PIPINGSOLUTIONS, INC.
6219 Brittmoore Road, Houston, Texas 77041-5114
Telephone: 1-713-849-3366 * FAX: 1-713-849-3654 * E-Mail: info@pipingsolutions.com

Piping Stress Analysis – Where do I start?

The following information will take you step-by-step through the logic of the data collection effort that should occur prior to beginning to model a piping system for a stress analysis:

1. First of all, prior to starting to build a piping model it is imperative to sort out what you wish to achieve in any analysis. The following questions may assist you in determining the reasoning for conducting a piping stress analysis:
   a) Are you interested in performing a piping stress analysis to evaluate the stresses in a specific piping system and to determine if these stresses are within the range allowed by the Piping Code?
   b) Are you interested in performing a piping stress analysis to evaluate the loads on a piece of rotating equipment?
   c) Are you interested in performing a piping stress analysis to evaluate the loads on a heat exchanger, pressure vessel or tank nozzle?
   d) Are you interested in performing a piping stress analysis to evaluate the loads on one or structural anchors?
   e) Are you interested in performing a piping stress analysis to evaluate the loads on one or more pipe supports?
   f) Are you interested in performing a piping stress analysis to evaluate the movements of portions of the piping system due to thermal growth or contraction?
   g) Are you interested in performing a piping stress analysis to evaluate the effects of wind loads on the piping system and/or attached equipment?
   h) Are you interested in performing a piping stress analysis to evaluate the effects of earthquake loads on the piping system and/or attached equipment?
   i) Are you interested in performing a piping stress analysis to evaluate the effects of wave loading on the piping system and/or attached equipment?
   j) Are you interested in performing a piping stress analysis to evaluate the effects of soil resistance to movement for underground or buried piping system and/or any attached equipment?
   k) Are you interested in performing a piping stress analysis to evaluate the effects of changes in temperature, pressure and weight on flanged couplings and to determine if there is a tendency for the connections to leak?

Once these questions have been answered, then check each of the following steps.

2. Determine which piping code will govern the design of the piping system.
3. Collect all the plan and elevation drawings necessary to fully document the piping routing.
4. Obtain or construct an isometric drawing of the entire piping system. If you have several piping isometrics documenting different parts of the piping system, make sure that the North arrow orientation is the same on all such isometrics. If they are different, re-draw those piping isometrics that are necessary to have all North arrow orientations the same on all isometrics.
5. Collect all the necessary physical properties for all of the piping components in the piping system as follows:
   a) Nominal Pipe Diameter or Actual Outside Diameter, if the Pipe is Non-Standard.
   b) Pipe Schedule or Pipe Wall Thickness.
   c) Corrosion Allowance.

d) The Specific Gravity of the contents of the pipe or the Weight per unit length of the contents.
e) The Insulation Material or Insulation Density and Thickness or the Insulation weight per linear unit length.
f) Piping Material or piping material density, modulus of elasticity and coefficient of expansion.
g) Operating Temperature (Minimum and maximum, if applicable), Design Temperature, Upset Condition Temperature and Base or Ambient Temperature.
h) Operating Pressure (Internal or External), Design Pressure and Upset Condition Pressure.
i) Flange Rating and Flange Type or Flange Weight and Length.
j) Valve Type (Gate, Globe, Butterfly, etc.) Rating or Valve Weight and Length.
k) Elbows and/or Bends Radius or Bend Radius Ratio, Fitting Thickness and the number of miter points, if applicable.
l) Reducer length, inlet and outlet diameters, schedule or wall thickness, concentric or eccentric and, if eccentric, the flat side orientation.
m) Branch Connections - welding tee, weld-in contour insert, weld-on fitting, fabricated tee with the reinforcing pad thickness, extruded tee with the crotch radius or lateral fitting data.
n) Expansion Joint Properties – Translational Spring Constants in force/unit length of travel – Axial and Lateral or Shear and Rotational Spring Constants in moment/degree of rotation – About the axis of the expansion joint (normally considered to be totally rigid) and about the radial axes. The length of the bellows component is needed and in the event that the expansion joints are not oriented along one of the axes of the X, Y, Z axis system, the angles required to define the skewed orientation will also be required. Further information is required. The length between tie rods is necessary as well as whether or not nuts are on the tie rods to restrict extension as well as compression in the expansion joint. The pressure thrust area is required in the event that tie rods do not restrain axial movements. If an expansion joint is hinged or gimbaled, then the orientation of the hinge or gimbal axes is required.
o) Structural Members – Any structural member that is welded or bolted to the piping system and is expected to act as part of the piping system must be defined. If the structural member is a standard structural shape, then the designation is required along with the orientation with regards to the X, Y, Z axis system. If the structural member is not a standard structural shape, then the moments of inertia about each axis is required along with the polar moment of inertia, the cross sectional area, and the distance from the member centerline to the outer surface. If the structural member is skewed, then the orientation with regards to the X, Y, Z axis system is also required.

