AGOM H-SAFE DEVICES

VISCOUS DAMPERS (VD)
SHOCK TRANSMISSION UNITS (STU)

H-SAFE DEVICES

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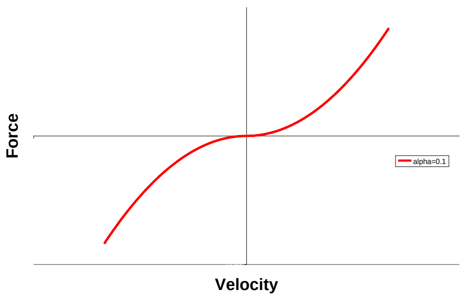
HYDRAULIC DEVICES

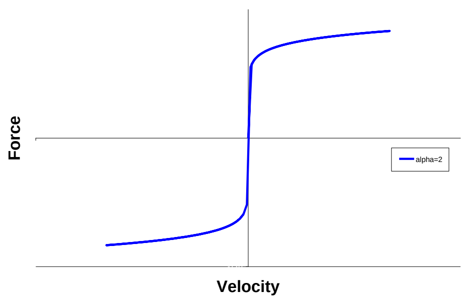
The hydraulic devices are basically composed by a cylinder filled by silicon fluid with a movable piston; controlling the fluid flow from one side of the piston to the other it is possible to obtain the required device response law. The device reacts to the imposed relative movement between its connection points that could be between structure and ground or between two internal nodes of a structure.
The fluid properties must be stable in time to ensure the durability of the device; the seal system must be capable to avoid leakage at low pressure (when the motion is very small that normally occurs for daily service conditions) and to support high pressure in case of fast motion (earthquake, wind storm or other significant dynamic forces on the structures). The device response has required to show very low sensibility to external temperature variation.
In general the device is connected to the structure by pins and spherical hinges to allow installation adjustments, structure service rotations and to avoid unwanted parasite bending effects of the piston.
The device overall dimensions are governed by the expected reaction force and by the stroke, the design movement in particular can lead to a relatively long devices that must be considered in the structure design to leave adequate space for the installation. The hydraulic devices can be installed both in bridges and in civil structures; providing there is an expected movement and velocity at device ends to activate its response.
In general the hydraulic devices response is governed by the velocity; the device can act as a displacement control device (STU = shock transmission unit) or as a force control device (VD = viscous damper).

The STU unit controls the displacement by stopping the fast movement increasing the reaction force up to the design value; this device allow the change of the structure connection scheme from static to dynamic condition. In a bridge for example the horizontal longitudinal force is normally taken by a fixed point in service static condition while the hydraulic devices give a negligible reaction for very small velocity due to temperature variation and/or irreversible movements (creep, shrinkage. etc.). In case of dynamic effects the device react and transfer the force in other selected locations. If one wants to obtain a uniform distribution of the dynamic loads a good rule is that the system (pier plus STU device) has approximately the same stiffness on each location where the dynamic load has to be transmitted.

The VD damper controls the force; for slow motion it works like the STU with a negligible reaction, in case of fast motion the device reaches the target force keeping the force level stable but allowing the movement to dissipate the energy imposed to the structure by the external excitation (earthquake, wind storms). The device allows to reduce the force into the structure and to mitigate vibrations and accelerations by damping effect due to energy dissipation.

The hydraulic damper can also work like a rigid-plastic device: in practise it is fixed up to a certain level of the force and then allows the motion by dissipating energy. In this case the device acts as a fixed connection for service condition and becomes a damper for dynamic conditions.





STU device response law: force - velocity

VD viscous damper device response law: force - velocity

VISCOUS DAMPERS

Fluid Viscous Dampers are applicable to both fixed and base isolated structures, including buildings, bridges, and lifeline equipment. The device can ensure damping levels higher than 50% of critical, it controls the reaction force and provides a very high seismic stress reduction in the structure.

The devices give a stable response force above a specified velocity limit; for slow movement the device can move with negligible force transmission or be fixed up to a target level of force.

These devices also have non-seismic applications as wind dampers on tall buildings, bridges and other structures.

The viscous damping model to represent the damper device response is the following:

$$F_{damper} = C\ V^{\alpha}$$

Where

- F_{damper} = device reaction force (kN)
- C = damping constant (kN*sec/mm)
- V = velocity (mm/sec)
- α= velocity exponent ($0.1 \leq \alpha \leq 1.0$)

Viscous Dampers absorbs the energy of earthquake or wind-induced motion, preventing structural damage and increasing occupant protection and comfort.

