# Optimization of FCCU Expansion Joint Application, System Design and Reliability Considerations

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# Optimization of FCCU Expansion Joint

## ***Expansion Joints in FCCU Application***

## ***Basic Considerations***

- Expansion Joints are the **Weakest Link** in the system
- **ELIMINATE**
- **OPTIMIZE** EJ by composite system design approach
- Consider effect of **refractory** on the **stiffness** of the system
- Implement Design & Fabrication **UPGRADES** of EJ's
- **MONITOR** movement during Dry-out and Operation
- Routine **INSPECTION** and **PREVENTIVE MAINTENANCE**
- **VENDOR SELECTION** is Key
- **Hot Wall versus Cold Wall**
- **Orientation** – Vertical versus Horizontal

# FCCU Expansion Joint

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## ***Systematic approach to Optimize FCCU Expansion Joints***

- Composite System Design Approach
- Eliminate EJ
- Minimize EJ
- Design Upgrades
- Fabrication Upgrades
- Proper Installation
- Monitor EJ during dry-out and Operation
- Inspect EJ during shutdown
- Preventive Maintenance of EJ

# FCCU Expansion Joint

## ***DESIGN***

## ***Primary Mechanical Design Consideration in an FCCU***

- Layout, Thermal Growth, Structure, Equipment
- Large Diameter (Refractory Lined) Transfer Lines
- High Operating Temperature
- Cold Wall vs Hot Wall
- Effect of refractory lining on stiffness and loading
- Thermal Movement and Banana Movement in transfer lines
- Erosion
- Upsets and Abnormal Operations including SLUMP Case
- Refractory and Thermal Conditions during Dry-Out
- Expansion Joint Application and Optimization

