Important Features to Consider for Making HRSG's Robust in a Cyclic Service Environment

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Introduction

- Over fifteen years of cyclic design at N/E
- We have learned much over this time frame
- Possible to design HRSG's for high cyclic operation
- There are two areas of focus:
  1. Mechanical details
  2. Operation

Introduction

- Important Mechanical Features:
  1. Coil Flexibilities
  2. Piping Layouts
  3. Component thicknesses
  4. Tube to header attachments
  5. Desuperheaters
  6. Condensate management systems
  7. Feedwater recirculation systems
  8. Auxiliary equipment (stack dampers, steam sparging, etc)
- Focus on two of these features: **Coil Flexibilities and Piping Layouts**
- All are important

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LCF versus HCF

- LCF – Low Cycle Fatigue
  1. Failures occurring in less than 1000 cycles
  2. Stresses resulting in high inelastic strains
  3. Normal Causes:
     - Restrained thermal growth
     - Water quenching
  4. Important to minimize or eliminate all LCF

- HCF – High Cycle Fatigue
  1. Normal fatigue caused by operation
  2. Two main causes:
     - Through thickness temp. gradients
     - Pressure stresses

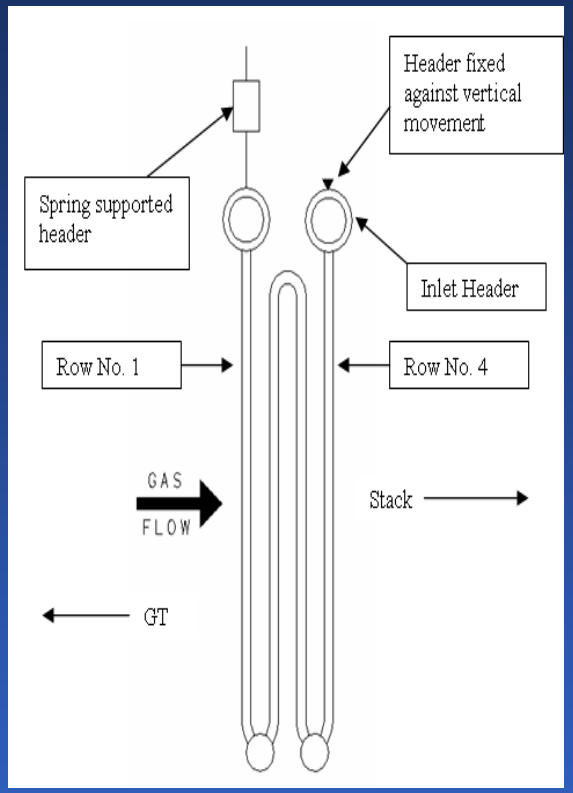
Importance of Coil Flexibilities

- Essential to eliminating low cycle fatigue
- Main concern:

  Longitudinal tube to tube temperature differences

Tube to tube temperature differences

- SH/RH each row different temperature
- Different ways to absorb movements
  1. Internal coil flexibilities
  2. Allow parts to move freely
- Support SH & RH from spring supports
- Stress orders of magnitude lower



General Rule: Allowing parts to move freely always better than relying on internal coil flexibilities

