SURVEY OF VIBRATION DAMPERS – ANALYSIS AND MITIGATION - PROJECT KKU52440

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About Efterklang®

We have provided advice on acoustics, noise and vibration control since 1956 when Ingemansson Technology was founded in Sweden. In 2006 AFRY acquired Ingemansson and today Efterklang is a leading acoustic consultancy.

We are represented in Denmark, Norway, Sweden and Switzerland. Our team consists of 130+ dedicated acousticians and sound designers.

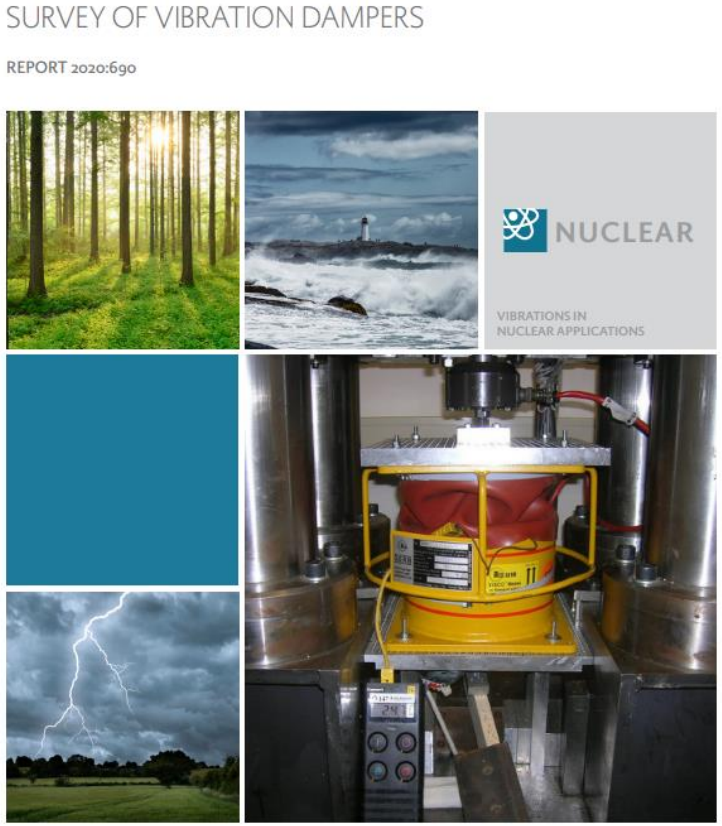
https://energiforsk.se/en/programme/vibrations-in-nuclear-power/reports/survey-of-vibration-dampers-2020-690/

Objective

Assemble knowledge and experiences in the area of vibration dampers.

Gather information of problems encountered that are related to dampers and how they were examined and mitigated.

Furthermore, summarize experience from vibrations dampers in the Nordic nuclear power plants.



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Effect of damping

Damper link with Small Bore Fitting (SBF) bracing with glued saddle plates

REGULAR PIPE WITH NATURAL LOW DAMPING

PIPE WITH ADDED DAMPING

Click to listen!

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2. Design of tuned dampers
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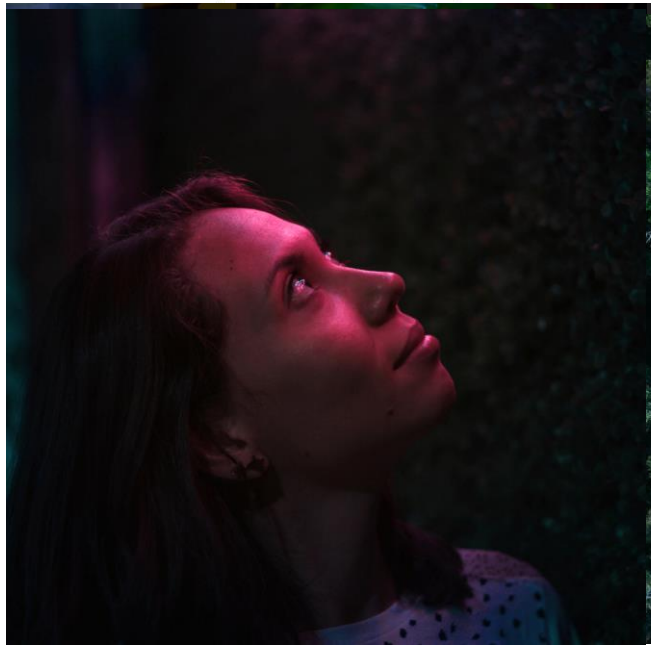
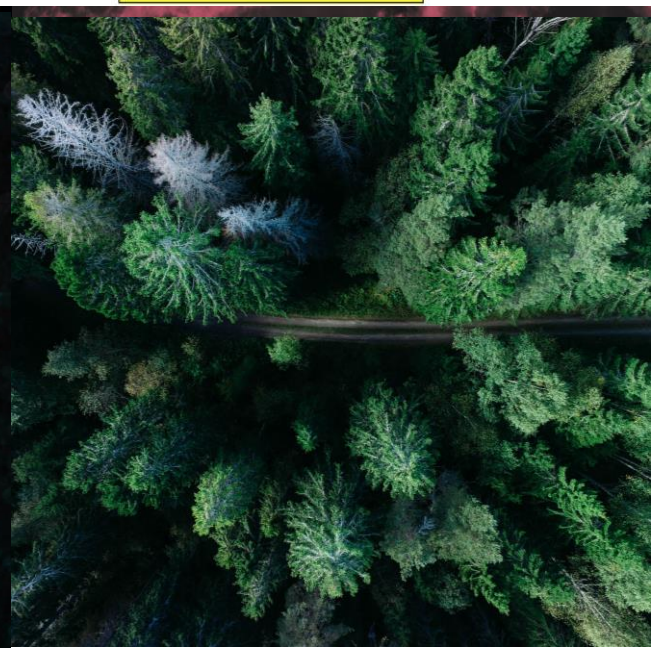
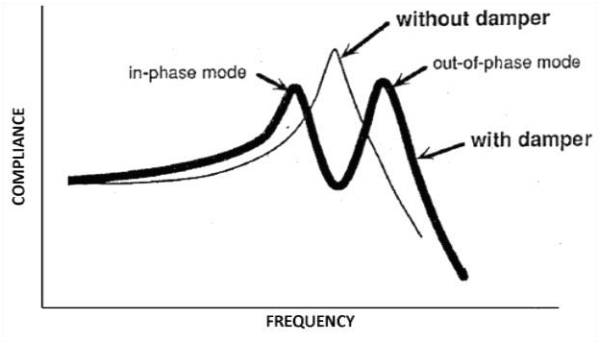
   3.1 NPP Vibration damper types
   3.2 Experience
   3.3 Installation examples
4. Laboratory tests