# FCCU Expansion Joint

## *Effect of Refractory Lining on the Stiffness of Steel Pipe*;

$$I_r = 0.6\, I_1 + 0.4 \left(\frac{I_2 + I_3}{2}\right) \qquad (17)$$

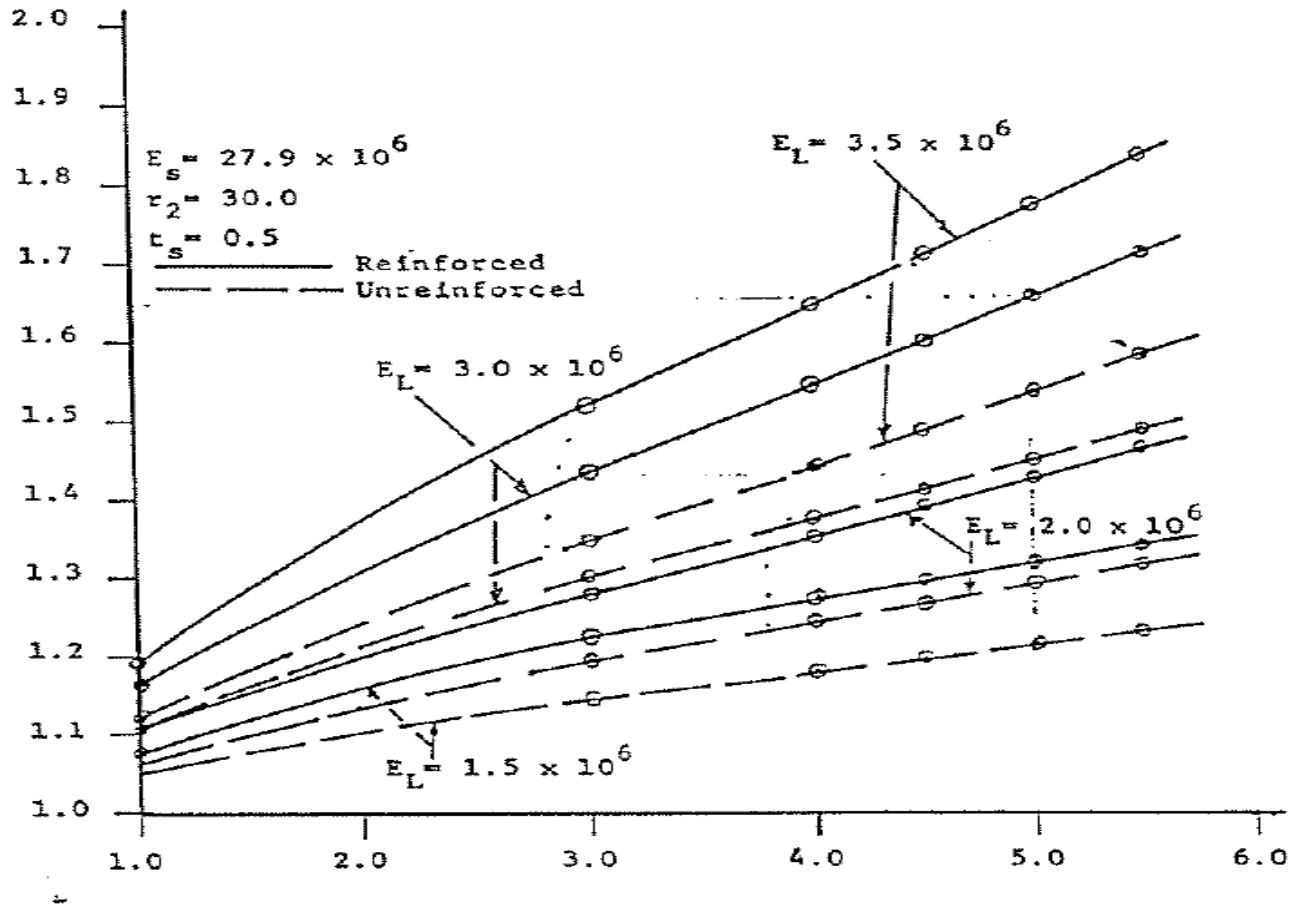



Fig. 3 Variation of $\left(\frac{I_{eq}}{I_{so}}\right)$ with Lining Thickness

**(Ref – PVP- Vol. 53)**

# Regenerator Flue Gas Nozzle FEA

## *Flue Gas Outlet Nozzle & Plenum*

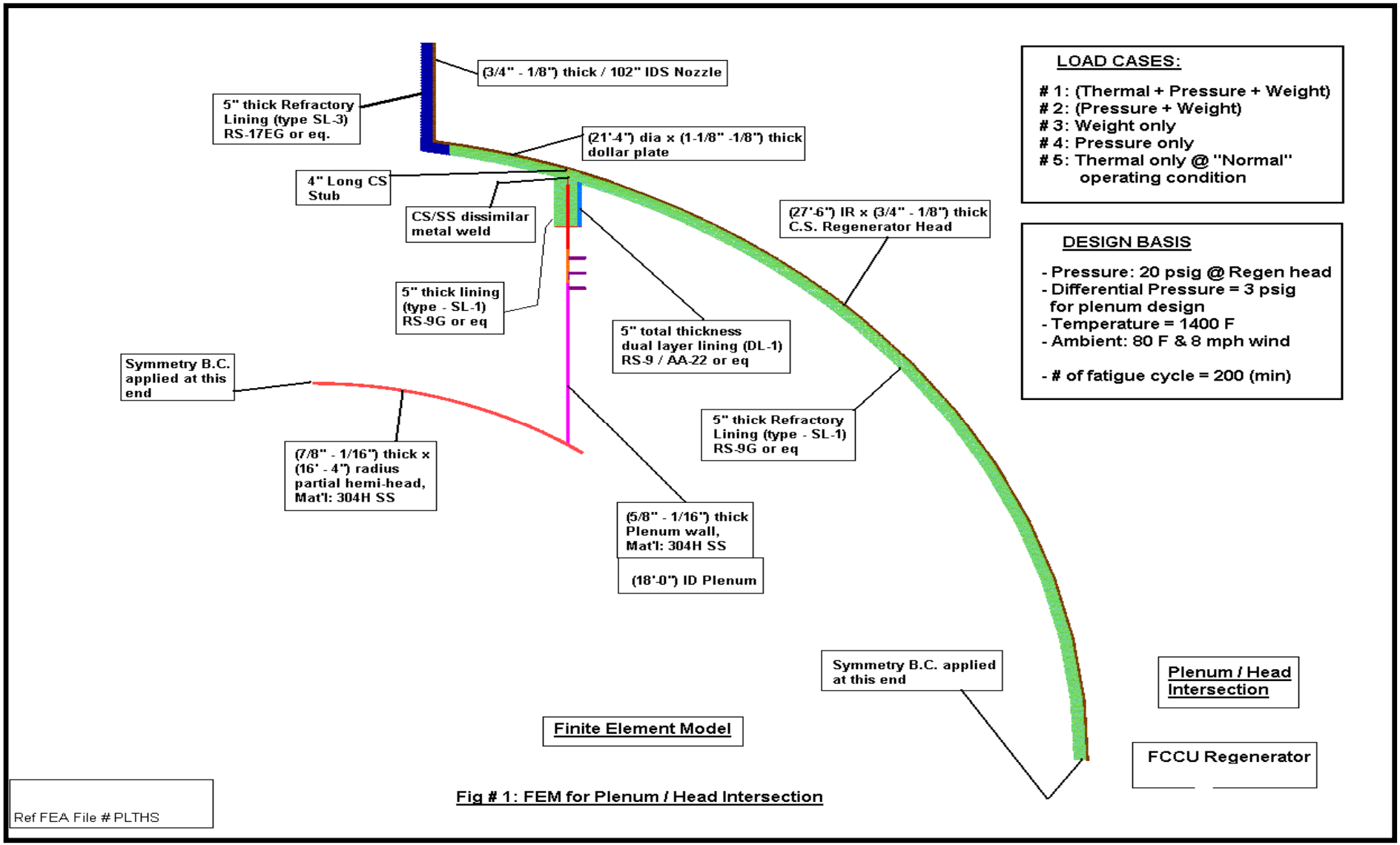


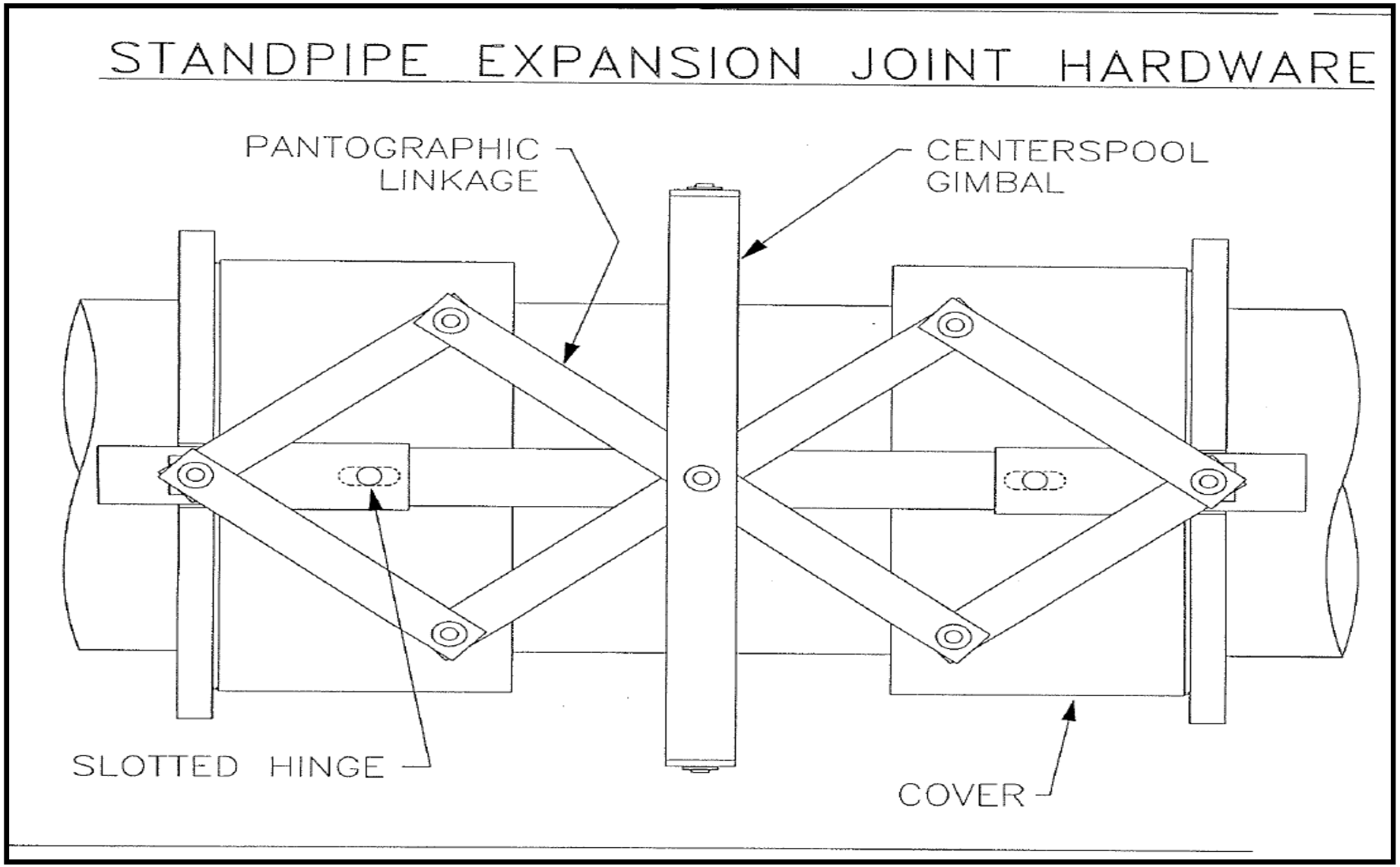

Fig # 1: FEM for Plenum / Head Intersection

# FCCU Expansion Joint

## ***EJ Fabrication***
## ***Upgrades and Consideration***

- **Vendor selection is key**.
- Use of 2- Ply testable bellows
- Bellow forming & attachment to body
- Packing versus Purging
- Gimbaled pantographic linkage
- Telescopic liner to coincide with center of bellows
- Thermocouples measure bellows skin temperature
- Hot Blankets, if required for condensation protection

# FCCU Expansion Joint



# FCCU Expansion Joint

## Monitoring during Construction and Refractory Dry-Out

- Minimize Fabrication and Construction Tolerances
- Monitor Proper Installation and Field Fit-Up of EJ
- Add thermocouples at critical locations to monitor system temperature during refractory dry-out.
- Monitor Thermal Operation during field dry-out and verify to be same as “system design” basis
- Monitor and verify Expansion Joint, spring hanger and system movement as “designed”

