PIPE RISERS
GENERAL DESCRIPTION

In practice, pipe riser Isolation is used for one or both of two functions. The first is to isolate the pipe from the structure and thereby minimize the noise and vibration transmitted into the structure by the vibrations that may be carried along the riser itself. The second, more common reason is to address the issue of relative expansion and contraction between the piping and the structure.

As there is nothing special about the vibration isolation application, this document will address the more specialized expansion/contraction issue.

Expansion or contraction occurs when in service, the fluid carried by the pipe is either heated or cooled. As the temperature of the pipe shifts away from the temperature of the structure, the pipe will either grow or shrink relative to it as well. As risers tend to be relatively long, a few degrees of temperature change can often result in as much as an inch length variation. If the pipe was to be hard-mounted, this growth or shrinkage could damage the riser, the support structure, or both.

The use of spring coils for riser support allows the pipe to grow or shrink with a minimal change in the support forces. Higher deflection coils allow greater expansion of contraction of the pipe where lower deflection coils allow less. Pads allow virtually none and hard mounting allows none at all. The appropriate suspension system needs to be selected based on a number of different factors that can vary from project to project.

<u>Riser Arrangement Options and Trade-offs</u>

The first factor of significant impact is whether the riser is made up of a single hard-connected Pipe system or multiple segments: A hard-connected single pipe riser is made up of lengths of pipe that are welded, hard bolted or otherwise locked together. A Multiple segment riser is made up of smaller lengths of pipe that are interconnected with expansion joints or couplings that allow relative motion. Where a single pipe system is used, the riser will expand and contract as a unit. Forces can be transferred up and down its length as desired and all expansions or contraction will be additive and will affect the total length of the riser system. A riser made up of multiple pipe segments joined be expansive couplings will not behave as a unit. Each segment will expand and contract and move independently. Forces cannot be transferred through the couplings, but will have to be absorbed in the segment in which they are generated.

The second key factor is whether the riser is anchored versus non-anchored: Anchoring the system will “fix” the anchorage point. Each pipe segment in the riser can have at most one anchorage point, but need not have any. To prevent expansion couplings from collapsing and becoming damaged, most multiple segment risers (as described above) will have an independent anchor on each segment. There are typically two benefits to anchoring, the first is that overall motion of the riser is limited (simplifying interfacing with it) and second, significant variations in weight can be absorbed by the anchor (and properly located, not transferred into the pipe itself as added stress).

Expansion or Contraction: If the system has a high operating temperature relative to the support structure, it will expand. If the temperature is low, it will contract. This can impact the desired

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location for the anchor and the isolator selection as indicated below.

Restrained spring isolators can be pre-adjusted and will, if properly applied, protect the riser from the excessive forces that would be generated by unrestrained coils (necessary to support the water) when the riser is empty. When using Restrained coils, it is critical that the riser system be designed such that in service, deflection on these coils always increases and never decreases. See also below.

Bottom Anchored systems will, if hot, grow from the bottom. If using non-restrained support coils above the anchor, these can be pre-loaded through the pipe against the anchor during installation and no significant issues are likely to result except that it will try to lift the anchor off the floor. If the coils are restrained coils however, uplift loads will be eliminated from the anchor, but in service the pipe will grow and since the isolators will be "locked out" by the restraint hardware and damage would result. This is not a good combination.

On the other hand, if the system is a cold system, the opposite would be true. The non-restrained coils would behave as above with no significant change. Restrained coils would now work as, with the drop in temperature, the shrinkage in the pipe would cause the coils to compress and come off of the restraint bolt, thereby picking up additional load.

The exact opposite is true of a Top anchored system. These work well for hot systems with restrained coils, but should not be used for cold systems with restrained coils.

Ideal Riser Design

From a piping standpoint, minimum stresses can be obtained through the use of an anchored system. Generally Isolators should be designed to support the weight load of the pipe. In cases where there is a section change in the pipe, Isolators should also be designed to absorb the hydraulic thrust that is generated. If anchored at the bottom, the anchor should absorb the load generated by the water column without transferring the load "up the pipe". If anchored at the top, the bottom isolator should be a preloaded coil with sufficient capacity to absorb the water column load.

With this arrangement, the pipe in service, will be exposed to the lowest stresses possible and the large hydraulic load can be dissipated at the bottom of the structure rather than spreading it out over several floors and then bringing it back down through the structure.

The use of restrained isolators in this arrangement will further reduce stresses in the pipe and structure during the installation process.

While this is ideal from a riser standpoint, it requires that the structure be capable of taking a large point load at the bottom of the riser that often times they cannot.

Distributed Support Riser Design

Where a large concentrated load cannot be carried at the base, it is frequently necessary to distribute the support load "up the pipe". While this can be done, the forces generated by the hydraulic reaction at the bottom are carried upward through the wall of the pipe until they are

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dissipated. This kind of a distributed load design will not work well with piping that incorporates a series for expansion couplings as, depending on the coupling type, they are not capable of transferring the load.

Other Riser Designs

In some cases, risers need to be designed that may run hot or cold, there may be interfacing issues or other criteria that make either of the above arrangements less than ideal. In these cases, a special system comprised of various of the above elements needs to be designed to offer the best and least expensive arrangement.