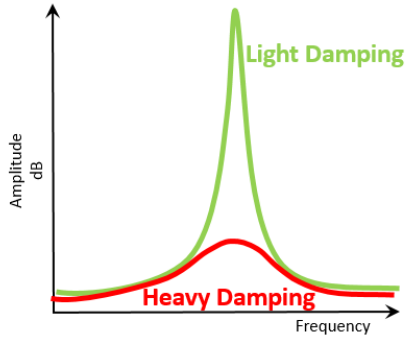


1. Different PASSIVE damper types

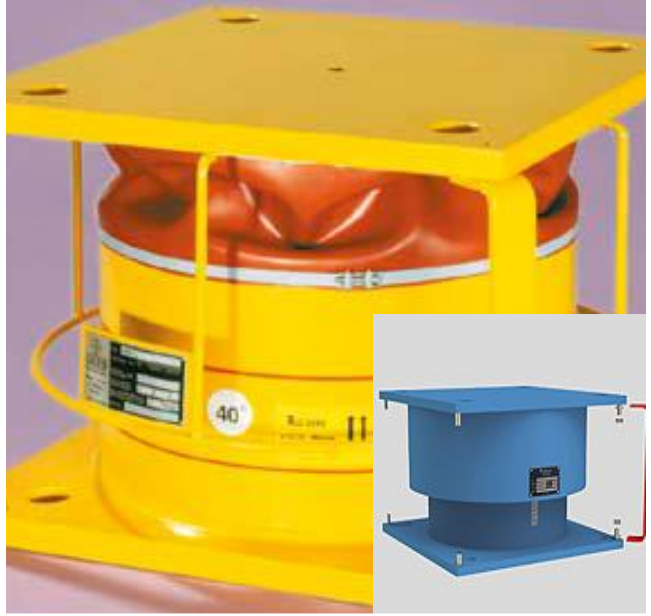
- Lisega snubbers (shock arrestor)
- GERB viscodamper* /Vicoda viscodamper
- Vicoda ReKi™ mass tuned damper
- Vicoda Eddy Current Dampers

