Schwingungsisolierungen

Pipework Dampers

Technical Report

July 1997

Dr. Frank Barutzki
Dr. Karl-Heinz Reinsch

TABLE OF CONTENTS

GERB Innovations

GERB Vibration Control Systems was founded in 1907 to provide vibration and structure-borne noise control for machinery and other equipment.

GERB has published many papers and has received many patents over the decades.

The pipework damper is an off-shoot of standard Viscodampers, which have been used for more than 50 years parallel to helical spring systems in machine foundation support. The development of pipework dampers in the seventies started with the request of power plant customers to provide a low price and maintenance-free replacement of snubbers without the well-known disadvantages of those elements.

The development took several years and ended in 1981 in a first TÜV certification, which allows the application of pipework dampers in nuclear plants as standard elements.

Different to standard pipework dampers below machine foundations, the pipework damper has to take heat expansion, has to stay functional at high temperatures, and should provide typically higher damping. In a response to special requests of pipework designers, pipework dampers are continuously further developed. This relates, for example, to

- improving and adapting the selection methods to the latest dynamic analysis methods for piping systems,
- changes in the Viscoliquid as far as temperature dependency, load capacity, and tolerances in the damping resistance are concerned,
- pipework dampers specially designed, for example, for high heat expansion.

GERB will always accept ideas, which may lead to an improvement of the product or this technical documentation.

1 Vibration Isolation - Vibration Damping

Certain basic knowledge of vibration control is necessary to understand dampers and how they work in general and especially pipework dampers. This includes the difference between vibration isolation and vibration damping.

Vibration isolation reduces the transmission of shock-type, random, or periodical dynamic loads to protect the surroundings from, for example, a machine causing such dynamic loads (active isolation) or to protect a building or a sensitive machine against incoming vibrations (passive isolation). In both cases the system is placed on springs or other elastic elements.

A machine on a conventional foundation will send its dynamic loads unaffected into the ground. In elastically supported equipment, a major part of those dynamic loads is transferred into kinetic energy causing periodical motion of that equipment, while only a minor percentage of the dynamic loads is transmitted via the springs. One of the main requirements in the design of vibration control systems for equipment is to keep its motion in permissible limits during operation. This requirement can be achieved by either adding mass to the system or by additional damping.

Damping will transfer part of the dynamic energy into heat, but depending on the amount of critical damping for the system, dampers will also transmit dynamic loads, something what pure elastic support wants to prevent. The efficiency of a vibration control system is, therefore, influenced by damping and vibration control, in reality a compromise between the transmission of dynamic loads and permissible motion of the elastically supported system.

In a typical GERB system, helical springs provide the elasticity while damping is provided by separate Viscodampers. This permits a perfect fine-tuning of parameters stiffness and damping.

The design requirements for piping systems are different. Caused by periodical or shock excitation during normal operation or in emergency cases, the piping system may be damaged by resulting non-permissible high dynamic displacements. Pipework dampers are designed to prevent such displacements in areas where heat expansion prevents fix points.

Different to standard vibration control, forces transmitted from the piping system into the substructure are not reduced, only the dynamic displacements in the piping system itself will be limited to a permissible range. The loads transmitted from the piping via the pipework dampers into the substructure are here deliberately accepted.

2 Design, Reaction, and Properties of Pipework Dampers

Pipework dampers consist of the housing, the Viscoliquid, and the piston **(fig. 2.1)**. The piston, dipping into the Viscoliquid, can move in all directions. Damping is, therefore, possible in all six degrees of freedom.

For small deflections, for example caused by operational vibrations, damper forces are a result of shearing the Viscoliquid. Friction between piston and Viscoliquid is of minor importance. Only in case of high deflections, for example as a result of heat expansion of the piping system, displacement effects will occur in addition.

The damper forces

$$F \approx r \times v \qquad \textbf{(2.1)}$$

are proportional to the relative velocity v between the damper piston and the damper housing. The proportionality factor r (N/(m/s) = Ns/m) is called the damping resistance and depends on frequency

$$r = r(f) \qquad \textbf{(2.2)}$$

Since one damper part is usually not moving, calculations are based upon the absolute velocity of the damper piston or the damper housing and not upon the relative velocity between those two parts.

