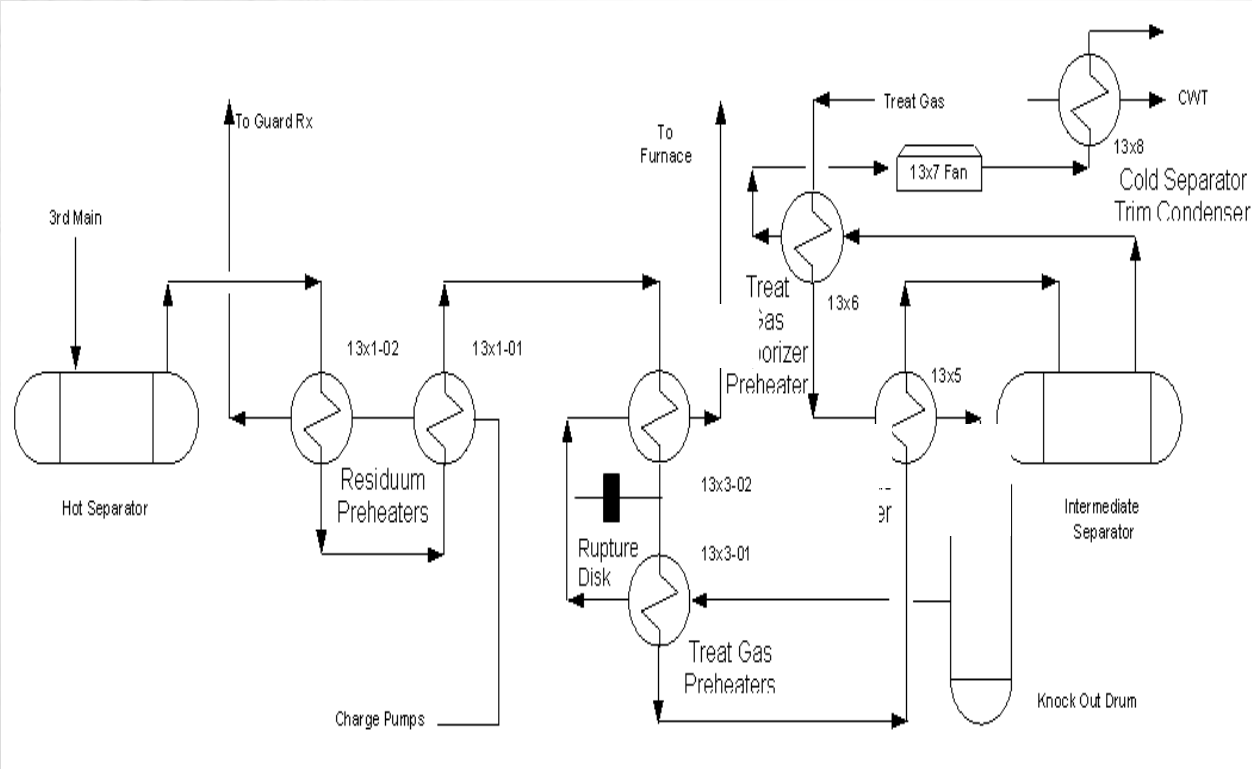
James R. “Chezo” Cesarini, PE | Managing Partner | Pro-Surve Technical Services



# Bio Slide

- James Cesarini aka “Chezo”
- Managing Partner
- Pro-Surve Technical Services, LLC. / ProSource Radiography Services, LLC. / ProForce Industrial, LLC
- 38 years in Engineering, Reliability, Inspection, Testing, Process Safety Management
- Field of Expertise: Pressure Vessel Design, Innovative Maintenance Solutions, Closed Loop Workflow, PSM Mechanical Integrity Practices
- Industry Involvement/Recognition: Steadfast Volunteer for API, ASNT, and ASME, Registered Professional Engineer, Industry Achiever, 2009