6. For all Anchors, the following data is required. The location of the anchor point in the piping system. A complete definition of the equipment or structure to which the piping system is connected. If a small piping system is connected to a strong beam, column or anchor block, then the anchor can be considered to be rigid. If a large pipe, say 24”, is anchored to an 8x13 beam, relatively flexible, then the anchor should be defined as a flexible anchor and the flexibilities of the structural member should be calculated and entered. If the anchor point is a nozzle on a pressure vessel, tank or heat exchanger, the flexibility of the nozzle may need to be entered should the stress level in the piping system

be computed to be too high. And the stress level in the nozzle to shell connection in the pressure vessel, tank or heat exchanger may need to be evaluated for an over stressed condition. In addition, equipment operating at a specific temperature will expand or contract from the ambient conditions. Therefore, the drawings for all connected equipment should be obtained. The lengths from the actual anchor point on the connected equipment are required as well as the temperature of the connected equipment. If the connected equipment is a piece of rotating equipment, the nozzles are considered to be completely rigid, but the casing will expand or contract from the ambient conditions to the operating conditions.

7. For all restraints, the following data is required. The location of each restraint acting on the piping system must be defined as well as the specifics as to how each restraint affects the piping system. The following discussion covers restraints acting along one of the X, Y, Z axes. If skewed restraints are in the piping system, then their orientation with respect to the X, Y, Z axis system must be defined.
   a) Translational Restraints - First of all, the axis along which or about which the restraint acts must be defined. If the restraint restricts movement along an axis (a translational restraint), then you must be able to define if the restraint acts in one direction along the axis or if it works in both directions along the axis and obviously if in only one direction, which one it is.
   b) Limit Stops - If the restraint allows a certain amount of movement and then restrains the pipe, this is known as a limit stop. For limit stops, the action axis must be defined as well as how much movement is to be allowed in the plus and minus directions along the specified axis. Further, when the limit is encountered, the stiffness of the resistance must be defined. Normally, a limit stop allows movement to a point and then stops the piping from going any further. In some cases, when a limit stop is encountered, the resistance to further movement is defined by a spring constant.
   c) Imposed Movements – If a movement is to be imposed on the piping system, the amount of the movement and the direction of the movement must be defined.
   d) Imposed Forces – If a force is to be imposed on the piping system, the amount of the force and the direction of action of the force must be defined. In addition, when the force is imposed, the force may have a spring constant associated with it. In other words, if a force is applied to the piping system and the force changes as piping system movement occurs, then the change in the force per unit of movement (spring constant) must be defined.
   e) Dampers – In the event that a restraint acting on a piping system allows gradual movements but resist impulse movements, this is commonly referred to as a damper or a snubber. In the event that dampers or snubbers are included in a piping system, the axis of action must be defined as well as the maximum load that can be resisted.
   f) Frictional Resistance to Movement – When frictional resistance can significantly influence the results of a piping stress analysis, it should be considered. The plane in which frictional resistance acts as well as the dynamic and static coefficients of friction should be defined.
   g) Existing Spring Hangers – When spring hangers have been installed in a piping system and a new piping stress analysis study is to be processed, the spring constant of the spring hanger must be known as well as the installed load, the operating load and the minimum and maximum loads that the spring hanger will successfully handle. It is also necessary to know if the spring hanger is attached from above and if lateral movement is

allowed by the support rod(s) and to what limit, if any. If the spring hanger is actually a support, then the limit of lateral movement should be defined and if a low friction bearing has been placed on top of the spring support. If a low friction bearing has been used, then the coefficient of friction must also be defined.