# FCCU Expansion Joint

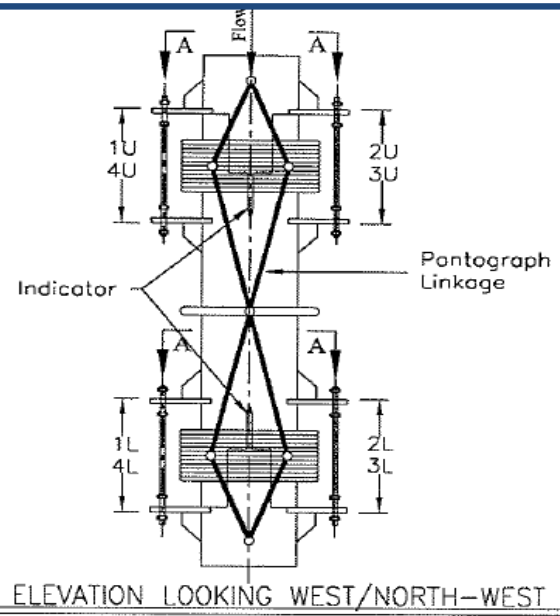
***(On-line Monitoring)***

## Routine Monitoring of Expansion Joint during OPERATION

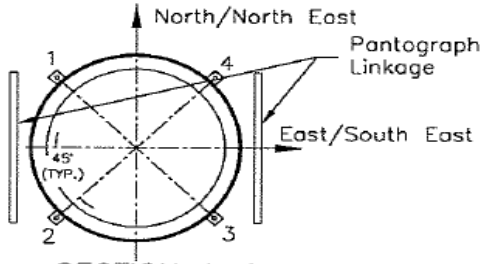
- Monitor Bellows movement on routine basis to verify any sign of excessive actual movement over Design limit.
- Monitor 2-ply testable bellows for any leaks
- Monitor bellow temperatures using installed thermocouples. Keep between (400 – 800) deg F range or as per Spec.

