What I learned in 30 years of Nuclear Piping Design: Part I - How to Start Well

D.H.Creates[1)]

1) Senior Piping Design Engineer, Ontario Power Generation Inc

ABSTRACT

Over a period of 30 years in the job of piping design, I started out as a junior piping design engineer who designed a floor drain and ended up as a senior design engineer for the Class 1 piping. My piping job brought me into working relationships with almost every other discipline in the project where I learned piping design is more than issuing a piping drawing. Here is what I experienced and learned so that others may be prepared for the opportunities and be informed about the responsibility to produce an integrated design that meets multi-discipline reqnirements: Assumptions – Beware; Ball park the design (boundaries), Communicate, communicate, Detail the design

ASSUMPTIONS – BE-WARE

To start well I learned to recognize and correct

A.1 False *Knowledge* Assumptions:

1. you know all of your assumptions
2. others know all your assumptions
3. your assumptions are the same as others' assumptions
4. engineers in other disciplines know all they need to know about piping analysis
5. you know all you need to know about others work
6. you know all the requirements for yonr design right at the beginning
7. there is only one set of conditions to design for
8. you always receive correct and final information from others, every time
9. yon need no design margins
10. everyone nnderstands ASME Service Levels A,B,C, & D

A.2 False *People* Assumptions

1. I do not need help
2. I do not need personal face-to-face connections with others
3. I do not need help from other disciplines
4. I do not need to help others
5. I do not need to learn what others do
6. My bosses understand my whole job

A.3 False *Piping Design* Assnmptions

1. valves don't leak
2. pressure differential is only one way
3. the line is cold because it is dead ended
4. the line is hot because it is connected to hot flow
5. A U-bolt is a pipe anchor
6. friction is a pipe restraint
7. friction has no effect
8. design only for components fully functional i.e. no failures, no change-of-state, etc

BALL PARK THE DESIGN

I eventually got the 'big picture' and learned how to fit my design in to the overall station design by

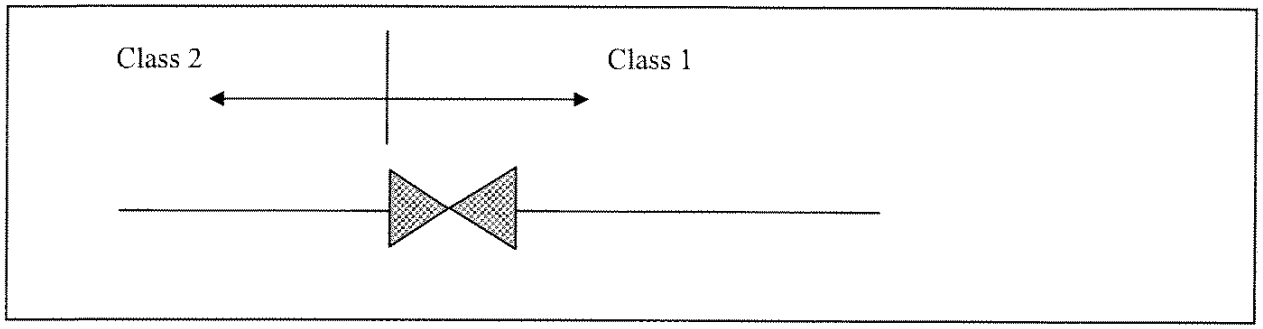
B.1 Understanding the piping system

- Design Manual (system requirements and operational description) and process designers
- Modification Design manual (MDR)
- Temporary Change Notices
- Design Specifications for equipment
- Radiation control

- System Interactions i.e. effect of one system on another – whether operating or failed
- Station Design Guides (generic requirements) i.e. seismic, environmental, postulated accidents
- Off-normal/failed/accident conditions of the systems from process designers and Nuclear Safety

B.2 Identifying Theoretical Boundaries

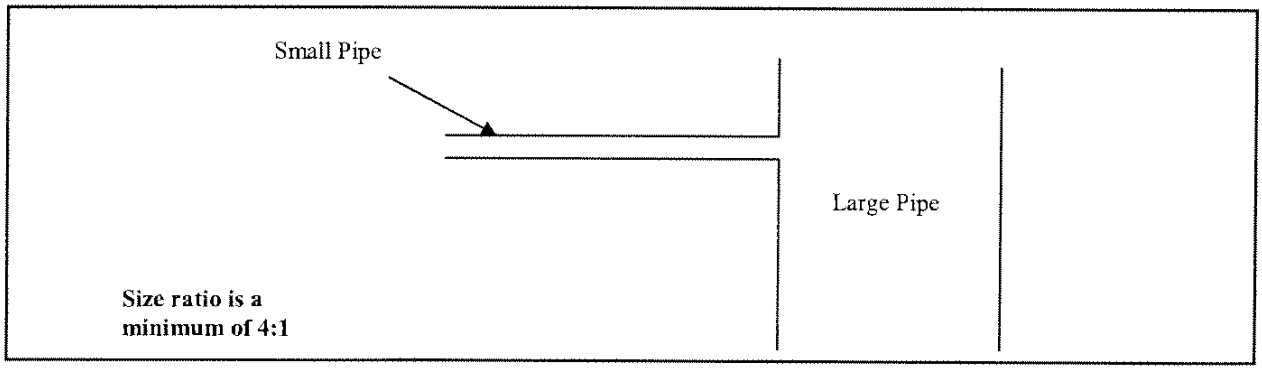
Class 1, 2, 3 and NF boundaries come from the system Design Flow Diagram/Codes and determine the allowable stresses for design.



