TUNED MASS DAMPERS & ACTIVE DAMPING DEVICES

Vibration protection for buildings, bridges and plants
VIBRATION PROTECTION FOR BUILDINGS, BRIDGES AND PLANTS

High rise buildings and long reaching civil engineering construction works tend to experience strong vibrations at their natural frequency. This effect should be avoided if possible. The vibration excitation is generated by external influences: wind loads at high rise buildings or towers, traffic or pedestrian movements at bridges or platforms, wave excitation at offshore wind turbines and rotating machines within plants can be the source. A special challenge is the protection against earthquakes, where a short but violent shaking of the earth leads to vibration excitation.

Vibrations in plant engineering are a safety risk. Correct selection of a tuned mass damper or an active damping device

In order to work effectively a tuned mass damper needs to be tuned to the structure of the building, i.e. the moving mass of the building and its vibration characteristics (natural frequency and amplitude). The moving mass of the building determines the mass of the tuned mass damper. Depending on the direction of the natural oscillation the tuned mass damper will work in vertical and or horizontal direction or, in case needed even work in all 3 dimensions. It is recommended to install the tuned mass damper in that location within the building where the highest amplitudes are observed. The available space within the building and the frame parameters will define the type and size of the tuned mass damper.

Vibrations should be reduced as much as possible in order to avoid damage on buildings, ensure safety and increase the living comfort.

Active and passive tuned mass dampers are a simple, cost efficient and reliable solution. They provide important advantages for the construction of the building. They allow the construction of unique designed buildings without any need to increase material cost in order to achieve the correct stiffness and damping of the construction structure.

VICODA, the expert in vibration control

VICODA has for all different applications the correct tuned mass damper. The innovative design provides an efficient reduction of vibrations and works reliably in all demanding applications. This is especially possible as the VICODA active and passive tuned mass damper is adapted to each individual requirement.

Vibration control technology at VICODA stands for:

- High quality
- Competent consultancy
- Innovative technologies
Passive and semi-active tuned mass dampers

The advantage of the VICODA tuned mass dampers (TMD) relies heavily on the use of eddy current dampers. They have compared to other dampers important advantages:

- The damping ratio is independent of the vibration amplitude and vibration frequency of the building structure.

- Given the contactless damping effect, the dampers are maintenance free, long lasting and reliable.

- The damping is independent from temperature, allowing their use in all climate zones, at all seasons and specially also on offshore structures.

- The tuning frequency of the TMD can be changed following simple methods. This principle makes it possible for the semi-active device to adapt to changing environmental conditions. Semi-active TMDs have, compared to passive TMDs, a wider operating range.

Active damping device

Wölfel, a shareholder in VICODA, has been the worldwide driver to engineer the active damping device (ADD) for market readiness. Based on its composition and its mode of operation, these systems differ from the previously explained passive damping devices. VICODA’s active damping devices are equipped with sensors detecting the motion of a vibrating system and with powerful linear actuators accelerating the reaction mass of the devices. Based on the input (sensor) the actuator signal is continuously and automatically calculated in the control unit of the device, thus securing an efficient counterraction of the damping device and hereby reducing the vibration.

This setting provides substantial advantages:

- The vibration reduction is possible in a very broad frequency range

- The needed mass is significantly smaller compared to passive TMDs

- The devices are mounted directly on the location where the vibration is being observed without the need of rigid abutments

- A very high damping ratio is achieved (up to factor 10)
Buildings
Vibrations coming from earthquakes or strong winds are the typical application for VICODA’s TMDs and ADDs. Especially in high rise buildings where strong winds occur the TMD/ADD will improve living comfort significantly. Vibrations are also frequent in stadiums, freestanding stairs, stages or visitor balconies. Even though these vibrations will not jeopardize the safety of the building, they will disturb the people’s comfort and therefore must be diminished.

Civil work construction
Vibrations in the sector of civil engineering lead to worries about the structure safety. Especially for bridges in coastal areas with strong winds or seismic regions the TMD or ADD provides the adequate solution. Resonant vibrations at pedestrian bridges transmit discomfort to walkers. VICODA offers different solutions and products to reduce vibrations on pedestrian, train or road traffic bridges. Wölfel was the pioneer in this sector by completing first tuned mass damper installation on a pedestrian bridge as early as 1973.

Plant engineering
Vibrations problems in plant engineering or in industrial applications are caused by internal processes or by external sources. For example offshore platforms or chimneys are put in motion by waves or winds. Vibrating pipes or vibrations in the steel structure can be the result of process driven excitations. VICODA offers tuned mass dampers or active damping devices which can be configured to fulfill the customer’s specific requirements.
ACTIVE DAMPING DEVICE (ADD)

VICODA’s ADD is an innovative solution with following characteristics:

- Modularity and scalability: depending on needed moving direction and needed counteracting forces, VICODA offers different sizes of ADDs. Further, several modules can be combined in order to add their effect.

- Active damping devices can be also combined with passive devices. In such a case, even without power supply to the active devices, some damping will be provided by the passive damper.

ADDs installed in a chemical plant, Germany

ADD module

One module of an ADD has following specifications:

Specifications:
Dimensions of one module: 60 x 22 x 11 cm
Scalability: several ADDs can be mounted in parallel.
Frequency range: 5 to 100 Hz
Working direction: 1, 2 or 3 dimensions
Force: 200 N (RMS) per module.