INTERPRETING THE KINETICS RISER DESIGN MANUAL

Section R1.0 – Riser Load Drawings

Section R1.0 of the design manual illustrates the various forces that must be recognized when designing a riser system.

In general, forces having to do with the fluid are concentrated. These forces may be the result of weight or for steam systems, may result from pressure. The forces act at changes of section or direction of the piping system and can significantly impact local stresses that occur in the pipe itself.

On the other hand, loads having to do with the weight of the pipe are distributed. The forces in the pipe to balance them accumulate as one traverses up (or down) the pipe and except for localized hardware (valves or the like) are not concentrated.

Sections R1.1 through R1.4 - Relative Pipe Loads in Various Types of Riser Systems and Applications

Sections R1.1 through R1.4 offer general input on the loads that are present in riser systems of a wide range of design types. All of these documents include a schematic layout of the riser itself as well as “Empty” and “Filled” load charts.

Support points are illustrated with arrows. Expansion joints are breaks.

The “Empty” charts refer to forces in the installed pipe when properly adjusted and empty. The “Filled” charts refer to approximate forces in the same pipe with no additional adjustment when filled. Minor variations in these forces due to expansion or contraction while having to be addressed in practice, are not illustrated here.

To ensure compatibility between the charts, all are based on 12” standard weight pipe. (I used the 12” pipe because the weight of the steel in the pipe is approximately the same as the weight of the water in the pipe). The intent of these charts is to illustrate the approximate distribution of forces in a riser for any pipe size and hence the force values do not include units. The charts are however consistent between one another such that a value of +1 on one chart can be assumed to be 1/3 of the +3 value on a different chart. The sign convention is the “+” loads are tensile and “–“ loads are compressive.

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Notes on the bottom refer to application recommendations and cautions.

Section R1.1 offers general load information on base restrained, hard-connected piping systems.

Section R1.2 offers general load information on top restrained, hard-connected piping systems.

Section R1.3 offers general load information on piping systems with couplings or expansion Joints.

Section R1.4 offers general load information on non-restrained, hard-connected piping systems.

Section R1.5 offers guidance in the design of expansion loops for welded steel piping.

Section R2.1 through R2.6, Sample Riser Calculations

The R2.X Sections of the Manual offer typical output data sheets for various types of installations. The program used performs a single axis analysis and does not account for significant forces being imposed on the at riser horizontal connection interfaces. Where doglegs or expansion couplings occur in the riser, independent calculations for the segment above and below the dogleg or couplings are needed.

Header information on the data sheet includes the expansion coefficient, the presumed installed or ambient temperature, the max or min pipe operating temperature and the elevation of the anchor (if present). Also identified is whether or not there is a static head at the top of this riser and whether or not water is being supported. These are useful when working with a riser made up of several smaller segments with expansion connections in between. The last bit of header information is whether or not the fluid supported is liquid or gas. If this is a steam pipe, the weight of the steam is ignored in the calculation.

Shown on the left is typical data indicating the presence of isolators on the various floors. Floor heights are listed in the "Floor Ht" column with Elevation relative to the base in the next column. Pipe size in inches is also listed.

The columns headed "Local Pipe Weight" and "Local Liquid Weight" allow the weight for short, riser supported horizontal runs (or doglegs) to be inputted.

The "Initial Support Load" column is the resultant force generated by the empty pipe weight at each support location. In effect, if a support were to generate this much force at this location, the stresses in the pipe would be minimized.

The column identified as "Hyd Thrust" indicates loads that are introduced to the riser system at each elevation by hydraulic forces. These could be either water weight or pressure generated. A positive sign on these forces indicates that the force is trying to lift the riser while a negative sign indicates that it is trying to push the riser downward.

The next to columns indicate the combined spring rate of isolators at each support location and the initial deflection. In the case of restrained spring isolators, they could be bench set and installed. In the case of non-restrained isolators, they would need to be adjusted to this in the field.

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The “Initial support point force” is the actual support force at each isolator location in the installed condition (unfilled riser).

At this point the program introduces the temperature variable, allowing the pipe to expand or contract and then either works off the anchor (if anchored) or balances the system support loads against weight and hydraulic forces to determine spring deflections in the operating condition.

This data is presented in the column headed “Oper Sprg Defl or Disp”. The operating deflection of the springs is listed under this heading for floors with support isolators. At the top and bottom of the riser or where guides are fitted, the vertical displacement is indicated. “+” Dimensions indicate downward motion of final spring deflections. “-“ Dimensions indicate upward motion.

The Operating Support Load is listed in the “Oper Supt Pt Load” column. This would be the actual support force at each support point.

Lastly there are four summary columns. The first two indicate the Initial and Operating force in the pipe (with “+” being tensile and “-“ compression). The last two compute the stress in the pipe resulting from the operating and installation forces.

RISER SUPPORT COMPONENTS

Section R3.1 through R3.6 – Riser Support Components

Details and submittal information for the most commonly used riser support components is included in this section. This is not a comprehensive section as high deflection and extreme high capacity isolators have been omitted, but are none the less available.

INSTALLATION

Section R4.0 – Installation Procedures

Basic installation procedures for 4 generic Riser installation arrangements are addressed in this document along with more detailed installation instructions for Anchors and Guides.

SPECIFICATION

Section R5.0 – Recommended Long Form Riser Specifications

This provides a specification for use in obtaining an appropriate Riser support system for a particular installation.

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