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
Outline of Routine Inspection and Monitoring Program
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
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**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
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Effect of Refractory Lining on the Stiffness of Steel Pipe;

\[ I_r = 0.6 I_l + 0.4 \left( \frac{I_2 + I_3}{2} \right) \]  

(17)

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

(Ref – PVP- Vol. 53)
Regenerator Flue Gas Nozzle FEA

Flue Gas Outlet Nozzle & Plenum

LOAD CASES:
# 1: (Thermal + Pressure + Weight)
# 2: (Pressure + Weight)
# 3: Weight only
# 4: Pressure only
# 5: Thermal only @ "Normal" operating condition

DESIGN BASIS
- Pressure: 20 psig @ Regen head
- Differential Pressure = 3 psig for plenum design
- Temperature = 1400 F
- Ambient: 80 F & 8 mph wind
- # of fatigue cycle = 200 (min)

Ref: FEA File # PLTH3

Fig #1: FEM for Plenum / Head Intersection
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**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
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STANDPIPE EXPANSION JOINT HARDWARE

PANTOGRAPHIC LINKAGE

CENTERSPOOL GIMBAL

SLOTTED HINGE

COVER
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**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”
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(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)

![Diagram of FCCU Expansion Joint](image)

## Elevation Looking West/North-West

### Section A-A

<table>
<thead>
<tr>
<th>Location or Date</th>
<th>Operating Condition</th>
<th>Expansion Joint Measurements</th>
<th>Indicator Reading</th>
<th>Calculated Results</th>
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<td>Conclusions</td>
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*Foster Wheeler*
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*(2-ply testable bellows monitoring)*
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**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.
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**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.
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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