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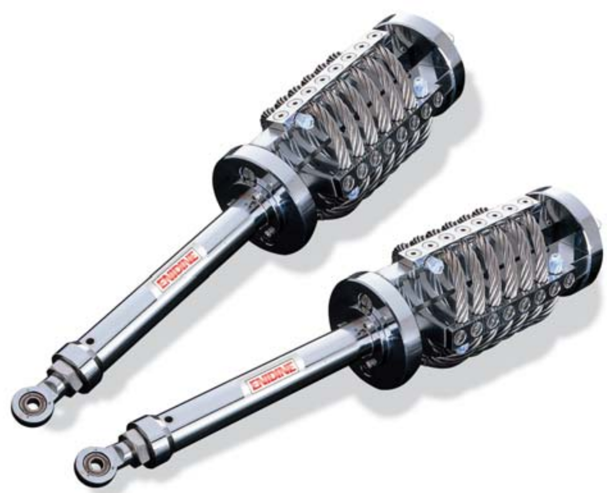
WEAR™ Restraint Structural Considerations

By Tom Zemanek

WEAR™ (Wire Energy Absorbing Rope) restraints are a single axis combined spring-dashpot device. In applications that incorporate WEAR™ restraints into a piping design to control steady state vibration, damping is added to the system by small displacements imparted into the WEAR™ unit. As a result, the structure that the WEAR™ restraint is connected to must have adequate stiffness in the direction of the restraint axis so the WEAR™ restraint deflects vs. the structure. The WEAR™ restraint and connecting structure act as two springs in series. If the structure is soft relative to the restraint, then the pipe steady state vibration pipe displacement will be imparted to the structure rather than the WEAR™ restraint. This results in two issues: first the structure is excited which is undesirable and second, the WEAR™ restraint imparts no damping to the piping system.



Good design practice is to connect the WEAR™ restraint to a structure, including any support auxiliary steel, with a stiffness that is an order of magnitude greater than the WEAR™ stiffness. To quantify this, the structural stiffness should be 10 times the WEAR™ tangential stiffness in the hot restraint position. Since the WEAR™ restraint is a non-linear device, the tangential stiffness varies with the position of the restraint.

The WEAR™ restraint is typically modeled as a Bi-Linear spring and Mid-stroke and Max-Stroke stiffness values are provided in the WEAR™ catalog. In most vibration applications, it is recommended that the hot restraint setting be equal to 50% of the restraints total half travel so as to maximize the amount of damping added to the system. Thus, for a restraint with a total travel of +1.5 inches, the recommended hot position would be either +0.75 inch or -0.75 inch depending on the growth direction of the pipe. A conservative estimate of the tangential stiffness at this setting is the published Max-Stroke Stiffness value for the particular restraint.

Thus, the recommended structural stiffness should be 10 times the Max-Stroke stiffness value provided in the WEAR™ catalog. Since this stiffness is an upper bound approximation of the tangential stiffness of the restraint in the hot position, a lower structural stiffness may be acceptable. As a minimum value, at least 5 times the Max-Stroke stiffness should be available for the structure including any restraint auxiliary steel utilized in the design. As an example, the recommended structural stiffness for a WEAR™ 24 kip with a +1.5 inch stoke would be 10 times 16,000 lb/in or 160,000 lb/inch with a minimum value of 5 times 160,000 or 80,000 lb/in.

Piping systems subjected to broad band flow induced vibration will typically respond in their fundamental frequencies. While high frequency excitation will be transmitted through the pipe, little high frequency response will occur in the pipe. Besides the added damping the WEAR™ restraint provides, it also has the benefit of acting as mechanical filter that isolates the transmission of vibration to the connecting structure. The amount of isolation depends on the tangential stiffness of the restraint and the mass of the pipe it is restraining. In general, the transmission of high frequency vibration to the structure will be isolated by means of the WEAR™ restraint. Minimizing the structural response to low frequency inputs at WEAR™ locations is done by insuring the structure has adequate stiffness so low frequency structural deflections are negligible. Excitation of the structure can result in structural fatigue issues and unwanted vibration perception issues with plant personnel.

The transmission of vibration to the structure is minimized by the use of WEAR™ restraints vs. rigid or snubber devices because of its isolation properties. By connecting to structures that are very stiff relative to the WEAR™ restraint, the possibility of a low frequency structural response is further reduced.

A common application of the WEAR™ restraint is the reduction of steady state vibration of Main Steam systems in power plants. Examples include the Farley, San Onofre and the Wol-Song Nuclear plants and the Labadie and Tenaska Fossil Fuel power plants. Often times, the concrete turbine pedestal is utilized as the supporting structure as exemplified in Figure 1. In this case, the legs of the concrete turbine pedestal are used as the primary mounting structure for the WEAR™ restraints. This provides a very stiff structure for mounting the WEAR™ restraint that will have a negligible response to the low frequency WEAR™ inputs. In this case, the stiffness of the auxiliary steel becomes the limiting structural stiffness. Connection to very stiff structures such as a concrete turbine pedestal also minimizes the possibility of vibration issues with rotating equipment supported by the connecting structure.

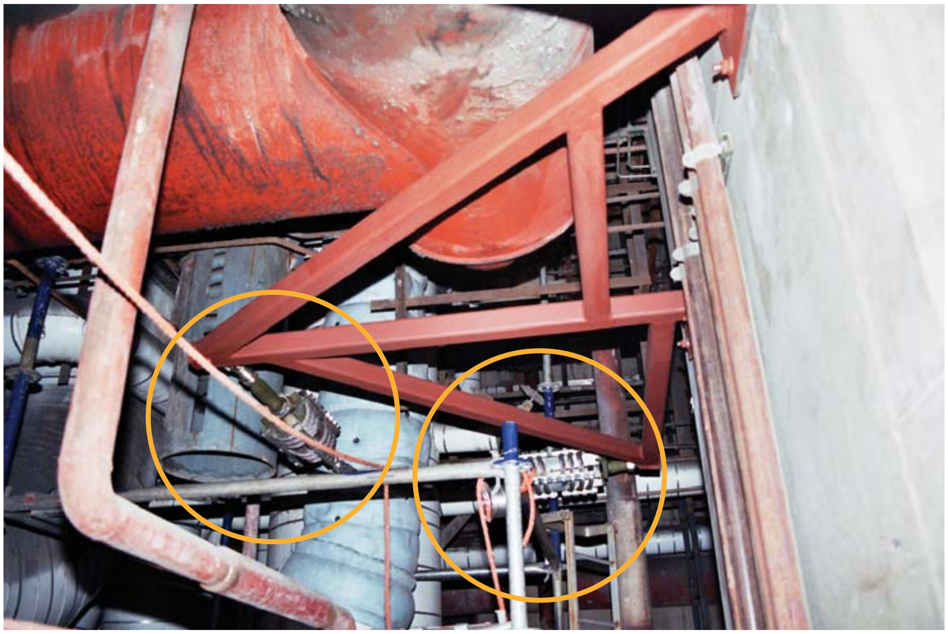


FIGURE 1 – Turbine Pedestal WEAR™ Supporting Structure