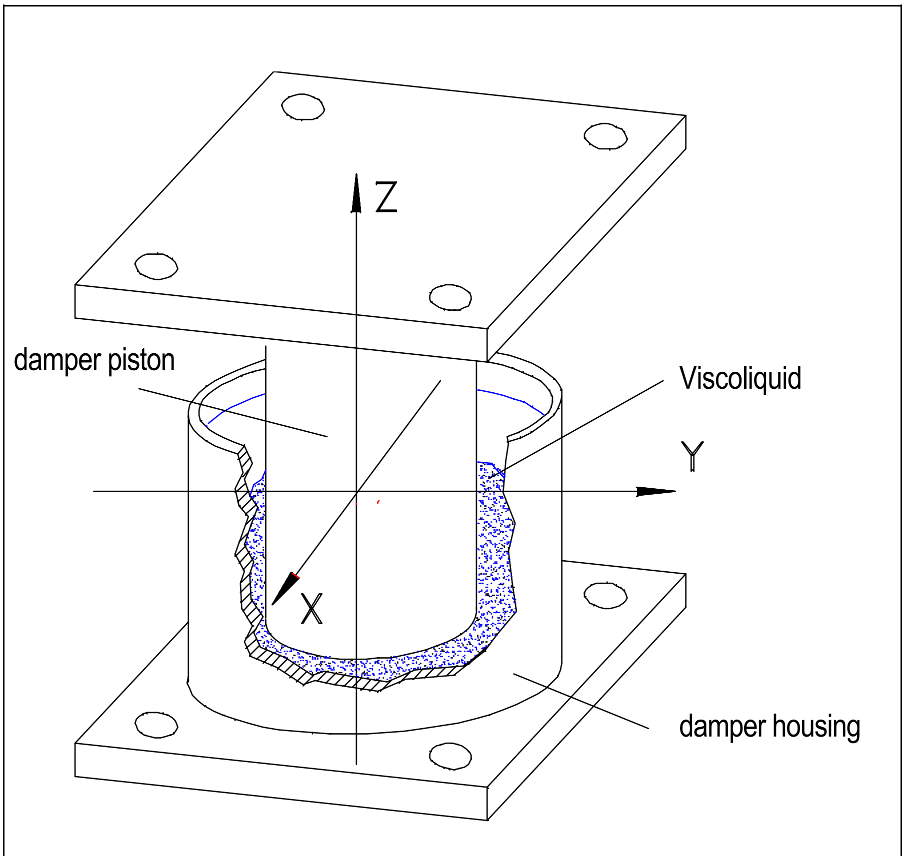

Fig. 2.1 Pipework Damper

Owing to the fact that pipework dampers react velocity-proportional, they cannot be used to support static loads.

The most important properties of pipework dampers are:

a) They respond without clearance, time delay, or minimal response deflection

The damper piston is always in contact with the Viscoliquid so that the pipework damper responds as a support without clearance, time delay, or minimal deflection. Damping resistance is always proportional to the relative velocity between the damper piston and housing.

b) High resistance under shock load

The pipework damper develops a high resistance against high input velocities in emergency cases. Inadmissible deflections of the pipework, caused, for instance, by earthquakes, aircraft impact, or pressure pulses, are thus suppressed.

Since the pipework damper reacts without delay, reaction begins already in the initial phase of the shock parallel to the increasing shock velocity. This leads to a smooth reaction of the piping system. The pipework damper develops its energy dissipating properties already at a time where snubbers, for example, don’t yet react **(fig. 2.2)**.