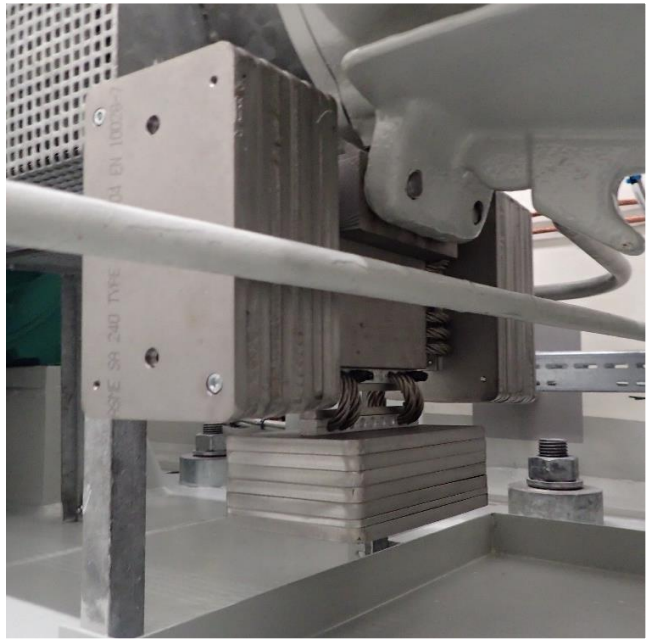


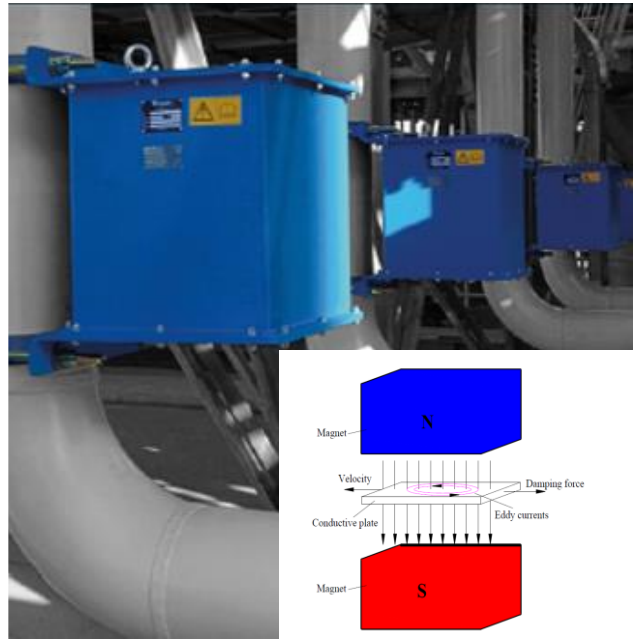
EFFECT OF MASS TUNED DAMPER



EFFECT OF VISCODAMPER

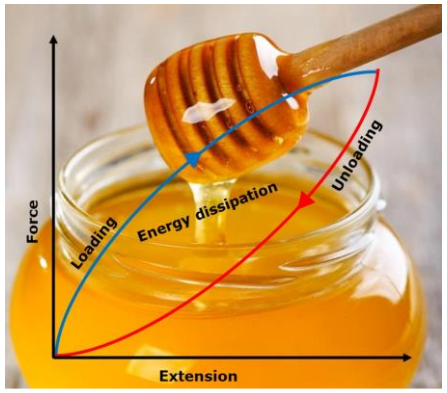


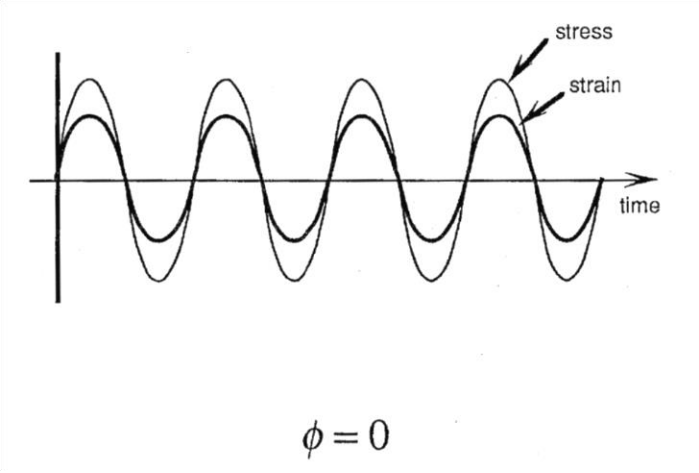




*MODEL "VES" ARE PERFORMANCE TESTED BY GERMAN TÜV FOR USE AS A STANDARD PART IN NUCLEAR POWER PLANTS AND FULFILLS KTA SAFETY STANDARD 3205.3

1.1 Materials



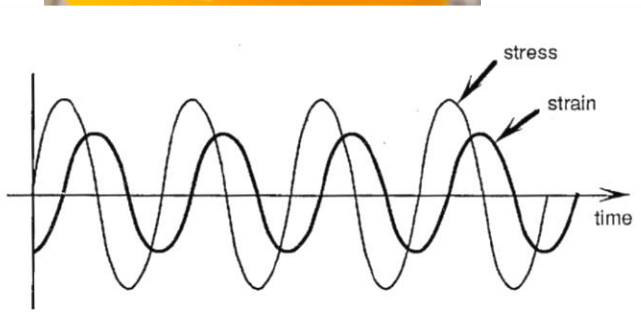


$$\phi = 0$$

PURELY ELASTIC MATERIAL

Stress is proportional to strain and an applied load is completely recoverable.

Phase difference, ϕ, between strain and stress is in-phase

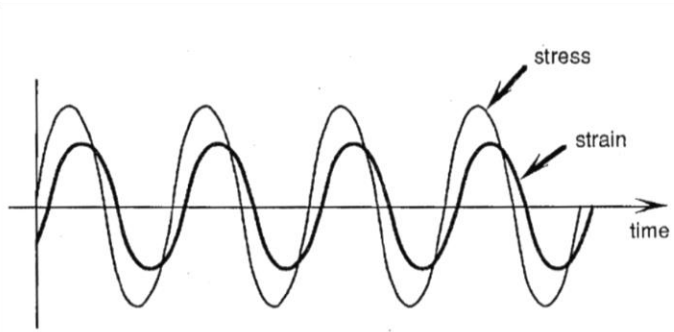


$$\phi = \frac{\pi}{2}$$

VISCOUS MATERIAL

Stress is proportional to rate of strain and none of applied load is recoverable.