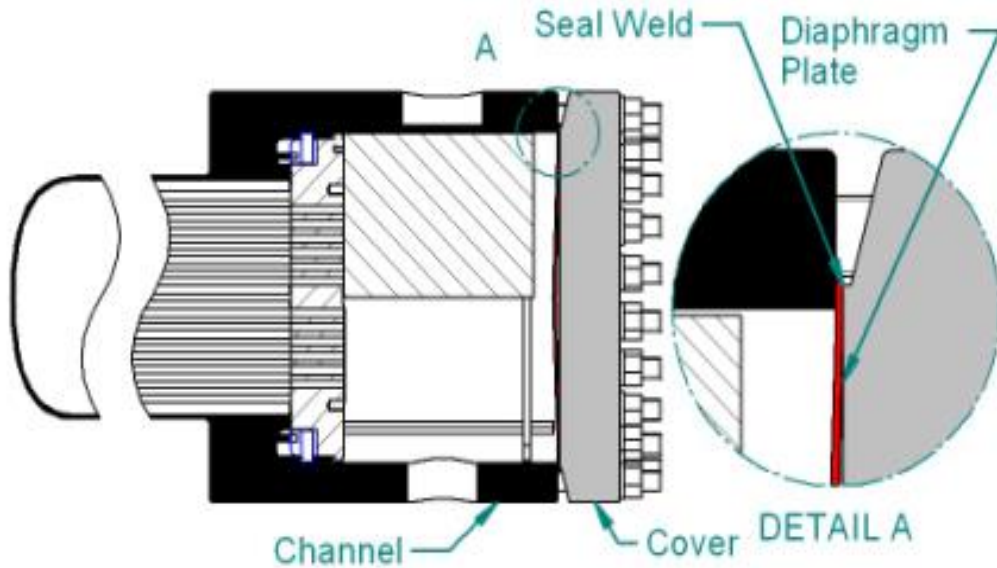
# Locations & Concentrations



## Typical Processes

- **Hydrotreaters**
  - Gas Oil
  - Diesel
  - Gasoline
- **Heavy Oil Crackers**
- **Residfiners**
- **Other –**
  - High Pressure
  - Hydrogen induced

# Criticality



- Hydrogen service
- Heavy Walled Exchanger
- No Gasket Utilized
- Thin Welded Diaphragm Plate
- Small, Thin Seal Weld
- Chrome Material
- Stainless Corrosion Liner
- Several Exchangers in Series
- No Block Valves In Between Equipment

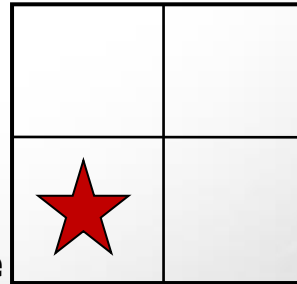
# Historical Bad Actors

## Cracking of the Diaphragm Seal Weld



- Recognizable
- Annoying
- Costly
- Repeating - more than once to get classified as “bad”
- Insanity Rule - just won't seem to go away