B.3 Identifying Inherent Boundaries for Piping Models

At these locations piping computer models can be started/stopped (decoupled) without the use of physical anchors. The large pipe, in effect, acts as an anchor to the small pipe.

Caution: movements and secondary response spectra/time history are required at the location of decoupling, and remember, the intersection must be analyzed in one of the two piping models.

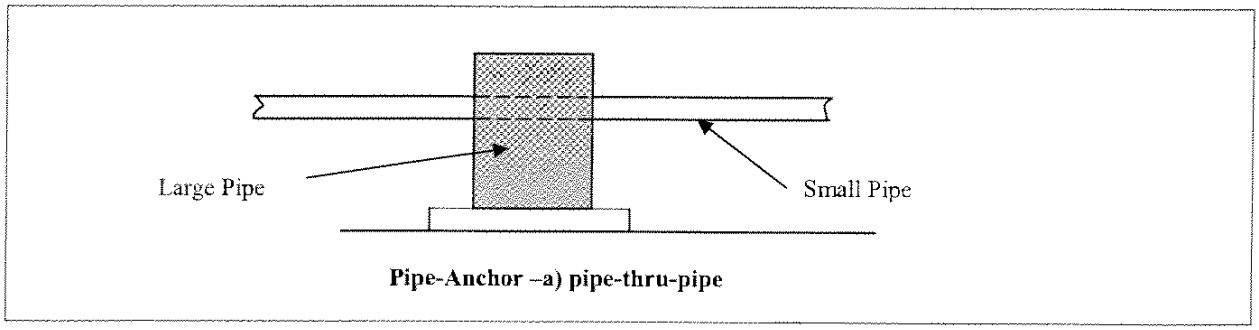


B.4 Making Physical Boundaries

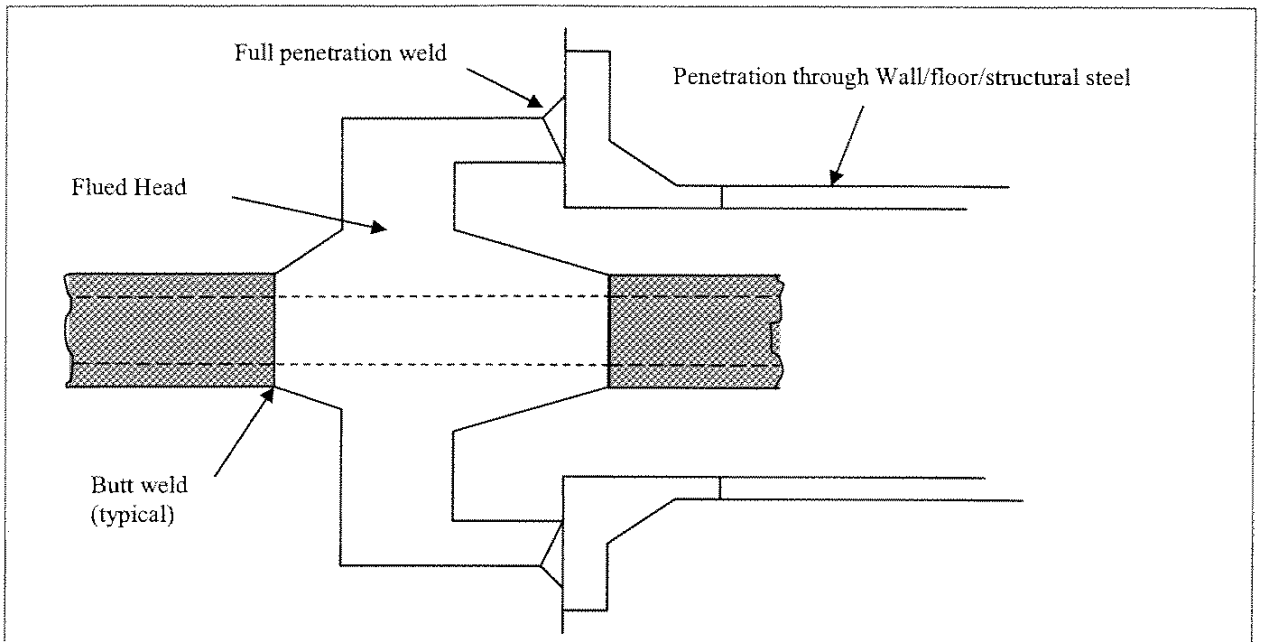
"If you don't stop, you go on forever" in a piping computer model. Piping needs anchors at which to terminate a model.