Phase difference, ϕ, between strain and stress is out-of-phase by 90



$$0 \leq \phi \leq \frac{\pi}{2}$$

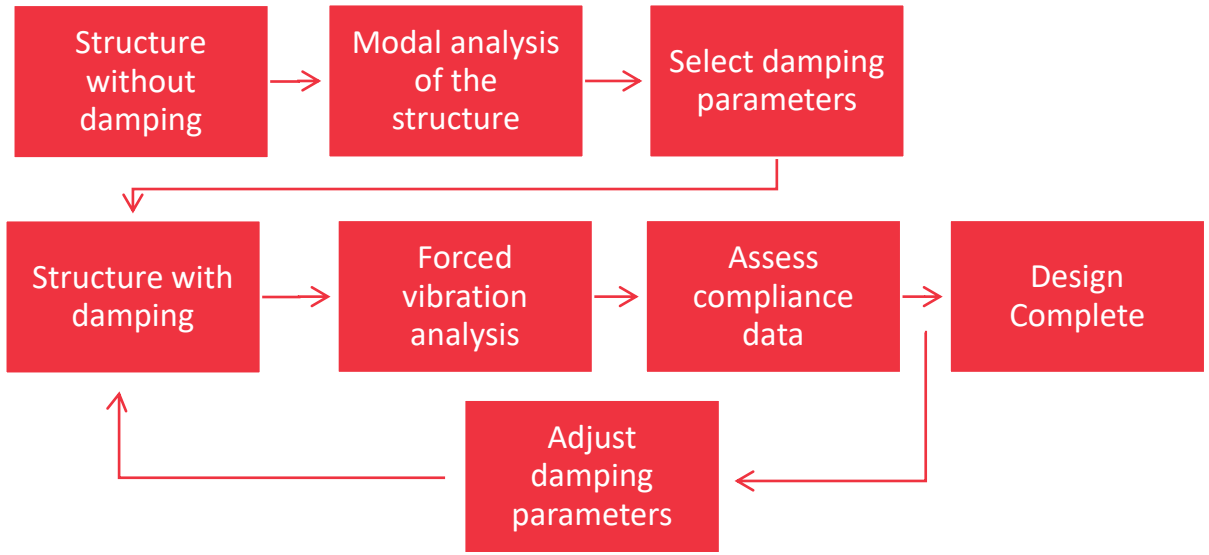
VISCOELASTIC MATERIAL

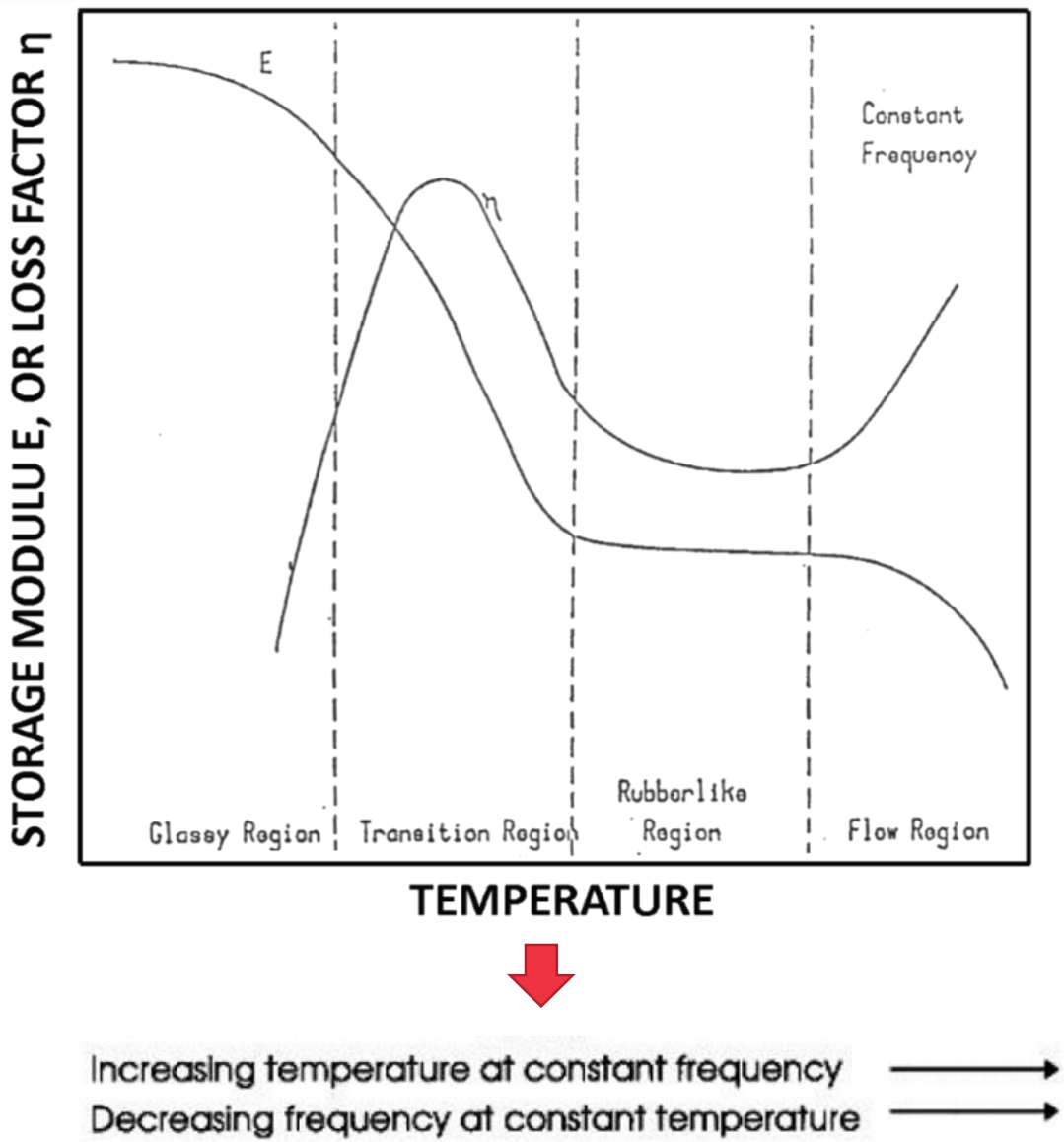
Has both elastic and viscous components of modulus. Here some of the applied load is recoverable and some is dissipated as heat.