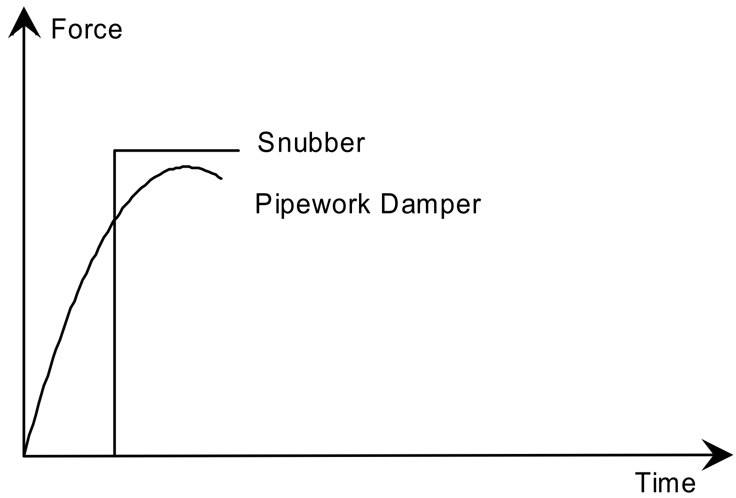

Fig. 2.2 Time/Force Reaction Diagram of Snubbers and Pipework Dampers

c) Transition from an emergency case to normal operation with no recovery time

Pipework dampers will react to operational vibrations immediately after a case of emergency and permit motion of the pipework since the damper piston and the Viscoliquid always remain in contact. Since the elasticity of the piping system remains, secondary damage can be prevented and internal damping of the piping system can be used for additional energy dissipation.

d) Permissibility of overloading the Viscoliquid

Even if the load limits are exceeded, the pipework damper will return to normal operation again after a brief regeneration period. Replacement of the Viscoliquid is not necessary.

e) Damping of operational vibrations

Modal system damping of piping systems is usually assumed to be 2 - 5 % of critical damping depending on different guidelines. Pipework dampers will provide in their locations additional velocity proportional damping. This will lead to an increased system damping, if type, size, and location of the pipework dampers are properly selected. Pipework dampers will, therefore, not only respond in emergency cases, but will also reduce operational vibrations.

f) Low damper forces when subject to slow motion

Pipework deflections resulting from thermal expansion are not restricted because of low expansion velocity.

g) Reaction in all degrees of freedom

Pipework dampers will react in all degrees of freedom at the same time. It is not necessary to use separate elements for different degrees of freedom.

h) No requirement of maintenance

Pipework dampers are expected to require no maintenance at least for a period of 40 years, because of their simple design and the lack of mechanical wear and tear parts. The Viscoliquid is resistant to aging for the same period.

3 Range and Limits of Pipework Damper Applications

Pipework dampers can be used, because of their properties, to overcome numerous dynamic pipework problems, for example in a replacement of snubbers and in damping operational vibrations.

Main application areas are condensate piping, feed-water piping, main steam lines, hydraulic piping, live steam lines, and dust channels of coal mills.

The production is based on a QA system as well as on a performance certification by the German Technical Inspection Authority (TÜV) and the Swedish S.A., which permit the application of pipework dampers type VES as a standard component even in nuclear facilities.

Standard pipework dampers are available for nominal loads up to 100 kN. Because of the reaction without time delay, it is possible to distribute dynamic loads on to several dampers. Single loads can be added in a linear way. Damping resistance, respectively the resulting system damping, depends on frequency.

Different Viscoliquids are available with very low, limited, and high temperature dependency. Temperature dependent Viscoliquid will provide in the same size damper the highest damping. Liquid with low temperature dependency is, on the other hand, of low viscosity and will, therefore, lead typically to bigger dampers and more complicated systems.

A major criteria in the selection of dampers with Viscoliquid of high temperature dependency is the so called operating temperature, which is the maximum temperature inside the Viscoliquid during continuous operation of the plant. It is typically much lower than the temperature inside the piping and depends in a major way on the ambient temperature.

The Viscoliquid will be adapted to the operating temperature and can be selected for temperature dependent Viscoliquid in the temperature range between 20 °C and 80 °C in steps of 10 °C.

Viscoliquid with limited temperature dependency can be used in the temperature range between -10 °C and 40 °C. Pipework dampers with nearly temperature independent properties are for applications in the temperature range between -30 °C and +130 °C.

Standard pipework dampers will allow heat expansion of ± 40 mm in all directions, but special dampers have been developed, permitting horizontal direction deflections up to ± 120 mm. Other combinations of vertical and horizontal heat expansion will need a special design, which is usually possible.

In case of high heat expansion, the operating temperature in the temperature dependent liquid should not be more than 20 °C above the start-up temperature, as otherwise very high loads in the connecting structure have to be expected during start-up. In case of high expansion velocities and high temperatures in the pipe, the connecting structure between piping and pipework damper should be designed in a way that as little heat as possible is transmitted from the pipe into the damper.