The devices are compact, offer multiple connection possibilities, dissipate a large amount of energy; the results are cost savings on both new and existing structures, allowing structures to be architecturally clean and elegant.

With most structures, a relatively small amount of damping provides a large reduction in stress and deflection by dissipating energy simultaneously reducing overall column stresses.

Fluid Viscous damping reduces stress and deflection because the force from the damping (governed by the velocity) is out of phase with stresses of the structure mainly governed by the displacement. Consider a structure vibrating during an earthquake, the stress is maximum when the structural resistant components are displaced at maximum; this is also the point at which the motion reverses direction to go back in the opposite direction. If a Fluid Viscous Damper is used, damping force is negligible at the point of maximum deflection because the velocity is almost zero at the motion inversion. As the structure moves back in the opposite direction, maximum damper force occurs at maximum velocity, which happens when the structure passes into the central position (maximum velocity).This is also the situation where stress is at a minimum. It is this out of phase response that is the most desirable design aspect of fluid viscous damping.

Fluid Viscous Dampers are also very effective in vibrations under wind loadings without changing the stiffness of the structure. For example in tall buildings, wind motion can also cause complaints of motion sickness and general discomfort from the occupants on higher floors, the use of Fluid Viscous Dampers reduces the wind deflection increasing occupant comfort. New buildings designed with Fluid Viscous Dampers for mitigation of wind motion can be built with reduced lateral stiffness detailing, resulting in a less costly overall structure.

Many structural engineering software allows for the modelling of the Fluid Viscous Dampers devices by special elements able to reproduce the response law showed before. Performing the non linear dynamic analyses the benefit effects of the motion and stress reduction can be calculated and also the device design displacement is obtained.

In order to design a Fluid Viscous Damper, the input data to be provided to Agom are:

- Maximum target reaction force for dynamic excitation
- Maximum design displacement (dynamic plus static due to temperature variation and irreversible effect as creep, shrinkage, etc.)
- Required response law (exponent α value and maximum design velocity)
- Available space for installation
- For bridges installation position (between pier cap and deck of between deck and abutment wall)

Advantages

- Structural motion and stress reduction in case of dynamic loads seismic or high winds
- Wide application range of application - Possibility to fit any force and displacement required by the structural designer to cover many structural application (bridges, building, cover roof, etc..)
- Easy installation and substitution due to pin connection
- Easy modelling in the design structural numerical codes
- Very simple inspection and low maintenance
- Stability in time and at wide temperature range

FLUID LOCK-UP DEVICES

Fluid Lock-up Devices can be applied for passive control the movement of structures subjected to earthquake or wind storm effects. The Lock-up Device (the device is very similar to the Fluid Viscous Damper) allows low translational speeds with negligible reaction force.
When a dynamic event occurs, the Lock-up Device activates, providing a rigid link between the connection points. After the transient event ends, the Lock-up Device reverts to low force output, permitting structural sections to thermally expand or contract without added relevant stress.
The mechanical components of the Lock-up Device (STU) are the same of the Fluid Viscous Damper but the hydraulic system that governs the piston motion is different; when activated it brakes the movement with consequent increasing of the reaction force so the device does not displace very far when maximum load is applied.

The STU model to represent the STU device response is the following:

$$F_{STU} = C\ V^{\alpha}$$

Where

- F_{STU} = device reaction force (kN)
- C = damping constant (kN*sec/mm)
- V = velocity (mm/sec)
- α= velocity exponent (usually > 2)

The STU has a short dynamic displacement that does not absorb or dissipate energy, but rather acts as a hydraulic lock. STU hydraulic system is designed to provide an output force that varies with velocity, usually with exponents higher than 2.

The lock-up speed for an STU is generally defined as the translational velocity at which the STU will put out its rated force. A typical specification call-out would be for the STU to be tested at maximum force by applying that force, and measuring the resulting velocity, which must be below a specified maximum, or within a specified range.

The maximum anticipated speed of expansion and contraction for a structure is usually much lower than the lock-up speed, this being measured across the mounting pins of the STU as a resultant value. Typical maximum thermal motion speed is generally less that 0.1 mm/sec., with allowable STU output forces being below 10% of the maximum rated force of the device. A typical specification call-out would be for the STU to be tested at a specified thermal motion.