Phase difference, ϕ, between strain and stress is in range of 0-90

2. Design of tuned dampers

- Investigate the dynamic stiffness of the anchor position of the supporting structure.
- Investigate the modal modes (frequency, damping, shape, mass) of the vibrating structure
- Select material which works in the “rubber region” wrt. frequency and operating temperature
- Investigate relative displacements (+/- microns) for relevant load conditions





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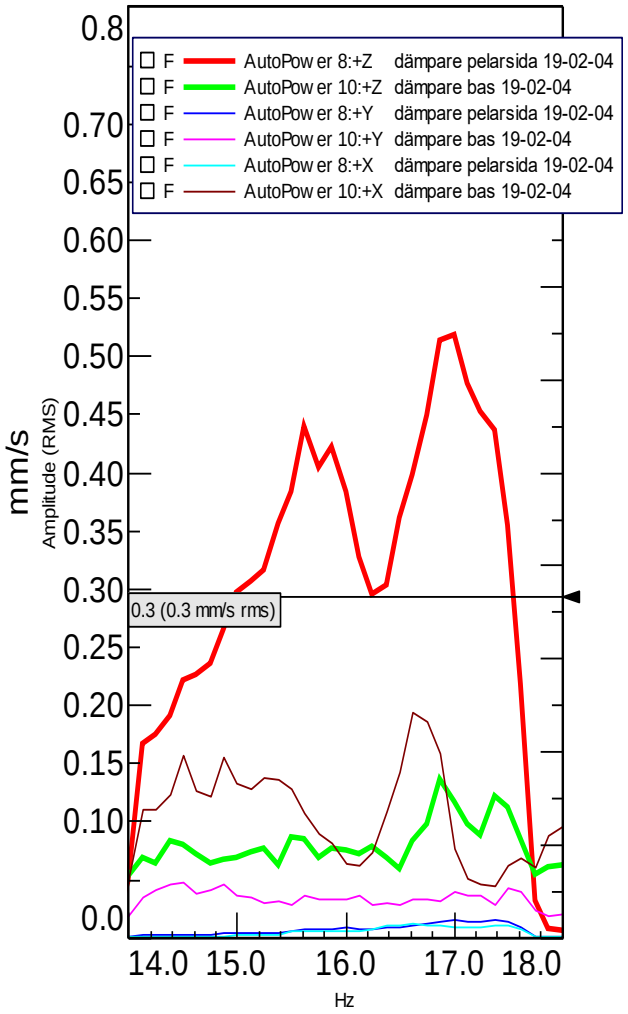
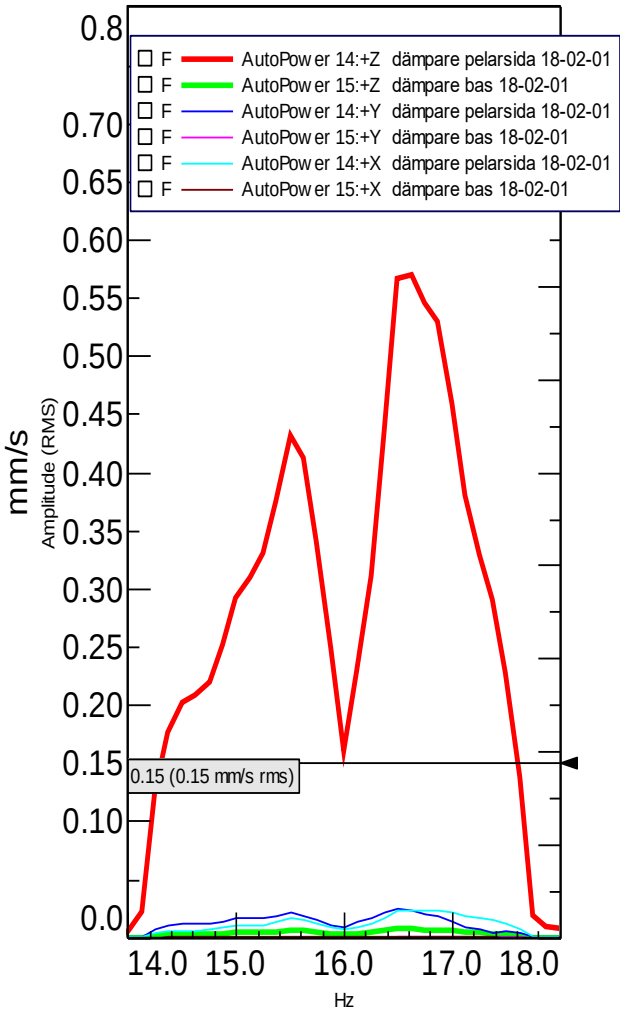
2.1 Example of effects of a non-rigid anchor support or misalignment of GERB viscodamper