A Pipe Anchor is a 6 degree-of-freedom restraint that is 10 times stiffer than the pipe.

How do you get one? We had to make them. Here are two such pipe anchors.



Pipe-Anchor –a) pipe-thru-pipe



Pipe Anchor – b) Flued Head

In order to have such a Flued Head pipe anchor, a new design was needed for a stronger embedment in the concrete. This was presented in a paper "Rationale for the Design of Containment Penetrations in a CANDU Nuclear Generating Station", at the International Conference on Containment Design, June 17-20, 1984 at Toronto, Canada.

B.5 Identifying Support Boundaries

Where can you hold the pipe? Identify walls/floors and additional structural supports required and then engage structural personnel to ensure adequate strength and stiffness.

How to grab the pipe - without welding to the pressure boundary?

a) Use single acting supports i.e. hanger rods (must be checked for lift-off in dynamic conditions

b) Use Double acting supports i.e. struts, snubbers (for dynamic conditions)

c) Use 2 degree-of-freedom restraints i.e. guides

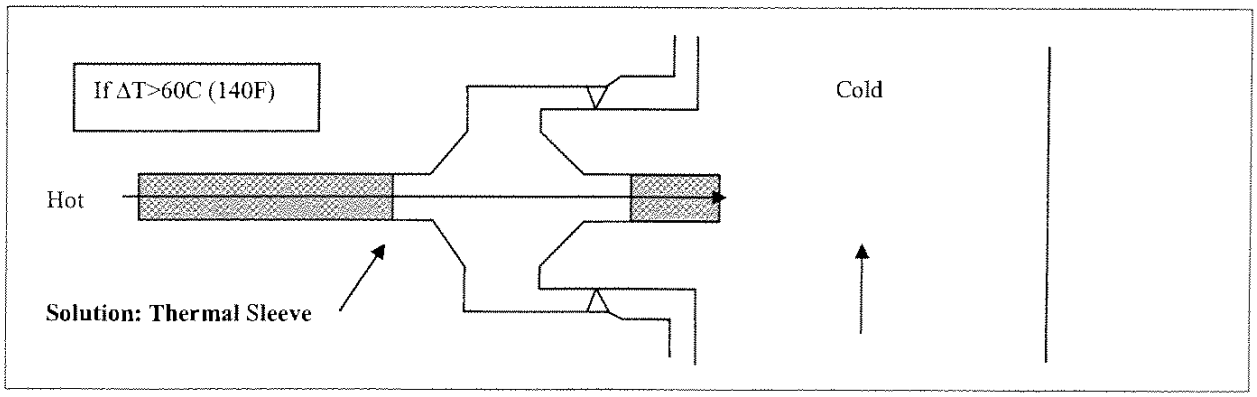
d) Use 6 degree-of-freedom anchors – see pipe anchors above

Caution: AVOID welding to the pressure boundary: to avoid additional analysis for fatigue effects of attachments.

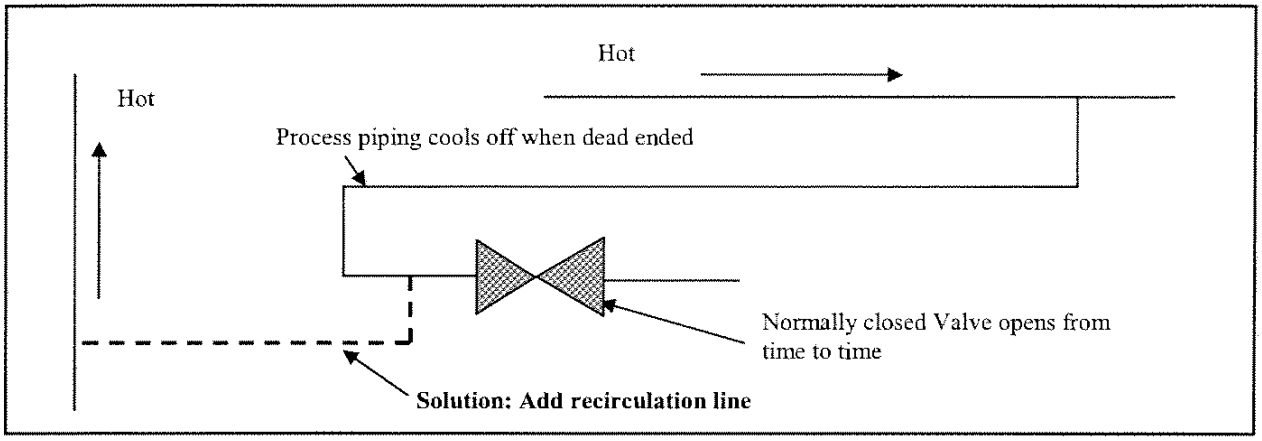
B.6 Identifying Threats to Pipe Life

B.6*Threat # 1:* Locations of hot/cold mixing i.e. at branch connections, piping/equipment interfaces