In order to design a STU, the input data to be provided to Agom are:

- Maximum target reaction force for dynamic excitation
- Maximum design displacement (dynamic plus static due to temperature variation and irreversible effect as creep, shrinkage, etc.)
- Required lock up maximum displacement
- Available space for installation
- For bridges installation position (between pier cap and deck of between deck and abutment wall)

Advantages

- Structural motion control in case dynamic loads seismic, high winds or vehicle/train braking, with the possibility to optimize the dynamic force distribution into the structure
- Wide application range of application - Possibility to fit any force and displacement required by the structural designer to cover many structural application (bridges, building, cover roof, etc..)
- Easy installation and substitution due to pin connection
- Easy modelling in the design structural numerical codes
- Very simple inspection and low maintenance
- Stability in time and at wide temperature range

Guidelines for the design of a structure with Agom H-Safe devices

In this section a simple guideline for the design of a structure equipped with Agom bearing is presented, the design procedure is summarized in the following steps:

1. Selection of the hydraulic devices (VD or STU) to be adopted. VD devices are suitable for energy dissipation link solution with consequent movement in case of dynamic loads and possibility to control the force level, STU devices are devices are suitable for changing the structure link system form static to dynamic condition allowing the transfer of dynamic loads in suitable positions by controlling the movements
2. Calculation of the dynamic load, movement and velocity (axial load and motion on the device) horizontal) on the devices by performing dynamic analysis of the structure equipped by devices that can be simulated by suitable elements available in the commercial finite elements codes.
3. Definition of static requirements of the device as: maximum reaction force slow motion (typical value is less that 10% of the design dynamic load), service movement due to structure (thermal variation, creep, shrinkage)
4. Definition of the device connection system to the structure as: axial connection typical between abutment and deck walls (example figure 2) or shear connection for example for deck fixing (see figure 1)
5. Prepare the requirements summary table with the definition of the device design parameters showed at items 2,3 and 4
6. Using the device drawings provided by Agom design the interface parts between structure and device as: axial distance to install the device with its connections; suitable voids for anchor bars, right operating space for installation, inspection after installation and eventual maintenance or replacement

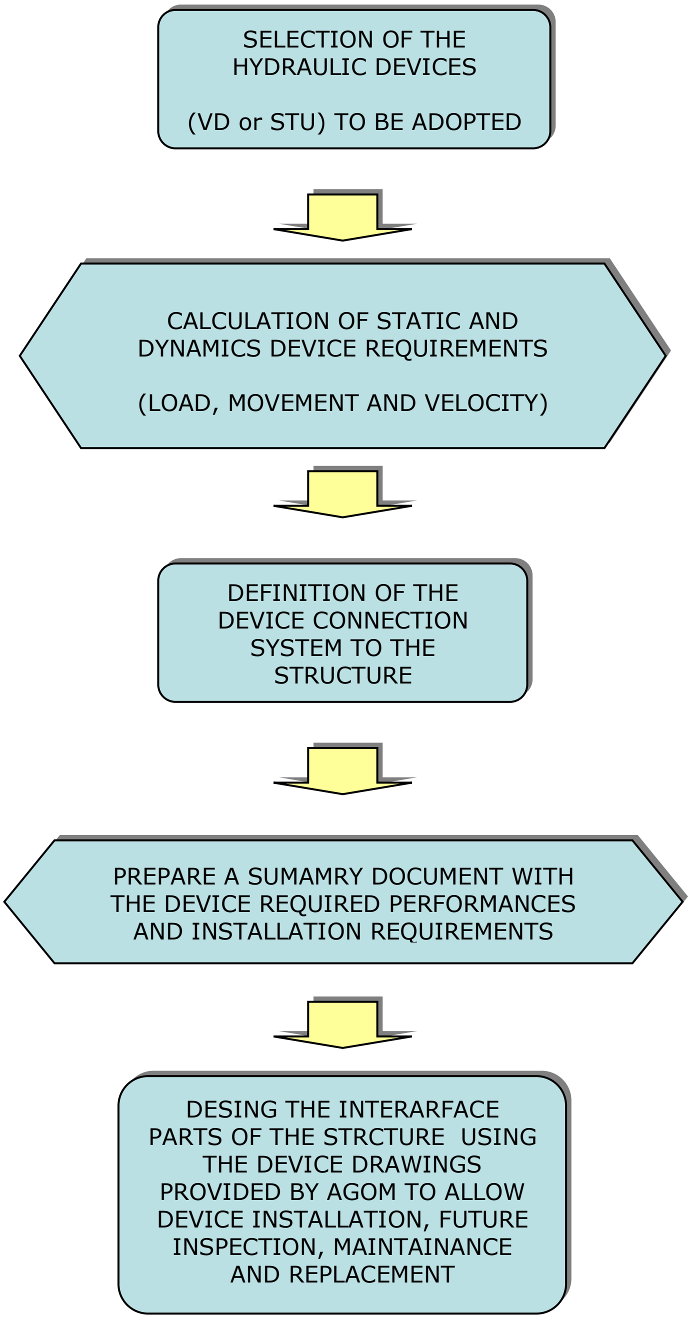
Figure 1

H-Safe device shear connection to the deck

Figure 2

H-Safe device axial connection between deck and abutment

DESIGN OF A STRCTURE WITH H-Max Hydraulic DEVICES



Qualification, approval tests and certifications

All the qualification and approval tests are performed by independent and worldwide recognized laboratories to assure that the H-SAFE hydraulic devices performances comply with the project and with international standard requirements.