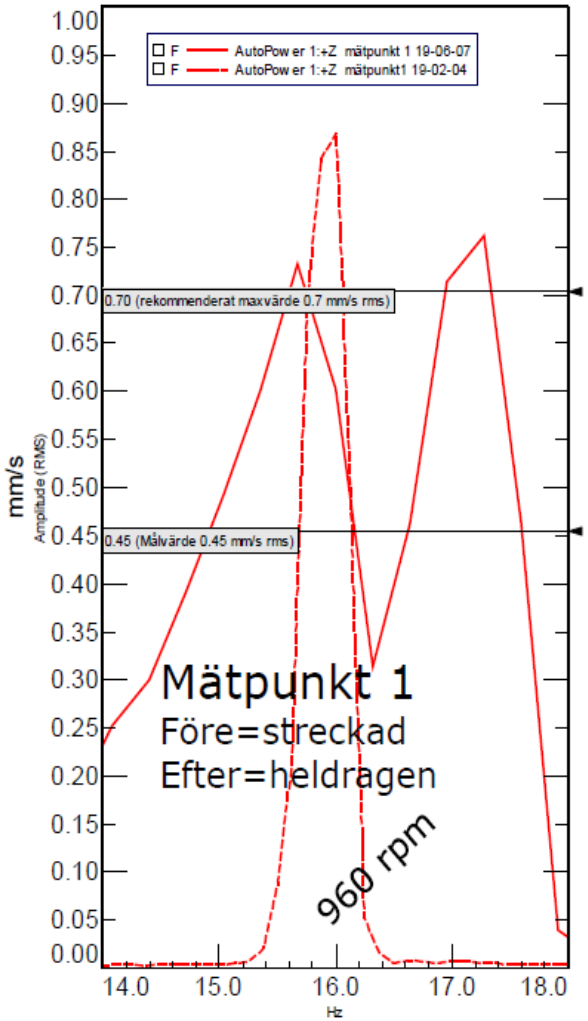


Anchor position which is too soft at 16 Hz



Anchor position with rigid support at 16 Hz

Viscodamper with vertical misalignment to approximately 7-9˚ (Acceptable 5˚)



Misaligned - Aligned

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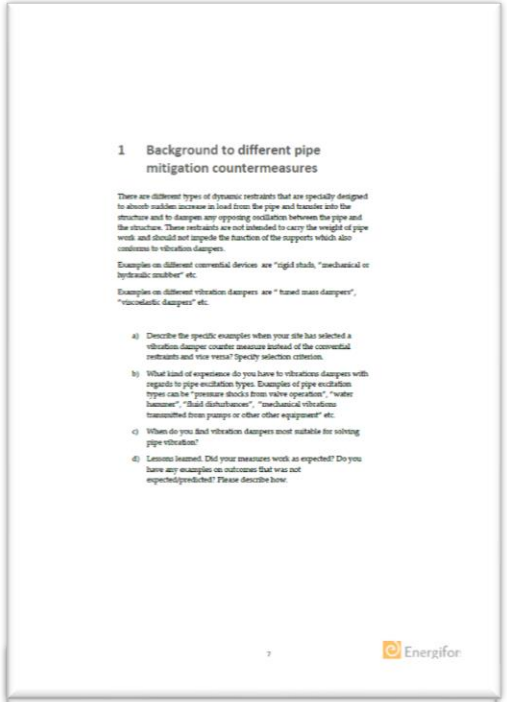
3. NPP Vibration Dampers Experience

Questionnaire

1. Background to different pipe mitigation countermeasures
2. Damper types with fluids
3. Fluid type damper degeneracy
4. Vibration dampers mass tuned dampers, MTD
5. Design of dampers
6. Installations of damper
7. In-situ and laboratory measurements of dampers

Interviews

Performed with each NPP via physical or digital meeting


1 Background to different pipe mitigation countermeasures

There are different types of dynamic restraints that are specially designed to absorb sudden increase in load from the pipe and transfer into the structure and to dampen any opposing oscillation between the pipe and the structure. These restraints are not intended to carry the weight of pipe work and should not impede the function of the supports which also conforms to vibration dampers.

Examples on different convential devices are "rigid studs, "mechanical or hydraulic snubber" etc.

Examples on different vibration dampers are " tuned mass dampers", "viscoelastic dampers" etc.

a) Describe the specific examples when your site has selected a vibration damper counter measure instead of the convential restraints and vice versa? Specify selection criterion.

b) What kind of experience do you have to vibrations dampers with regards to pipe excitation types. Examples of pipe excitation types can be "pressure shocks from valve operation", "water hammer", "fluid disturbances", "mechanical vibrations transmitted from pumps or other other equipment" etc.

c) When do you find vibration dampers most suitable for solving pipe vibration?

d) Lessons learned. Did your measures work as expected? Do you have any examples on outcomes that was not expected/predicted? Please describe how.

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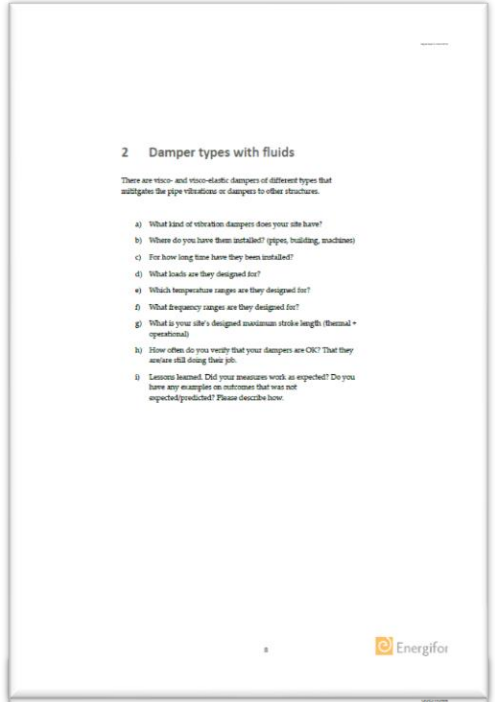

2 Damper types with fluids

There are visco- and visco-elastic dampers of different types that mitigates the pipe vibrations or dampers to other structures.

a) What kind of vibration dampers does your site have?

b) Where do you have them installed? (pipes, building, machines)

c) For how long time have they been installed?

d) What loads are they designed for?

e) Which temperature ranges are they designed for?