# FCCU Expansion Joint

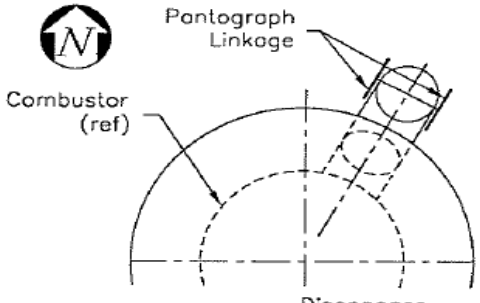
## *(Bellows Movement Monitoring)*




ELEVATION LOOKING WEST/NORTH–WEST




SECTION A–A

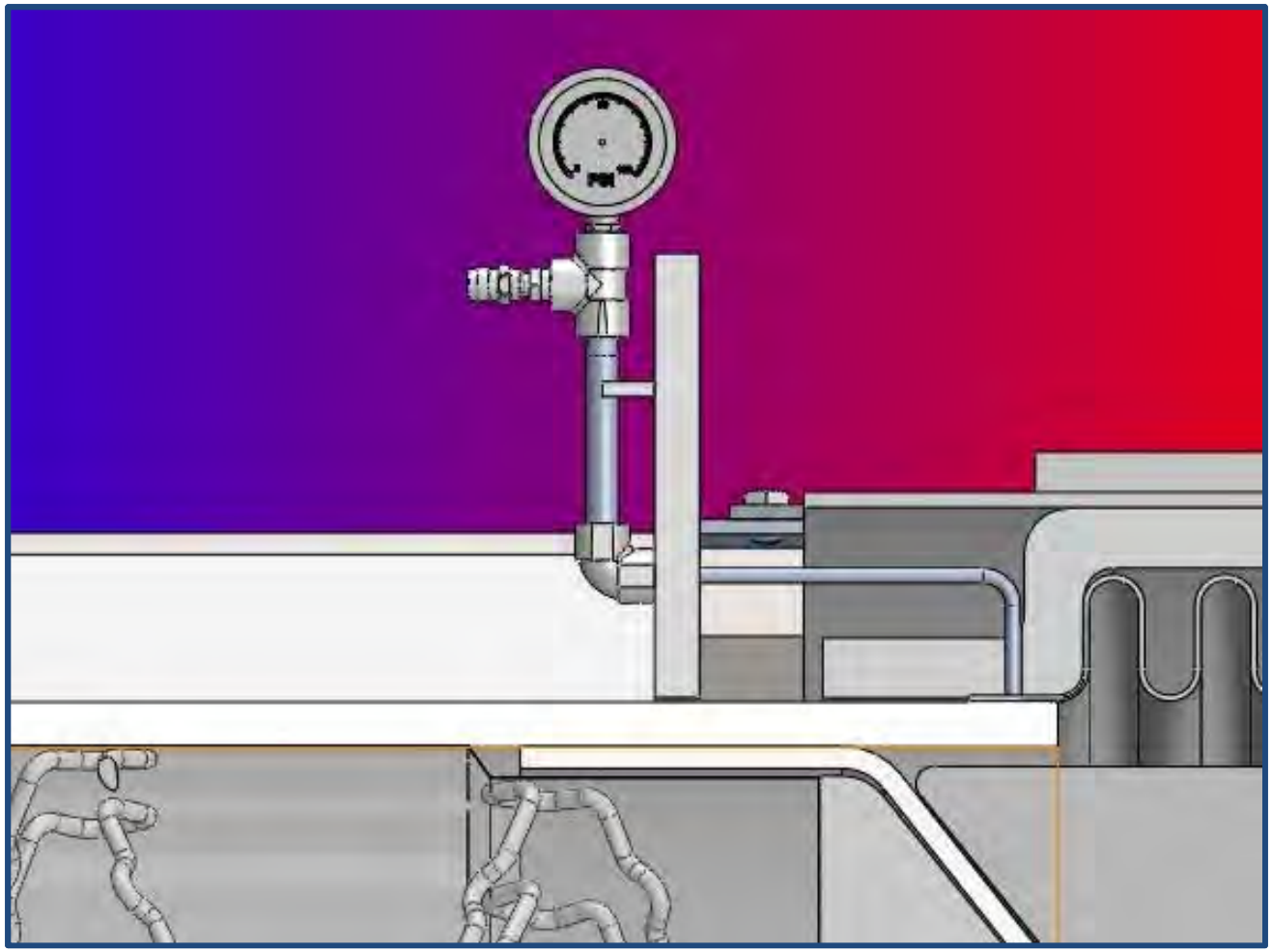



PLAN

| Location or Date | Operating Condition | EXPANSION JOINT MEASUREMENTS | | | | | | | | INDICATOR READING | | | | CALCULATED RESULTS | | | | | Remarks and Conclusions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LOWER BELLOWS | | | | UPPER BELLOWS | | | | LOWER | | UPPER | | Resultant Axial Movement | Lateral Movement | | Angular Movement | | |
| | | 1L | 2L | 3L | 4L | 1U | 2U | 3U | 4U | Axial | Angular | Axial | Angular | | In–Plane | Out–of–Plane | In–Plane | Out–of–Plane | |
| | BEFORE OFFSET | | | | | | | | | | | | | | | | | | |
| | AFTER OFFSET | | | | | | | | | | | | | | | | | | |
| | AS INSTALLED | | | | | | | | | | | | | | | | | | |
| | SHIP BARS REMOVED | | | | | | | | | | | | | | | | | | |
| | DURING DRY–OUT | | | | | | | | | | | | | | | | | | |
| | START–UP/ OPERATION | | | | | | | | | | | | | | | | | | |

# Optimization of FCCU Expansion Joint

## *(2-ply testable bellows monitoring)*



# FCCU Expansion Joint

## ***Common Failure Areas of expansion joint to inspect***

- The common failure areas are the bellows inner ply leaking.

  Routinely monitor testable 2-ply bellows using the test port .
- Bellow Attachment welds
- Braided seal hose and inner pillow failure
- Internal liner to duct weld joint failure due to stress / vibration
- Loss of refractory due to mechanical & thermal reasons.

# FCCU Expansion Joint

## ***Routine Inspection of Expansion Joints during Shutdown***

- Perform leak test for 2-ply bellows and verify sign of leak.
- Look for evidence of cracks on hardware and distortion of hardware such as pantographs.
- Perform interior inspection of refractory and liner gaps.
- Determine that insulation pillows are still in place.
- Look for evidence of hot spots and loss of refractory.
- Inspect the refractory at the hot wall liner to cold wall refractory transition to determine if the liner weld at that point is cracked. This is high stress area.
- If needed, contact EJ Vendors such as SFI, EJS and others to perform hot & cold inspections and reports

# FCCU Expansion Joint

## *Optimization, Monitoring and Life Improvement*

**DESIGN**
- Avoid or Optimize Application
- Design & Fabrication Upgrade
- Consider Normal & SLUMP
- Refractory Dry-out & Operation

**‘FABRICATION**
-Select Vendor Carefully
- Design, Fabrication & Testing
-Bellow Attachment
- Refractory Installation

**EXPANSION JOINT OPTIMIZATION, SAFETY & OPERATIONS RELIABILITY**

**FIELD MONITORING AND PREVENTIVE INSPECTION**
- Bellow Movement
- Bellow Metal Temperature
- Inner Ply Testing

FOSTER WHEELER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