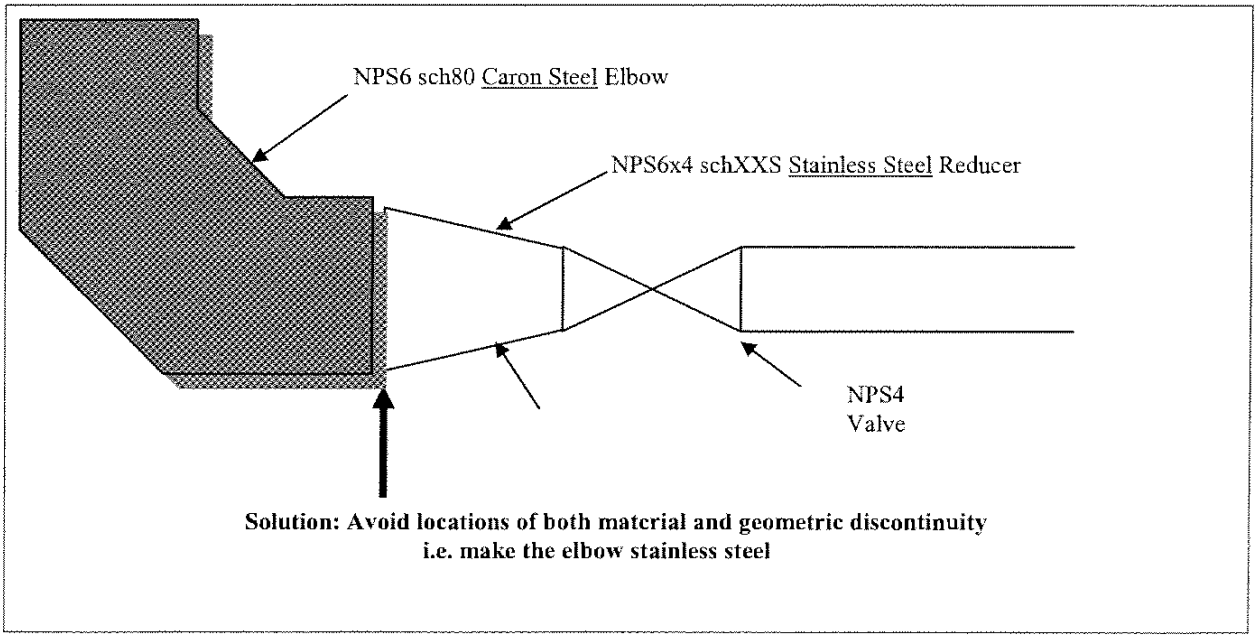
Identify these locations and prepare an appropriate design to avoid fatigue failures



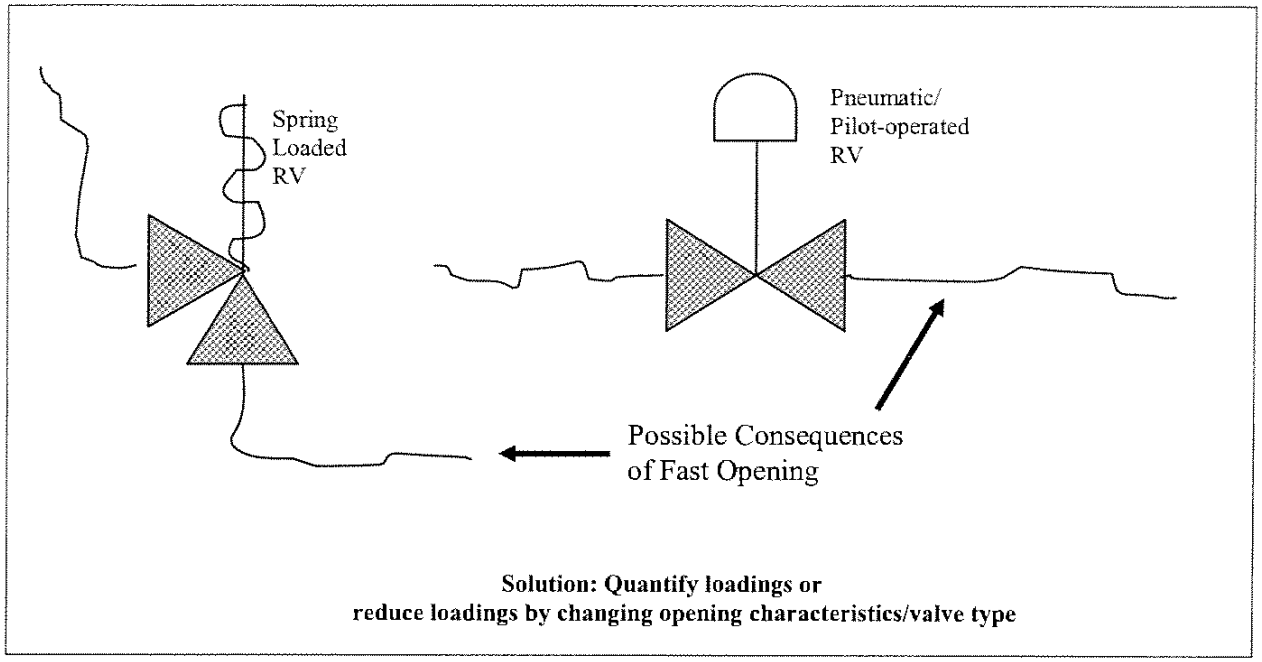
B.6 *Threat # 2:* Dead Ended Lines with intermittent flow
Many recirculation lines had to be added to eliminate thermal shock in dead ended lines where a normally closed valve opens from time to time. These secondary lines added a lot more piping but were needed to preserve the fatigue life of the process piping.