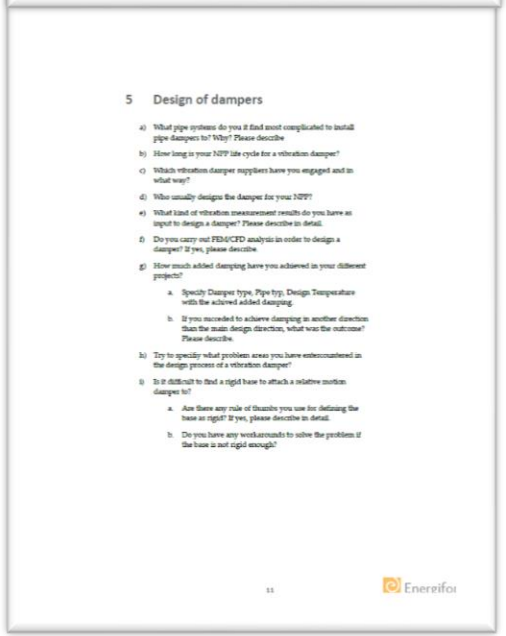
f) What frequency ranges are they designed for?

g) What is your site's designed maximum stroke length (thermal + operational)

h) How often do you verify that your dampers are OK? That they are/are still doing their job.

i) Lessons learned. Did your measures work as expected? Do you have any examples on outcomes that was not expected/predicted? Please describe how.

Energifor


5 Design of dampers

a) What pipe systems do you it find most complicated to install pipe dampers to? Why? Please describe

b) How long is your NPP life cycle for a vibration damper?

c) Which vibration damper suppliers have you engaged and in what way?

d) Who usually designs the damper for your NPP?

e) What kind of vibration measurement results do you have as input to design a damper? Please describe in detail.

f) Do you carry out FEM/CFD analysis in order to design a damper? If yes, please describe.

g) How much added damping have you achieved in your different projects?

a. Specify Damper type, Pipe typ, Design Temperature with the achived added damping.

b. If you succeded to achieve damping in another direction than the main design direction, what was the outcome? Please describe.

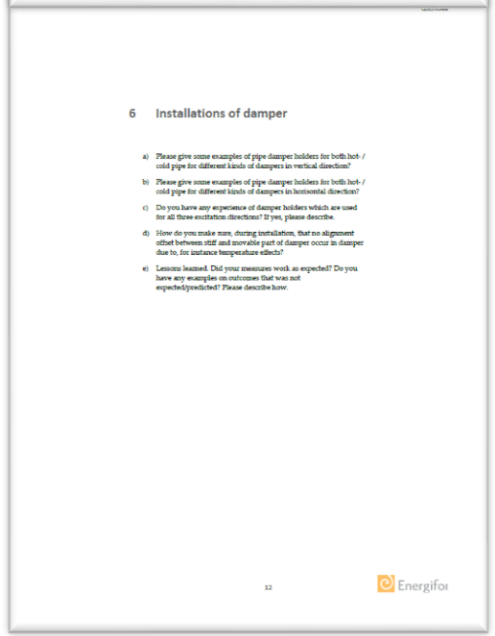
h) Try to specify what problem areas you have encountered in the design process of a vibration damper?

i) Is it difficult to find a rigid base to attach a relative motion damper to?

a. Are there any rule of thumbs you use for defining the base as rigid? If yes, please describe in detail.

b. Do you have any workarounds to solve the problem if the base is not rigid enough?

Energifor


6 Installations of damper

a) Please give some examples of pipe damper holders for both hot- / cold pipe for different kinds of dampers in vertical direction?

b) Please give some examples of pipe damper holders for both hot- / cold pipe for different kinds of dampers in horisontal direction?

c) Do you have any experience of damper holders which are used for all three excitation directions? If yes, please describe.

d) How do you make sure, during installation, that no alignment offset between stiff and movable part of damper occur in damper due to, for instance temperature effects?

e) Lessons learned. Did your measures work as expected? Do you have any examples on outcomes that was not expected/predicted? Please describe how.

Energifor

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3.1 NPP Vibration damper types

RINGHALS

- Viscodampers
  - GERB
  - Since 1996/1997
- Snubbers
  - Hydraulic dampers Lisega
  - First 1997

OKG

- Viscodampers
  - GERB
  - Since 1980's
  - ~32
- Snubbers
  - Hydraulic dampers Lisega
- Mass tuned dampers
- Regular pipe hangers and spring hangers.

FORSKMARK

- Viscodampers
  - GERB
  - Since 1980's
  - ~100
- Snubbers
  - Hydraulic dampers, Lisega
  - Mechanical dampers, Pacific Shock Arrestor/PSA-dampers
- Regular pipe hangers and spring hangers.

TVO

- Viscodampers
  - GERB
- Snubbers
  - Hydraulic dampers
  - Lisega
- Mass tuned damper
  - ReKi® from Vibrol
  - On pump

FORTUM

- Viscodampers
  - GERB
  - Total ~95, 48 - VRD, 8 - VES and 39 - VD
- Snubbers
  - Hydraulic dampers, Lisega
- Mass tuned dampers
  - Turbine bearing pillars
- Regular pipe hangers and spring hangers.