ADD for piping systems:

For piping systems, VICODA has developed a special device. It offers several important advantages:

- Acting in a broad frequency range.
- High vibration reduction: up to factor 10.
- No abutment required – easy retrofit.
- Low mass.
- No modification of the structural design of the plant required.
- Robust control algorithm provides for ruggedness and reliable results even with fluctuating parameters of the plant.
- Series for diverse pipe diameters.
- Automatic functional monitoring with messages transmitted to the control room.
- Possibility of remote maintenance.
- If required, condition and vibration monitoring of the plant.

ADDs (Active Damping Device) are fully active systems. They are composed of sensors, controllers and actuators.

One module of an ADD (Design by Wölfel)
VICODA’s ingenious TMDs have following advantages:

- Precise setting of the tuning frequency: Adjustment is done at the factory and can be fine-tuned on site
- Stability of set tuning frequency during operation. No changes of settings as there is no wear of components and the surrounding temperature has no impact on it.

**TMD on diesel engine**

VICODA’s TMD was the perfect solution for a vibration problem on a diesel engine.

**Application of eddy current dampers**

Due to the use of eddy current dampers the TMD is far more efficient than vibration absorbers applying conventional dampers:

- The damping is independent from environmental conditions, in particular on temperature. This allows for outdoor use in all climates in all seasons and in particular for offshore structures.
- The damping effect is independent of the vibration properties of the piping system, resulting in a robust and reliable effect, even under changing conditions.
- Due to the contact free damping effect the eddy current dampers and hence the TMD.Pipe are maintenance free, durable and reliable.

The delivered TMD required only small space (1.5m x 0.5m x 0.2m) to damp horizontal forces in one dimension at a frequency rate of 25 Hz. The damping method is based on eddy current. The damping mass is 690 kg.
TUNED MASS DAMPER FOR PIPES: TMD.PIPE

Innovative Design

TMD.Pipe is based on an innovative design allowing for the use of only one product to solve a wide range of vibration problems in a wide variety of facilities and piping systems.

- Two sizes are preconfigured, covering all major vibration phenomena. Customized sizes are available upon request.
- Owing to a modular design system, the damping parameters to be set can be flexibly adjusted.
- The fine tuning is done by a few simple actions at the factory. This provides a very high accuracy and effective vibration reduction.
- The connection is made via a standardized clamp design allowing for the smooth application with pipe diameters of 250 to 2,000 mm.

Properties and advantages

- Absolutely non-wearing system
- System works independent of environmental conditions, in particular of temperature
- No rigid abutment required; easy installation and design: on new or for retrofitting existing systems
- Modular system: thus individually adaptable to the respective vibration problem
- Highly accurate tuning to the respective piping system possible: high vibration reduction achievable, even with application of minimum damper mass
- Suitable for application in potentially explosive areas
- All components have increased corrosion protection. In addition, it is suitable to operate reliably even under rough and changing environmental conditions.

Areas of application

In chemical plants, power plants and in the engineering industry in general, with vibration excitation induced by:

- Steady state flow
- Water and liquid hammers
- Pressure pulsations
- Separate excitations

VICODA together with Wölfel has developed a unique TMD to reduce significantly resonant vibrations on piping system: TMD.Pipe

TMD.Pipe on LNG piping system

A worldwide active customer realized at their LNG plant in Australia that vibrations on an existing piping system were excessive.

The customer provided VICODA the measurement parameters. These were analyzed by VICODA specialists and jointly decided that a TMD was the ideal solution. The delivered TMDs have a moving mass of 350kg and a damping ratio of 25%
A special application of the TMD is to work also as a pendulum, being necessary to mitigate horizontal, two dimensional vibration problems. It is used to control vibrations in tall buildings.

The important advantage of VICODA’s TMD is its eddy current damping method, being maintenance free, damping efficiently without being influenced by the harsh external environment.

**TMD AS PENDULUM**

**Specifications:**
- Dimensions: depends on building and available space
- Frequency range: 0.1 to 0.7Hz
- Damping direction: horizontal, two dimensions
- Damping mass: 1t to 50t
- Damping method: eddy current

**VICODA’s mission statement:**
Provide for every vibration problem the optimum solution, by
an extensive know how in vibration control  +  a comprehensive product portfolio  +  a complete package of services

**Our products:**
- Elastomeric devices
- Spring devices, dampened or undampened
- Viscoelastic dampers
- Hydraulic dampers
- Tuned mass dampers
- Active damping devices

**Our services:**
- On site data assessment of vibration parameters
- Data analysis
- Root cause analysis
- Solution design
- Installation and start-up
- Vibration monitoring
- Replacement and retrofitting

**References:**
The founders of VICODA have served customers all over the world such as:

- Siemens
- Alstom
- Mitsubishi-Hitachi
- GE
- Krauss
- Maffei
- Cummins
- Babcock
- RheinEnergie
- MTU
- Tüv-Süd
- Caterpillar
- EnBW
- Vattenfall
- EDF
- Dema
- Bilfinger
- Areva
- Worley
- Parsons
- ABB
- Braun
- Sandvik
- Linde
- Black & Veatch
- Bechtel
- IHI

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