B.6 *Threat # 3:* Material/geometric discontinuities
Material and geometric discontinuities make for stress risers and are unavoidable. However, these two types of discontinuities should not be combined at a single location as is shown below

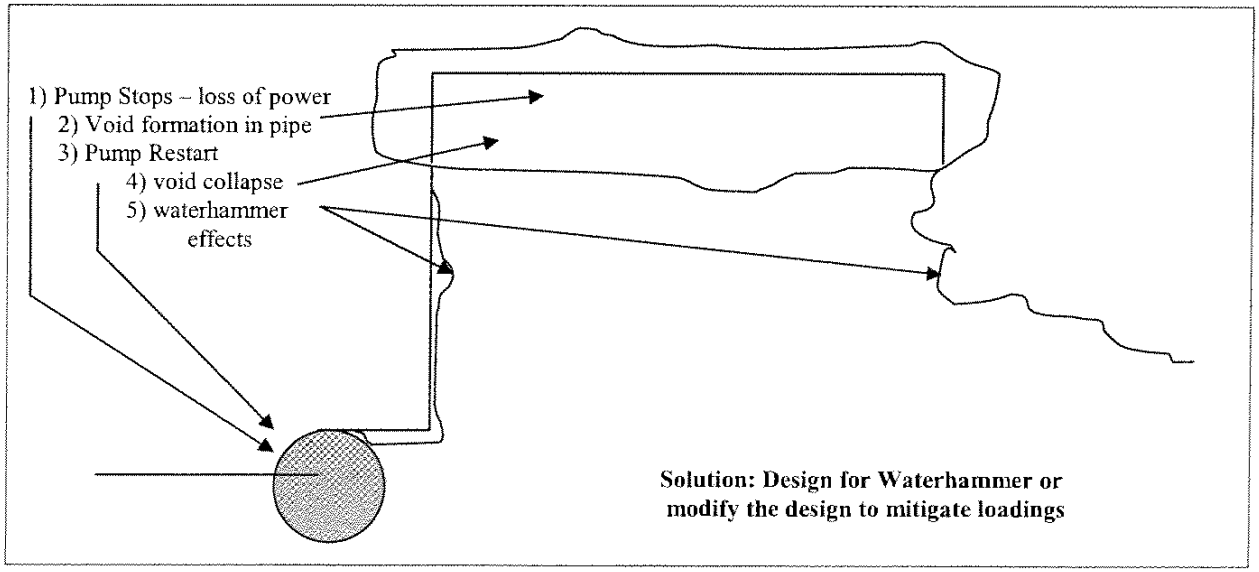


B.6 *Threat 4:* Relief Valve (RV) Operation – thrust load/waterhammer/chattering loads
The quick opening of valves and/or chattering can produce waterhammer. This must be quantified/eliminated by examining/adjusting the valve opening characteristics of C_v vs. stem position and stem position vs. time. Chattering may require a different solution i.e. a process change from the process designer, etc