**Paddle**

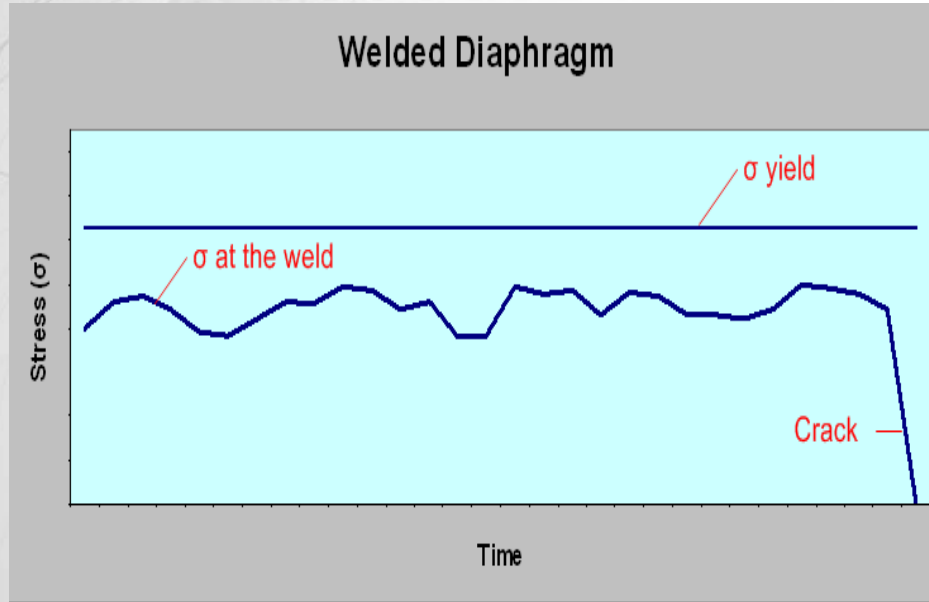


**No Paddle**

**Up Creek**

**Down Creek**

# Why Cracks Occur

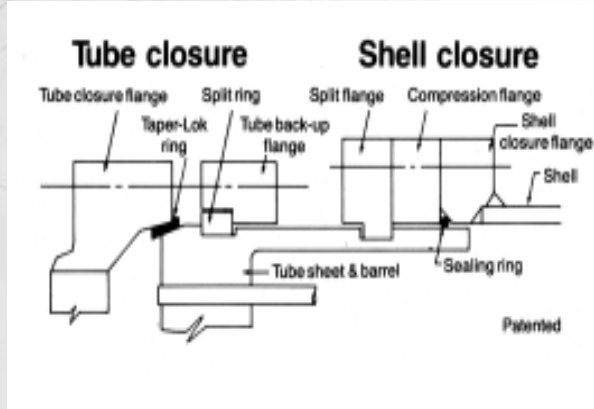


- Tensile overload - thermal expansion of low alloy channel (carbon or Cr-Mo) and the SS diaphragm.
- Chloride Stress Corrosion Cracking (SCC) – Salt dropouts in effluent exchangers is ammonium chloride.
- High residual stress
- Crevice between the diaphragm and channel contain concentrated Chlorides
- Polythionic Acid Stress Corrosion Cracking –formed during shutdowns



# Similar Situation & Service

## Industrial Applications



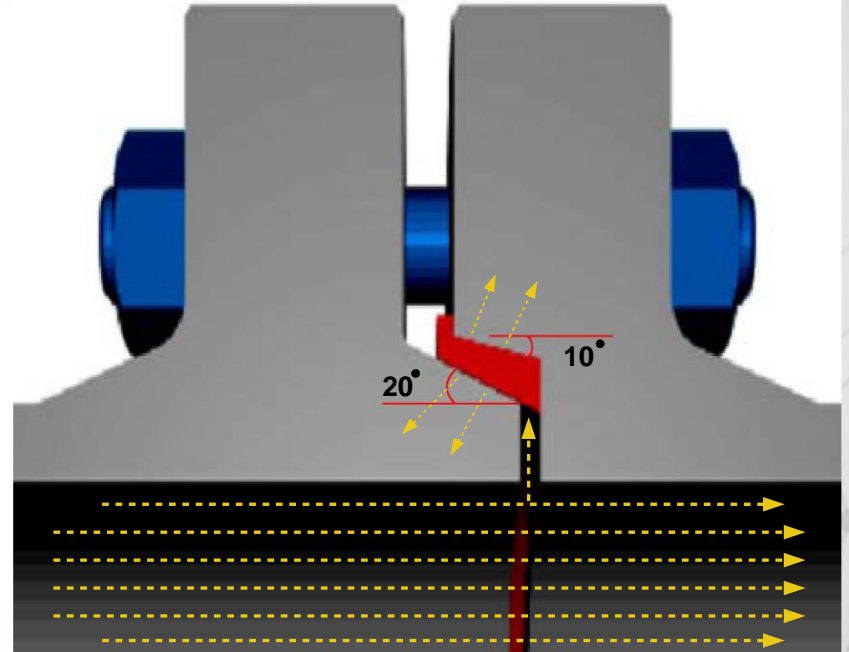
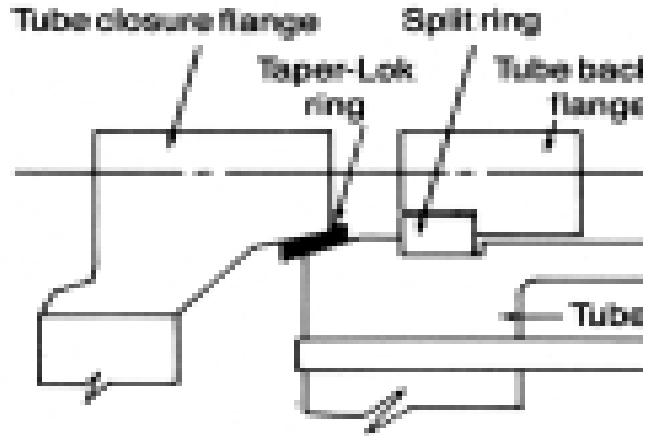
Brown Fin-tube  
Hairpin Heat Exchanger