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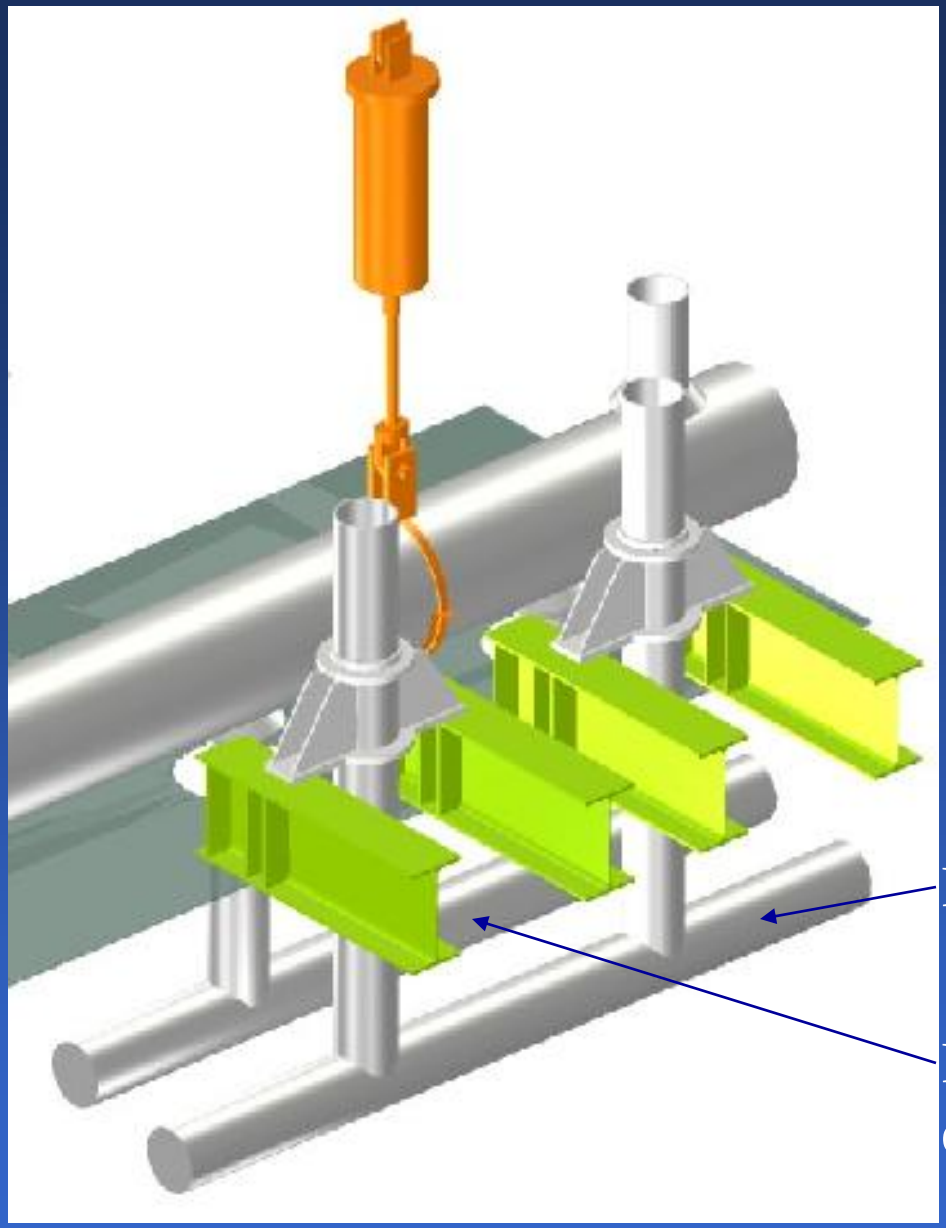
Spring Support of Header



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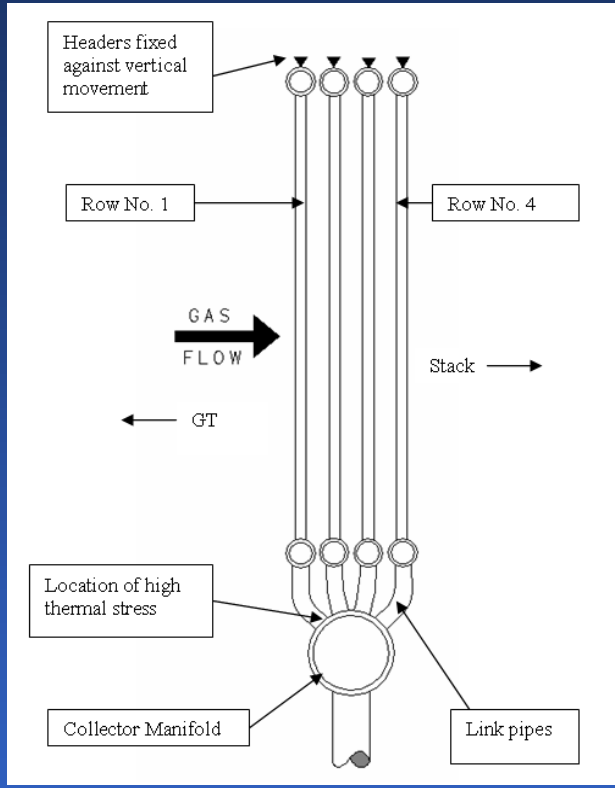
Example poor coil arrangement

- Fixed upper headers
- Tubes not allowed to move
- Relies on flexing of stiff link pipe, header and manifold rotation.
- High stresses at link plate to manifold