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STU SLOW AND DYNAMIC TESTS

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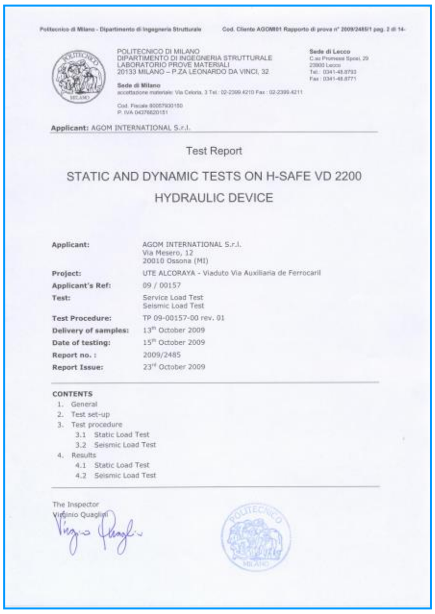
STU IMPULSE LOAD TEST

STU device tested at the EUCENTRE independent test laboratory

DAMPER DYNAMIC TEST



Politecnico di Milano - Dipartimento di Ingegneria Strutturale   Cod. Cliente AGOM01 Rapporto di prova n° 2009/2485/1 pag. 2 di 14-

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Applicant: AGOM INTERNATIONAL S.r.l.

Test Report

STATIC AND DYNAMIC TESTS ON H-SAFE VD 2200
HYDRAULIC DEVICE

Applicant:	AGOM INTERNATIONAL S.r.l. Via Mesero, 12 20010 Ossona (MI)
Project:	UTE ALCORAYA - Viaduto Via Auxiliaria de Ferrocaril
Applicant's Ref:	09 / 00157
Test:	Service Load Test Seismic Load Test
Test Procedure:	TP 09-00157-00 rev. 01
Delivery of samples:	13th October 2009
Date of testing:	15th October 2009
Report no. :	2009/2485
Report Issue:	23rd October 2009

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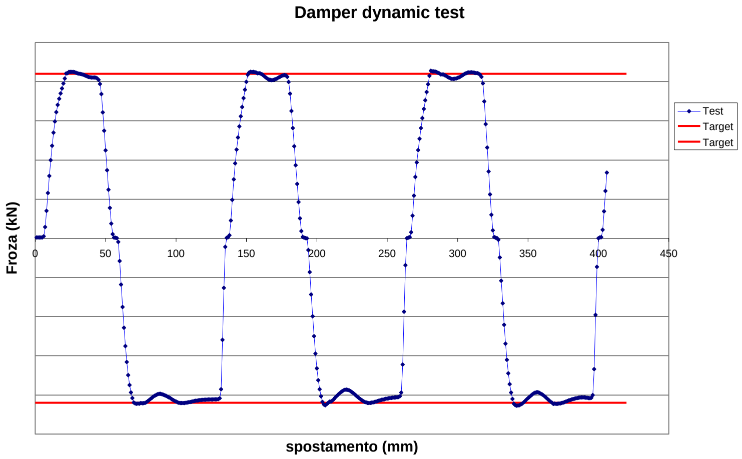
The Inspector
Virginio Quaglini