Pressures up to 40,000 psig  
Temperatures: -350F – 160 °F

# Proven Existing Technology

## Same Service – Different Application

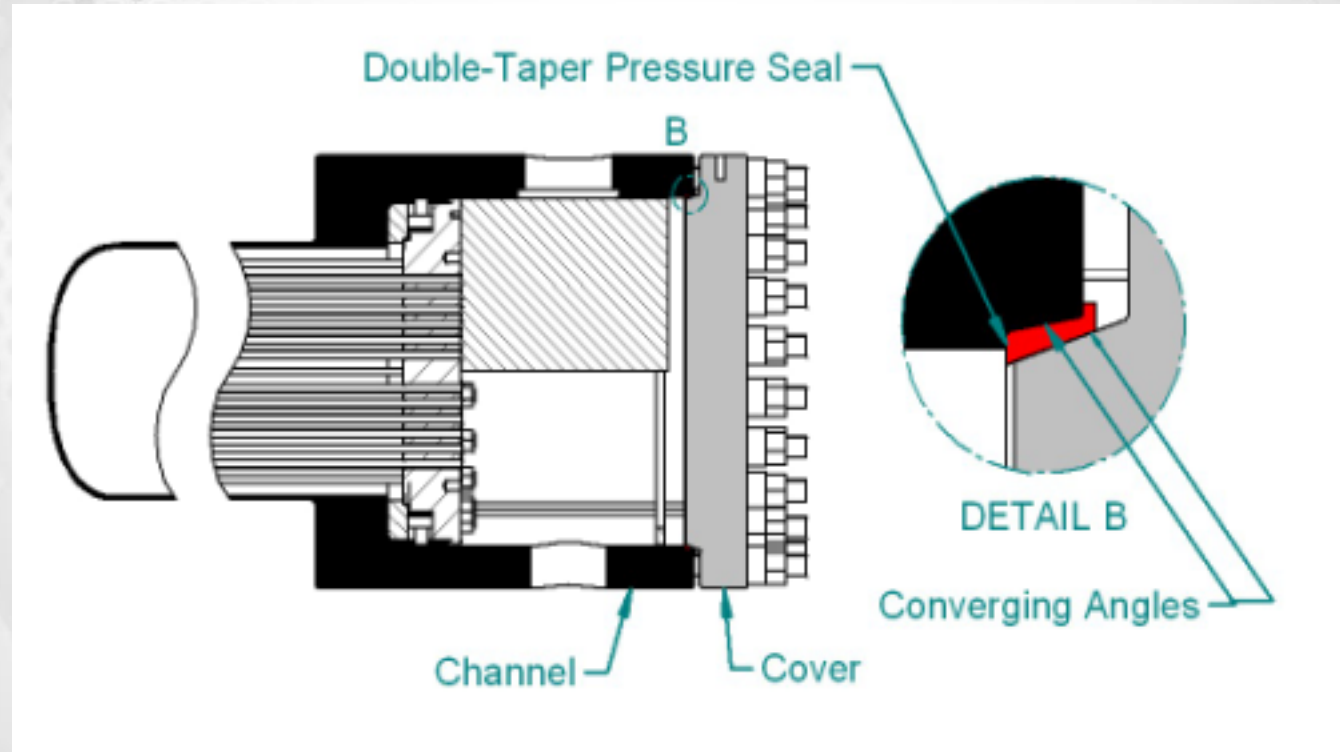
### Tube closure





# Novel Solution

Less Time – Less Inspection & Testing



# Inspection & Testing Comparison

Time Line Comparison		
Conventional Method (List of Job Steps)	Delta (Hrs)	Using Seal Ring Design (Exceptions Shown – Post Modification)
Unit S/D, de-pressure, N2 cool		
LOTO, Blinding, etc.		
Remove channel cover – 2 cranes, impacts	12	1 crane, torque wrenches
Drill hole in diaphragm, Sniff for LEL	8	No Diaphragm
Arc gouge out center of diaphragm	6	No Diaphragm
Machine off outer diaphragm and fillet weld	10	No Diaphragm
Disassemble baffle cage (2 Pass)		
Remove tube sheet bolting		
Remove tube bundle		
Clean \ Inspect \ Repair per Inspection		
Replace tube bundle & bolting (washers)		
Reassemble baffle cage		
Test channel edge for weld contamination	2	No Diaphragm, Seal Ring Like Material
Add nickel overlay “butter coat”	6	No Diaphragm, Seal Ring Like Material
Machine nickel overlay butter coat	6	No Diaphragm, Seal Ring Like Material
NDT - chemical test – copper sulfate	2	No Diaphragm, Seal Ring Like Material
Weld on diaphragm	6	No Diaphragm, Seal Ring Like Material
NDT - Test fillet weld (PT)	1	No Diaphragm, Seal Ring Like Material
N2 Test channel (small psig)	6	No Diaphragm, Seal Ring Like Material
Add cover plate		
Torque nuts with impacts or tensioners	8	1 crane, torque wrenches
Perform final testing per Inspection		
LOTO, Blinding, etc. – return unit to Operations		
	72	3 days – 6 Maintenance Shifts

**Insp or Test Activity**

**Maintenance Activity**

### Large Diameter Flanges: Technical Evaluation

		ANSI Flange	Rank	Taper Lok	Rank
1	Flange Material <sup>(1)</sup>	ASTM A350 LF 6	A	ASTM A350 LF 6	A
2	Gasket Material	RTJ gasket will be made from softer material than the flange material.	C	Gasket material is same as the flange material.	A
3	Bolt Material	ASTM A193 Gr-B7	A	ASTM A193 Gr-B7	A
4	Corrosion <sup>(2)</sup>		C	Lesser exposure to corrosion <sup>(2)</sup>	A
5	Bolt Tension	Requires higher bolt tension to keep the RTJ gasket in contact with the gasket groove.	B	Smaller bolt tension because the pressure energized seal and less likelihood of separation due to the tapered seal surfaces.	A