h) New Spring Hangers to be Designed – When spring hangers are to be sized and selected, the number of spring hangers to be located at that support point must be defined. Usually one spring hanger is to be placed at each support point. Occasionally because of restricted headroom, a trapeze assembly with two spring hangers providing support will be used. In addition to the number of spring hangers, the desired manufacturer should be defined as well as the desired maximum load variation.

i) Rotational Restraints - If the restraint restricts movement about an axis (a rotational restraint), then axis about which rotation is restrained must be defined.

j) Imposed Rotations – If a rotation is to be imposed on the piping system, the amount of the rotation and the direction of the rotation must be defined.

k) Imposed Moments – If a moment is to be imposed on the piping system, the amount of the moment and the direction of action of the moment must be defined. In addition, when the moment is imposed, the moment may have a spring constant associated with it. In other words, if a moment is applied to the piping system and the moment changes as piping system rotation occurs, then the change in the moment per unit of rotation (spring constant) must be defined.

8. Special Effects such as cold spring must be defined. First, the location of the cold spring in the piping system must be specified. This must include the direction or directions of the cold spring. Cold spring along the X axis, the Y axis and the Z axis can be placed in a piping system. Then it must be specified whether the cold spring is a Cut Short or a Cut Long. In addition, the amount of the cut short or cut long must also be specified.
9. Special Loading Conditions

a) Wind Loading – When wind loads are to be considered in an analysis, the piping components on which the wind loads are to be applied must be identified. TRIFLEX calculates wind exposure and does not apply wind loads on a piping component when the axis of the component and the wind are coincident. To define wind loads, the direction of the wind loads with respect to the X, Y, Z axes must be defined. Then the magnitude of the wind loads must be quantified as a wind speed or a pressure per unit of surface area and a shape factor or a load per unit of length of the piping component.

b) Wave Loading – When wave loads are to be considered in an analysis, the piping components on which the wave loads are to be applied must be identified. TRIFLEX calculates wave exposure and does not apply wave loads on a piping component when the axis of the component and the wave are coincident. To define wave loads, the direction of the wave loads with respect to the X, Y, Z axes must be defined. Then the magnitude of the wave loads must be quantified as a wave speed or a pressure per unit of surface area and a shape factor or a load per unit of length of the piping component.

c) Uniform Loads such as Snow and Ice - When uniform loads are to be considered in an analysis, the piping components on which the uniform loads are to be applied must be identified. TRIFLEX applies uniform loads on a piping component as defined by the analyst. To define uniform loads, the direction of the uniform loads with respect to the X, Y, Z axes must be defined. Then the magnitude of the uniform loads must be quantified as a load per unit of length of the piping component.

d) Seismic Loads - When seismic loads are to be considered in an analysis, the magnitude of the loading must be quantified and a decision as to the analysis method to be employed must be made. When seismic loads are to be evaluated in a static analysis, they are to be defined as a percentage of gravity along the X, Y, and Z axes. The percentages should be identified and the various combinations of loading conditions should also be identified.
e) Soil Interaction – When soil loading is to be considered, the piping components on which the soil interaction is to be modeled must be identified. The analyst can elect to calculate and enter spring constants to simulate the soil stiffness. Stepped stiffnesses may be entered if required because of the movement and the soil properties. Alternatively, the analyst may employ the guidelines published in the B31.1 Power Piping Code. When using these guidelines, the following data will be required: Soil Density, the Type of Backfill, the Depth of the Trench, the Width of the Trench, the Load Coefficient, the Horizontal Stiffness Factor and the Axial Friction Coefficient.

10. Once all the physical data has been collected, the Global (overall) Axis System (X, Y, Z) must be oriented on the isometric drawing for easy reference. (The standard right-hand rule axis system is used with Y being the vertical axis. All weight calculations are based upon gravity exerting a negative Y force on the piping system.)
11. Now you are ready to begin assigning data point numbers to all pertinent piping components in the piping system. All such data point numbers should be placed on the isometric drawing. A data point must be assigned to any location in the system for which output data is desired. The data point describes the specific location in the system and the preceding segment of the piping system. Assign a data point number at each blind end or nozzle (which begins a Branch). Even if an Anchor is totally free to move and rotate, it will still be specified as an Anchor point at the beginning of a branch.