VD damper device tested at the Politecnico of Milano independent test laboratory

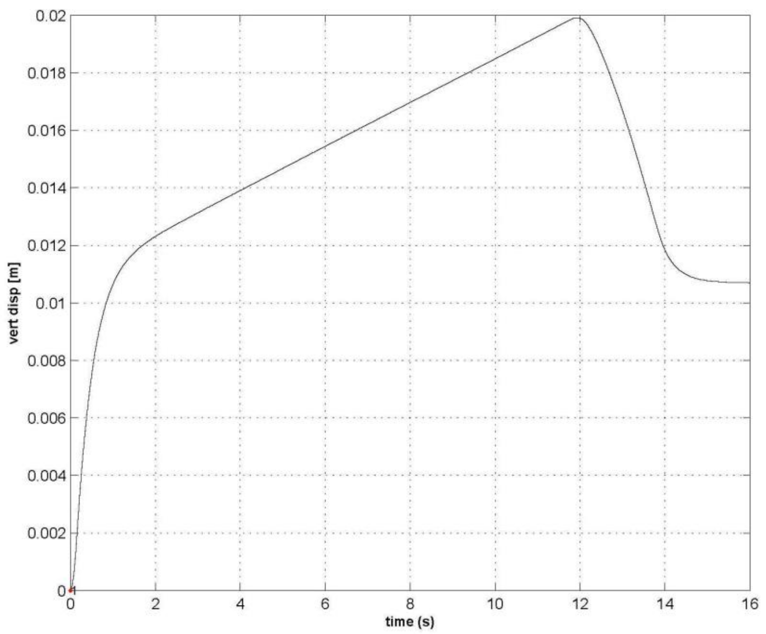
Example of VD damper dynamic tests, device reaction force vs imposed axial displacement.

The device shows a stable response force so it works as per design controlling the force level with consequent displacement and energy dissipation.



Example of STU device dynamic tests, device reaction force vs imposed axial displacement.

Imposing a dynamic force the device reacts as a linear spring up to a defined force level, then keeping the force constant and applied for a certain time the device shows always a linear response with a different stiffness.



International standards

The behaviour of the Agom H-SAFE devices and the technical and mechanical features of the materials used to manufacture them, comply to the requirements of international standards as European codes on construction EN1998-1, EN 1998-2, EN 1993-8 and European code on anti seismic devices prEN15129.

Agom can also design and manufacture seismic isolators complying with different design requirements prescribed by other international rules and standard.

CONSTRUCTION MATERIALS

Depending on seal materials selected, piston rods should be passivated stainless steel or high strength carbon steel, which may be chrome plated for seal compatibility. The balance of the materials used to construct the STU are usually corrosion protected steel. Articulation of the STU is provided by spherical bearings at the mounting interfaces to the structure. The use of spherical bearings allows multi-axis end rotation of the STU, preventing binding and providing ease of installation.

All other structural parts (cylinder, connections, etc..) are made of S355JR and/or S275JR steel.

Corrosion protection

Steel components exposed to the elements are protected against corrosion. Agom adapts the corrosion protection in accordance to the aggressiveness of the environment in which the bearings are to be installed and to each customer’s requirements.

The standard corrosion protection according EN 1337-9 is as follows:

- sandblasting SA2.5 grade
- two components high thickness epoxy zinc paint:
  250 μm

The high resistant corrosion protection (metallization) is as follow:

- sandblasting SA 2.5 grade
- metal spraying to 85 μm with Zn/Al 85/15
- sealing: Epoxy sealer 20-25 μm
- top coat: Polyurethane paint 100 μm

Comprehensive Labelling

All H-SAFE devices with external steel plates are provided with a metal label detailing the properties of the bearing:

- device type
- maximum axial load
- maximum movement
- order number
- date of manufacturing

SEISMIC BEARING SYSTEMS

To solve a wide range of connection problems between bridge beams or decks and piers, under earthquake or wind loads, dampers or shock transmission devices can be both connected to the standard bearings to make a single device, compact and efficient.

This kind of solution assure small dimensions, reduced weight and a very easy installation.

The hydraulic devices installed on the bearings (POT Agom V-Max or spherical Agom R-Max) can be viscous damper Agom H-Safe VD or STU devices Agom H-Safe STU according to the structural designer requirements.

MORE THAN 50 YEARS EXPERIENCE DESIGNING AND MANIFACTURING DEVICES FOR CONSTRUCTION, OFFSHORE AND INDUSTRIAL MARKETS





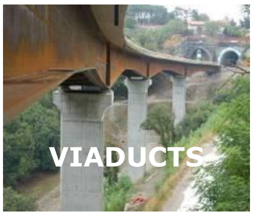


Bridge bearings
- Elastomeric Bridge bearings
- Pot bearings
- Spherical bearings
- Incremental Launching bearings
- Horizontal load bearings
- Special bearings

Seismic Isolators
- High damping rubber bearings
- Lead core rubber bearings
- Multilayer rubber bearings
- Shock transmitters
- Shock absorber
- Rubber dampers

Expansion joints
- Elastomeric joints
- Joints for high movements
- Finger joints
- Buried joints
- Railway joints

Services
- Design
- Consulting
- On site assistance
- Installations
- Tests
- Inspection

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SISTEMA DI GESTIONE QUALITÀ CERTIFICATO

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