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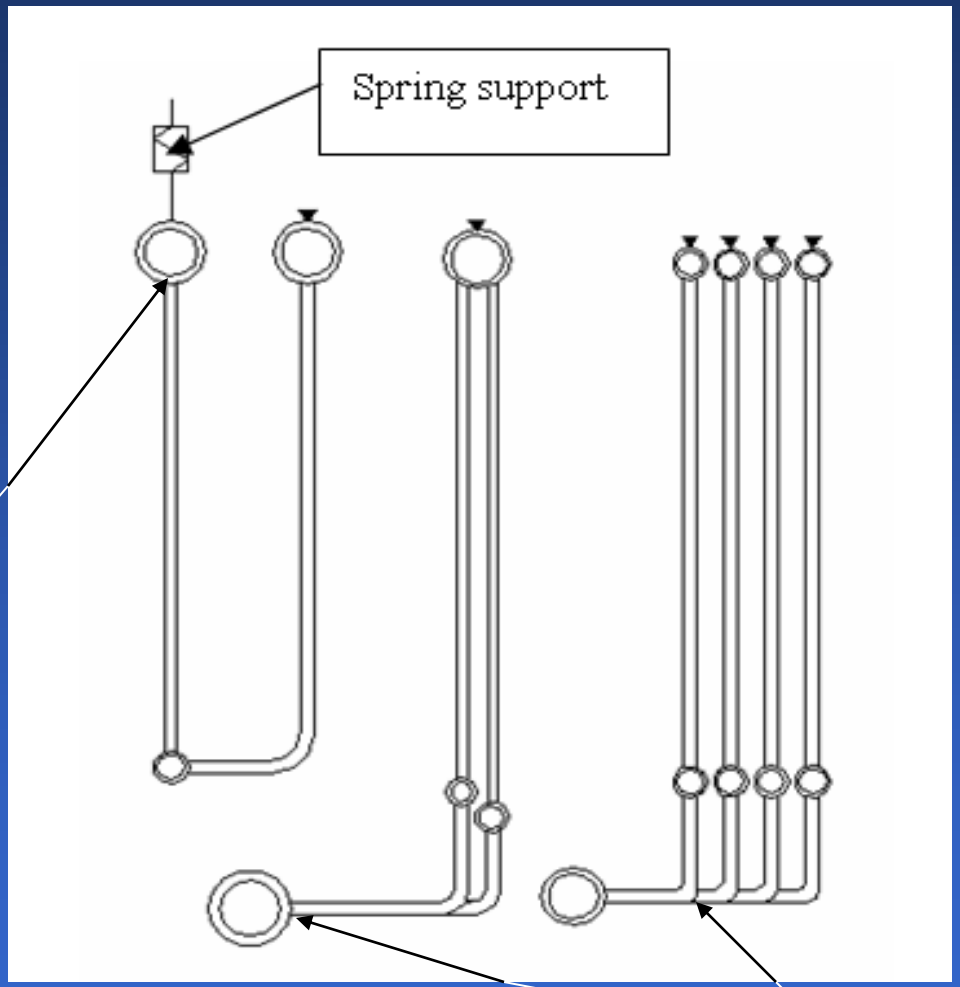
Other examples of good coil configurations