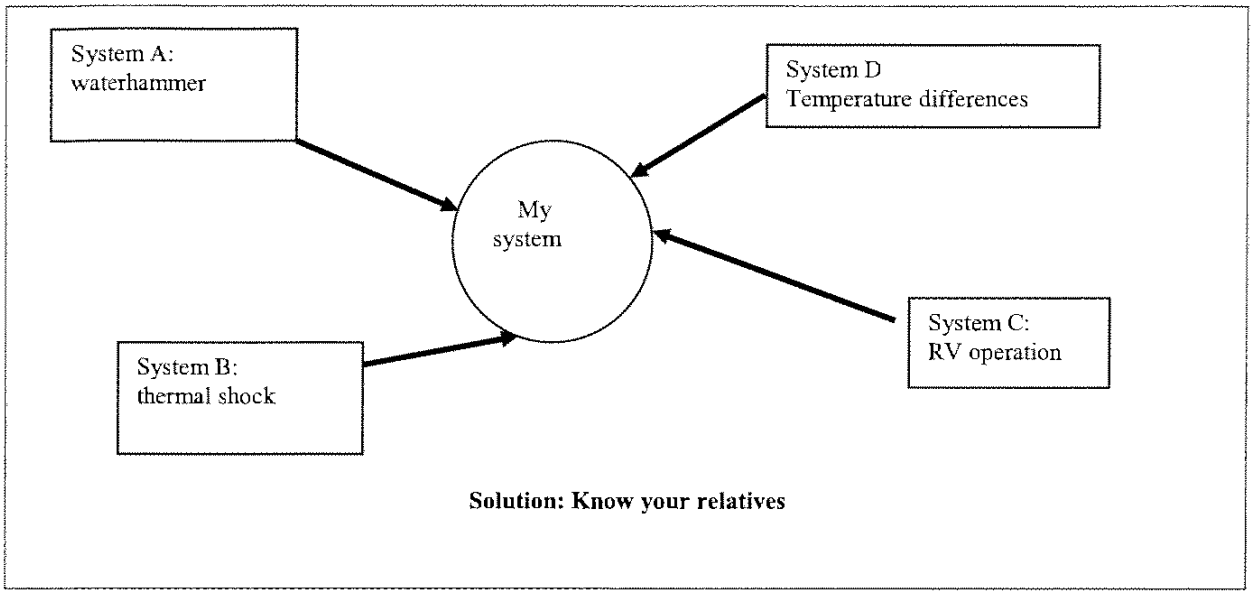
Solution: Quantify loadings or reduce loadings by changing opening characteristics/valve type

B.6 *Threat 5:* Active Component Change-of-State
When an active component like a pump or valve changes state i.e. start/stop or open/close (as designed or from a postulated accident scenario), the potential consequences must be identified and quantified.



Solution: Design for Waterhammer or modify the design to mitigate loadings

B.6 *Threat 6:* Attached Systems – their influence
Piping systems are interconnected and attached systems can be the source of additional loadings to the system of interest. A broader perspective and knowing the context enabled me to start well.



Solution: Know your relatives

COMMUNICATE, COMMUNICATE, COMMUNICATE
I learned that to start well involved connecting with people by

C.1 Communicating Personally
The personal touch is invaluable, so learn to do it constructively

- Meet people face-to-face
- Know the team: computer support, civil designers, process designers, nuclear safety designers, human factors designers, operations/maintenance personnel, contractors
- Establish contacts
- Make friends – not enemies
- Encourage respect – earn respect

C.2 Communicating Permanently
A record of decisions and data transfer is a referenceable basis for design and repeat designs.

- In Reports
- In written Guidelines
- In calculations
- In emails

C.3 Communicating Piping Influences
Piping affects most other disciplines/stakeholders and they need to know what is happening to get their feedback in a timely manner

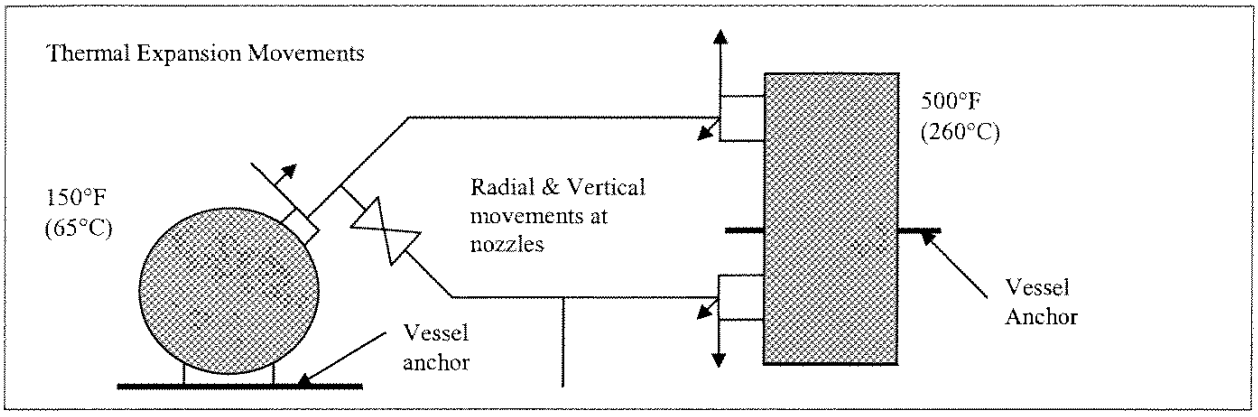
- Piping Needs – pipe anchors, pipe penetrations sealing/shielding, minimum stiffness , minimum strength requirements are to be commnnicated to structural designers, radiation control
- Piping Design Layout is to be shown to structural designers, nuclear safety, process designers, human factors engineers…..
- Piping Design Output in the form of piping support loads is to be communicated to structural designers, nozzles/anchorage loadings to equipment suppliers, stress resnlts to inspection personnel, etc