3.2 Experience

Hydraulic snubbers

- Simple use/installation
- Risks
  - Oil leakage
  - Flame point 300 ˚C
- Silicon based oil approved for reactor encl.
- Maintenance: Visual inspection + quality control. (rig testing)

Mechanical snubbers

- Great in reactor enclosure
- Simple use/installation
- Risks
  - Get 'stuck' due to old type grease
  - Mechanical wear at att. points
  (Red dust)
- Maintenance: Visual inspection + quality control (rig testing)

Viscodampers

- Good results 50-75% amplitude reduction
- Minimal signs of wear/tear/ageing
  - 20-40 years lifespan
- Identified problems:
  - Broken Sleeve
  - Cracked/stiff fluid
  - Design temperature
  - Misalignment
  - Anchor position rigidity
- Maintenance: Visual inspection
- GERB VES in reactor enclosure (approved TÜV) – secure against leakage

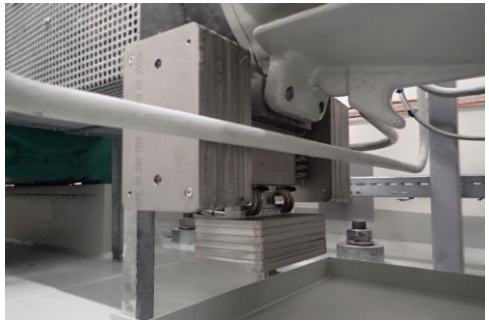
Mass tuned dampers

- Turbine pedestals, pumps
- Risks
  - Design/installation difficulties
  - Added mass
  - Broad-band ReKi® damper under evaluation. Oil sensitive, reduces effect
- Maintenance: Visual inspection

Viscodamper with broken sleeve

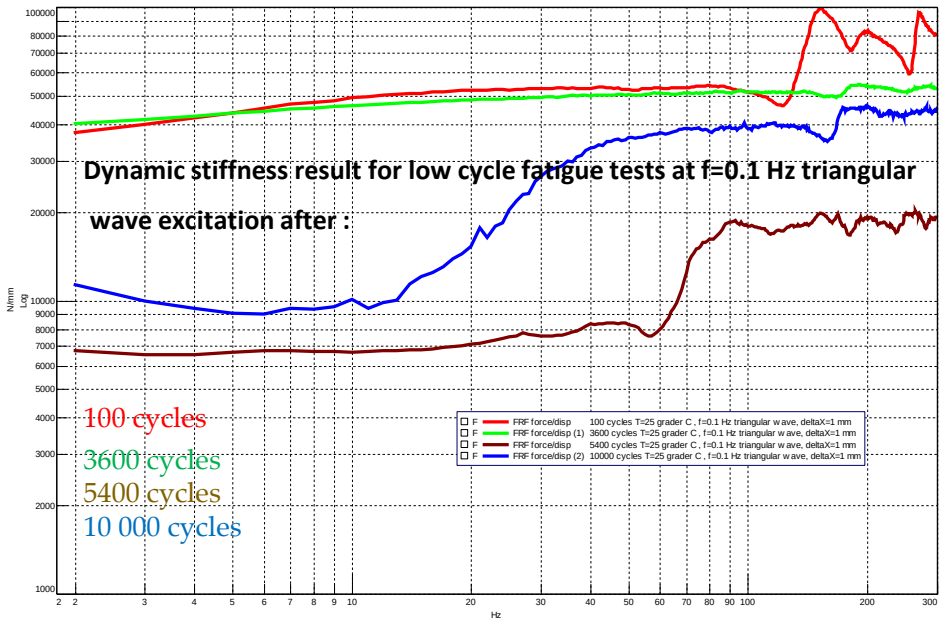
Viscodamper with cracked fluid

3.3 Installation examples



4. Laboratory Tests

- Low cycle fatigue i.e. slow temperature variations
- Control of supplier’s data sheets
- Temperature/Preload effect
- Control for maintained life cycle, aging etc.
- Product development



Measurement of dynamic stiffness and damping resistance for resilient products, in a test rig which conforms to ISO10846-2.
Placed in Gothenburg office Efterklang

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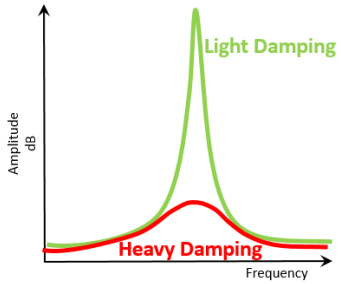
Summary



Is it a modal problem?

Correct stiffness of anchor position?

Correct mounting ?

Control for maintained life cycle, aging, temperature effect etc.

By adding modal damping to the pipe system by mounting viscodampers and/or viscoelastic dampers, the pipe system obtains:

a) High resistance under shock load

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

c) Permissibility of overloading

d) Reaction in all degrees of freedom

e) Limited maintenance compare to traditional snubbers.

f) More rapid decay of unforced vibrations

g) Faster decay of freely propagating structure-born waves.

h) Reduced amplitudes at resonance of structures subject to steady periodic or random excitation with accompanied reduction in stresses and increases in fatigue life.

i) Allow for slow movements (i.e. for instance due to thermal effects).


Thank you!
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