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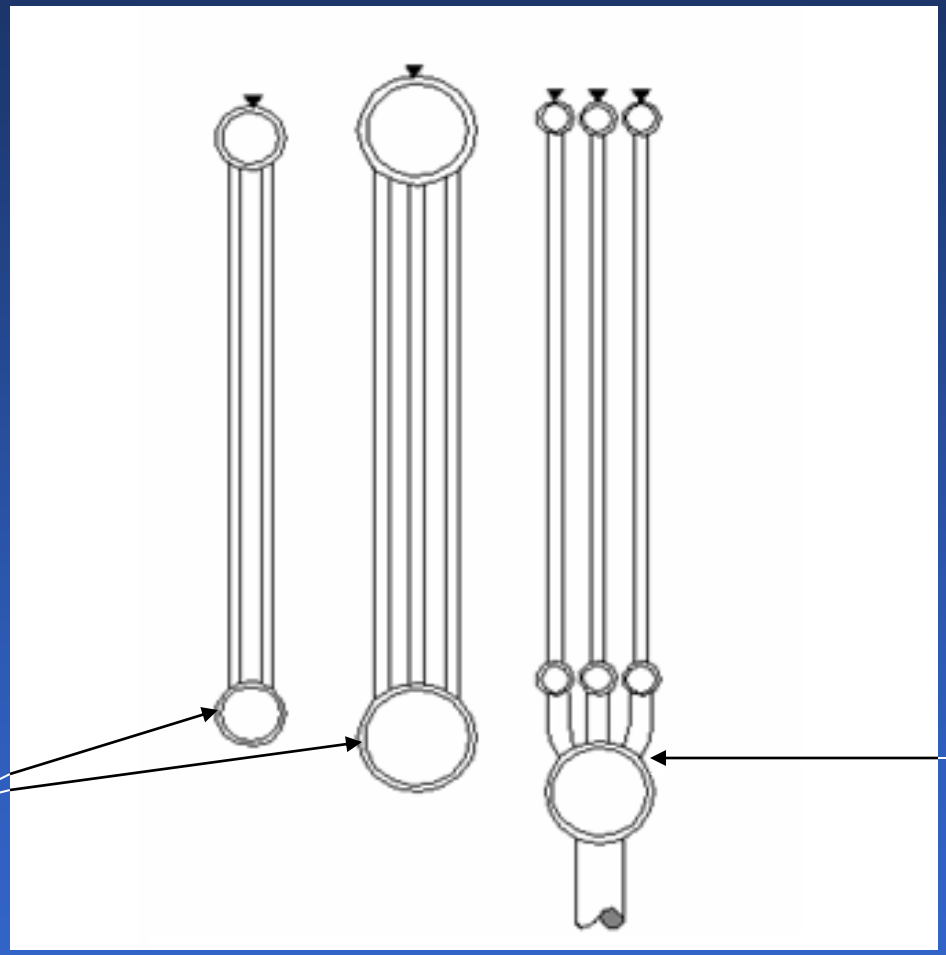
Other examples of poor coil configurations



Tubes fixed by headers

Tubes fixed by lower manifold and link pipes

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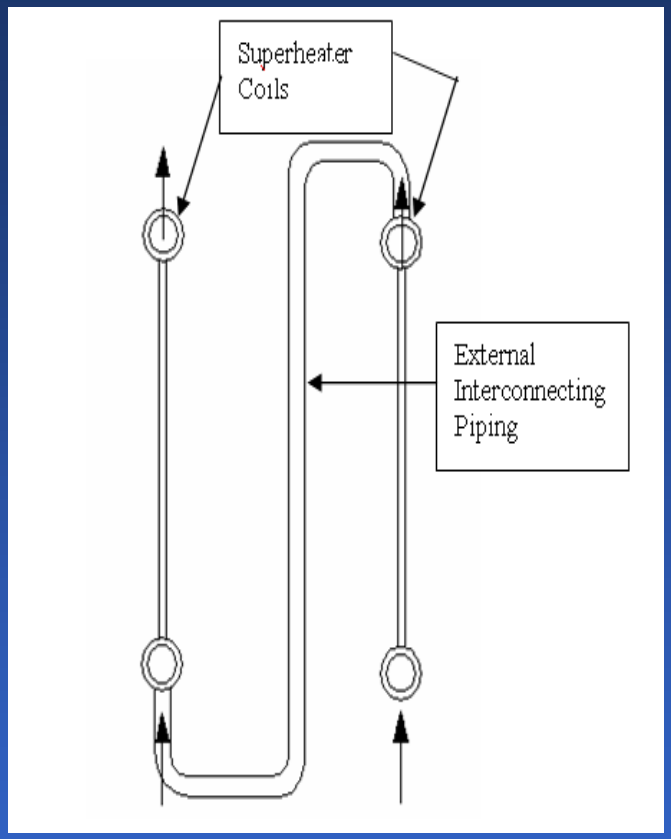
Piping Layouts

- Often over looked
- Start up transients important
- Coils will heat up before piping
- Routing piping top to bottom not desirable
- Additional flexibility required if routed top to bottom



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Piping Layouts

- Some times not possible to prevent
- Must provide sufficient piping flexibilities
- If done, do not attach to headers with springs

Summary

- Cycling can be accounted for in designs
- Long equipment life result of good design and operation
- Important to have good coil and piping flexibilities
- Have focused only on two of several features
- Other features are important and should be considered

Component thicknesses	Tube to header attachments
Desuperheaters	Condensate management
Feedwater Recirculation	Aux equipment

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Summary

- Mechanical Features less than half the story
- How you operate most important
  1. Understanding most damaging cycles
  2. Minimizing or eliminating water quenching
  3. Planning for when things go wrong
- Paper: *"Cyclic Service Features for Heat Recovery Steam Generators"* – by Lewis R. Douglas and Samuel Perez.

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