DETAILING THE DESIGN

I learned that "Nothing is fixed. Everything moves" by

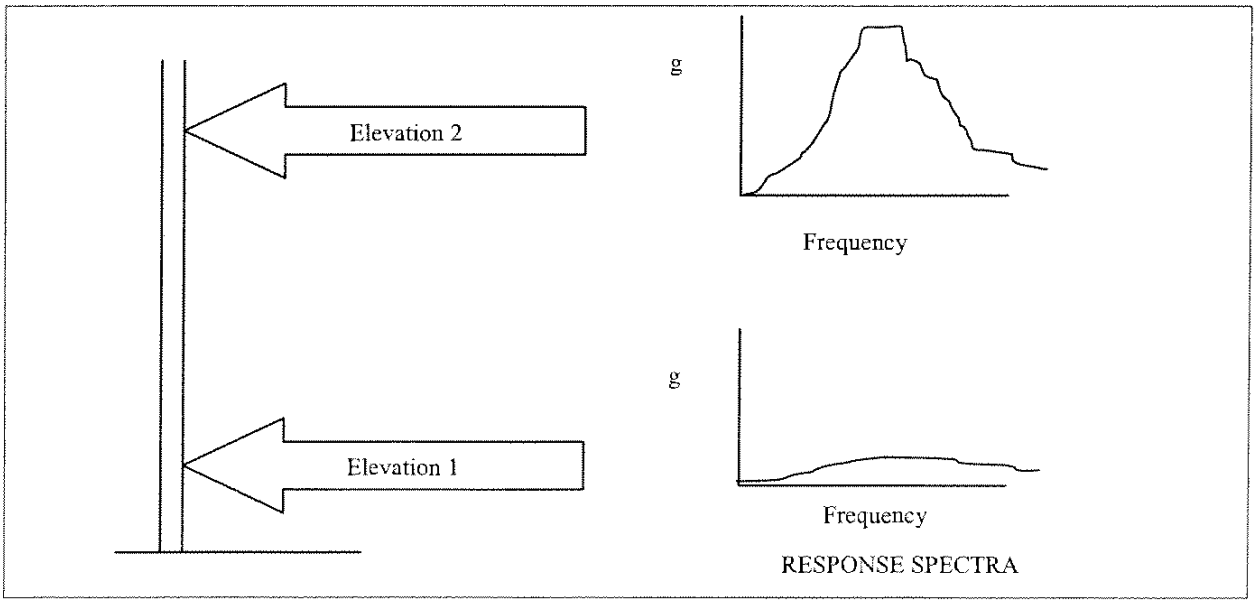
D.1 Identifying Thermal anchor/nozzle movements

Pipes will move at anchor points due to thermal movements of equipment. How the equipment nozzles move relative to each other and other reference point of pipe anchorage must be identified from equipment engineers.



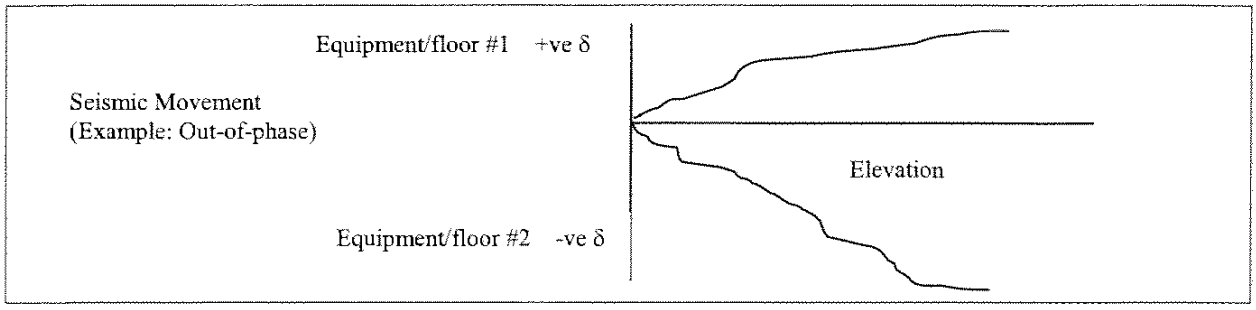
D.2 Identifying Seismic Loadings

Seismic response spectra/time-history are usually provided for equipment and structures. Additional seismic input may be needed at some specific locations of pipe connections to structures/equipment from the structural designers. Pipe support points can then be gronped according to the appropriate seismic excitation.