6	Bolt Diameter	Code specified bolt & bolt circle diameter.	B	Size optimized to fit pressure end load of flange and bending loads.	A
7 a	Make up gap	About 3/4" for 48" flange.	A	About 1 1/4" for 48" flange.	B
7 b	Misalignment	Zero misalignment capability.	B	Some misalignment capability because of the tapered gasket design.	A
8	Bending Moment Capacity	Smaller bending moment capacity because inability to misalign w/o breach of seal.	B	Higher bending moment capacity because of ability to misalign slightly and maintain full contact of seal surface around gasket diameter.	A
9	Bolt relaxation	Possible because the gasket is plastically deformed during make-up.	B	Less likelihood of relaxation because the gasket loads remain below 90% of yield.	A
10	Design Flexibility	No flexibility because the dimensions are specified by the code.	B	Flexible design, dimensions can be changed to match the requirements.	A
11	Flange Weight	Flange size is fixed by B16.47 or SP-44.	B	Smaller and lighter than ANSI flange.	A
12	Availability of misalignment flanges	Misalignment Flanges up to 10 degrees are available.	A	Taper Lok make flanges with max. 10 deg misalignment.	A
13	Susceptibility to damage	Mating flange may hit the projected half of the RTJ gasket.	B	Male flange has a projection that may hit the female flange.	C
14	Leak Test	Requires pipeline to be pressured.	B	Seal can be tested without pipeline pressure.	A
15	Pressure energized seal	No	B	Pressure acting against seal drives seal tighter into converging tapered seal surfaces.	A
16	Made up gap	Need to check for uniform made up gap.	B	Need to check for uniform made up gap.	B
17	Effect of Check Valve Clapper Impact Loads.	Bearing stress may exceed allowable.	B	Bearing stress is within allowable.	A
	<b>TOTALS</b>	<b>4 A's, 12 B's, and 2 C's</b>		<b>15 A's, 2 B's, and 1 C</b>	

# Third Party Consultant Evaluation of Retrofit

- Elimination of Mtce
- Elimination of Inspection
- Elimination of Failure
- *Elimination of Failure Mechanism*
- Material of Seal
- Increased Safety
- Increased Reliability
- Ease of Entry & Close

# Questions?

## Design, Insp & Testing

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