ASME B31.3 Process Piping

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Piping Development Process

1. Establish applicable system standard(s)
2. Establish design conditions
3. Make overall piping material decisions
   - Pressure Class
   - Reliability
   - Materials of construction
4. Fine tune piping material decisions
   - Materials
   - Determine wall thicknesses
   - Valves
5. Establish preliminary piping system layout & support configuration
6. Perform flexibility analysis
7. Finalize layout and bill of materials
8. Fabricate and install
9. Examine and test

9. Reactions

- General Considerations
- Fabricated Equipment
- Rotating Equipment
- Supports
- Cold Spring

The Material in This Section is Addressed by B31.3 in:

Chapter II - Design

General Considerations

- Main purpose is to provide sufficient support and flexibility to prevent the piping from exerting excessive reactions on equipment and restraints
- The calculation methods are different for fabricated equipment than for rotating equipment or supports
- Reaction limits are determined differently for fabricated equipment than for rotating equipment or supports

Fabricated Equipment

- Calculation Methods
- Reaction Limits
- Nozzle Flexibility

Calculation Methods

- Usually the accuracy of a formal analysis using a computer stress analysis program is required
- Both sustained loads and displacement loads are considered
- Failure modes for fabricated equipment include:
  - Gross deformation or collapse
  - Fatigue

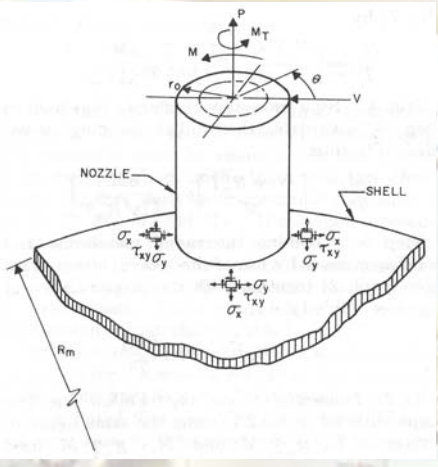
Calculation Methods

- In order to evaluate fatigue, the entire range of loads must be considered, so the temperature range for this calculation is the same as for calculating the displacement stress range

Reaction Limits

Reaction limits for nozzles are calculated using

- Welding Research Council Bulletin 107 "Local Stresses in …Shells due to External Loadings"
- Finite element analysis



Reaction Limits

- Allowable stresses values used in the calculation are taken from the applicable Code, and stress evaluation is usually done using the stress evaluation criteria described in ASME B&PV Code Section VIII, Division 2, Alternate Rules for Pressure Vessels
- Advantages to doing these calculations yourself
  - Cycle time is reduced considerably
  - Easier to decide between reinforcing the nozzle and lowering the reactions

Rotating Equipment

- Calculation Methods
- Reaction Limits

Calculation Methods

- Usually the accuracy of a formal analysis using a computer stress analysis program is required
- Failure modes for rotating equipment include:
  - Detrimental misalignment
  - Rubbing interference
- In order to evaluate failure modes, only the magnitude of the loads during operation needs to be considered, so the temperature range from the installed condition to the operating condition is used

Temperature Range Examples

- Outdoor cooling tower water line:
  - Minimum water temperature is 45ºF (7ºC)
  - Maximum water temperature is 90ºF (32ºC)
  - The piping is installed during February, which has an average daily temperature of 53ºF (12ºC)
  - Minimum average daily temperature is 30ºF (-1ºC)
  - Temperature range is _____ to _____

Temperature Range Examples

- Outdoor compressed air piping
  - Minimum compressed air temperature is ambient
  - Maximum compressed air temperature is 150ºF (65ºC)
  - The piping is installed during July, which has an average daily temperature of 64ºF (18ºC)
  - Minimum average daily temperature is -30ºF (-35ºC)
  - Temperature range is _____ to _____

Temperature Range Examples

- Outdoor steam traced water line:
  - Minimum water temperature is 40ºF (4ºC)
  - Maximum water temperature is 60ºF (16ºC)
  - The piping is installed during September, which has an average daily temperature of 76ºF (24ºC)
  - Minimum average daily temperature is 30ºF (-1ºC)
  - Calculated maximum temperature for no flow condition with steam tracing on is 280ºF (140ºC)
  - Temperature range is _____ to _____

Reaction Limits

- Limits are specified by the equipment manufacturers
- Manufacturers of certain types of equipment are required to at least meet the allowable reaction requirements in applicable industry standards, so
- Many manufacturers refer the users to these standards

Reaction Limits

Equipment	Industry Standard
Centrifugal Pumps	ASME B73.1 API 610
Steam Turbines	NEMA SM-23 API 611 API 612
Centrifugal Compressors	API 617
Positive Displacement Compressors	API 619

Supports

- Calculation Methods
- Reaction limits

Calculation Methods

- Usually the accuracy of a formal analysis using a computer stress analysis program is required
- The failure modes of concern for supports is collapse and excessive deformation
- The structural codes don't recognize the distinction between displacement and sustained loads, so only the magnitude of the loading extremes needs to be considered, so
- The temperature range from the installed condition to the operating condition is used
- Some codes differentiate between "normal" loads and "occasional" loads

Reaction Limits

Reaction limits are determined by either the maximum stress or the stability limit of the structure.

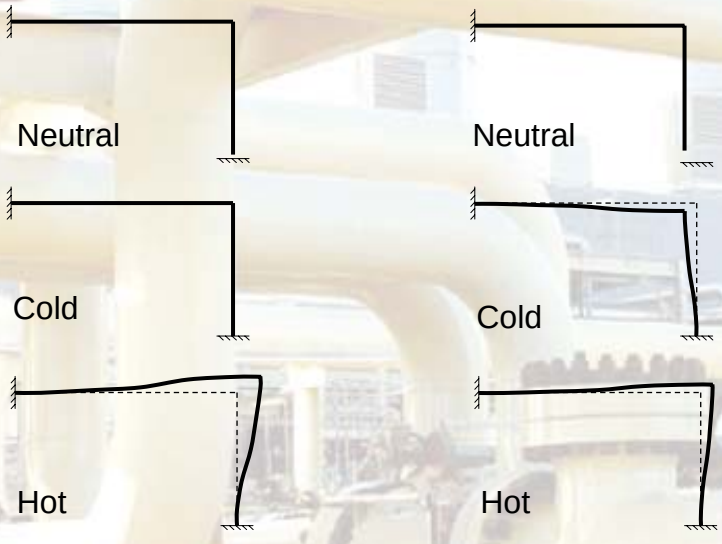
Cold Spring

Cold spring is the intentional deformation of piping during assembly to produce a desired initial displacement and stress. (319.2.4)

Cold springing:

- Does not change the stress range
- Does not change the reaction range
- Is not helpful for reducing reaction ranges at fabricated equipment
- Can be helpful for reducing reactions rotating equipment and supports
- Can be used to control displacements

Cold Spring



Cold Spring

Because cold spring is difficult to achieve accurately in practice, B31.3 permits only partial credit in calculating reaction forces

- For two anchor systems with no intermediate restraints, B31.3 gives equations for estimating reactions giving 2/3 credit for cold spring (319.5.1)
- For other systems, B31.3 requires that each case be studied to estimate reactions (319.5.2)

Cold Spring

Note that unintentional cold spring (misalignment) has the same effect as intentional cold spring.

- The Code says “Any distortion of piping to bring it into alignment for joint assembly which introduces a detrimental strain in equipment or piping components is prohibited.” (335.1.1)
- Some owners are more restrictive than the Code on misalignment.