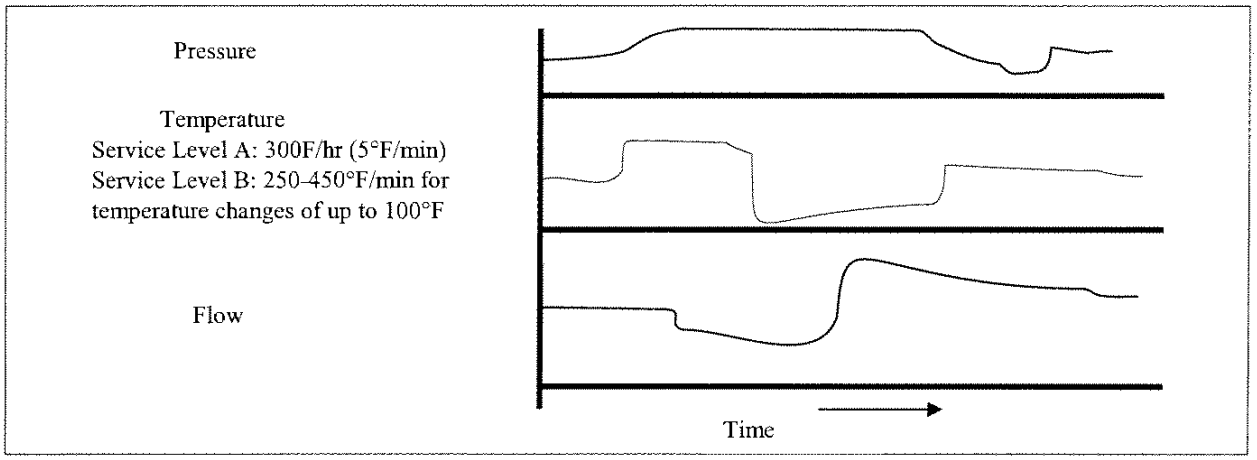
D.3 Identifying Seismic Movements & Phasing of Pipe Restraints

Points of piping support at walls, floors, eqnipment, and steel structures move relative to each other in a seismic event and this mnst be identified. Stiffnesses of structures may need to be increased. Pipe anchor points will move with the structure and increase/decrease pipe stress accordingly. Communicate with structural designers to determine in-phase/out-of-phase structnres/equipment. Since there will be more than one structural analysis model, phasing between separate structural models also needs to be identified. Then the piping designer can group pipe support movements that are in-phase in each of the three translation directions and also determine the phasing between groups and directions.



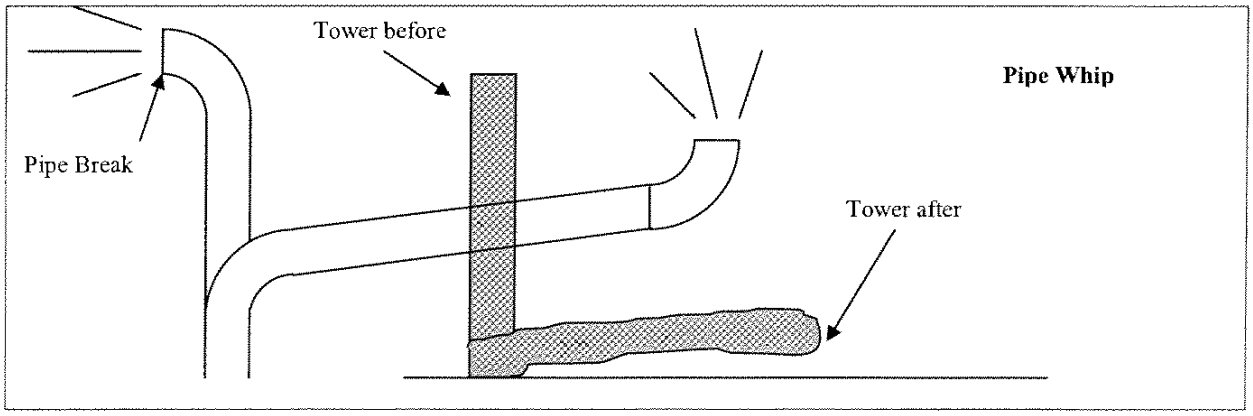
D.4 Identifying Pressure/temperature/flow Transients for fatigue effects

Fluid pressure/temperature/flow changes induce stresses in the wall of the pipe/fittings creating fatigue. The faster the changes, the more fatigue damage is done to the pipe fittings and may require negotiations with the process designer to modify the process or procedure or the piping designer may have to modify the piping design.



D.5 Identifying Special (exciting) Loadings

Loadings from Main Steam Line Break (MSLB), Pipe Whip, rail line blast, tornado, flooding, etc are identified by communicating with the Nuclear Safety to understand/develop the postulated failure scenario and protection needed.



SUMMARY

I learned that 'How to Start Well' as a Piping Designer involved knowing my stakeholders and to remember Assumptions - Beware; Ballpark the design (boundaries), Communicate, communicates, communicate and Detail the design.