ЦКТИ–ВИБРОСЕЙСМ
ИНЖИНИРИНГ ПРОЧНОСТЬ ВИБРОЗАЩИТА И СЕЙСМОСТОЙКОСТЬ

CKTI–VIBROSEISM
A STRUCTURAL–MECHANICAL CONSULTING ENGINEERING FIRM

G E R B Schwingungsisolierungen
GmbH & Co.KG
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Summarizing of experience in operational vibration eliminating of nuclear, conventional power plants and chemical plants using 3D-Viscodamper technology

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Introduction

In collaboration and by the order of the Energiforsk - Swedish Energy Research Center Group - CKTI Vibroseism (CVS), Ltd. Co., Saint Petersburg, Russia and GERB Schwingungsisolierungen GmbH & Co. KG, Berlin/Essen, Germany have prepared the Report:

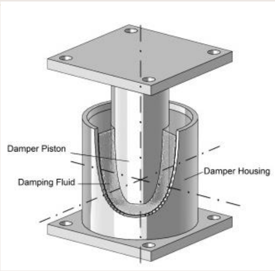
„Summarizing of experience in operational vibration eliminating of nuclear, conventional power plants and chemical plants using 3D-Viscodamper technology"

The authors of the Report are Dr. Frank Barutzki, GERB, Dr. Victor Kostarev (Project Manager, CVS President), Dr. Dmitry Pavlov and Dipl.Eng. Irina Evzikova, CVS.

The Report Content

3D Viscodamper Basics

VES Type



VD Type

- The first Patent for a high viscous damper (HVD) having a housing filled with bitumen was obtained by Dipl. Eng. **William Gerb in 1937**. Since **1908** GERB Vibration Control Systems is engaged in the development, design and manufacturing of elastic support systems for machinery, heavy industrial equipment and structures.
- In 1937 GERB introduced viscoelastic fluid dampers to increase system damping and restrict dynamic motions of vibrating systems. The damper was originally used to dampen vibrations of diesel engines on ships and submarines. GERB developed Viscodampers for piping systems in the early 1970's. They work as dynamic restraints, increasing system damping, limiting dynamic displacements but not interfering with slow pipe motions like thermal motions.
- The first application of Viscodampers VES in the nuclear industry dates back to the early 80s of the last century as part of the "Konvoi-project" at nuclear plants in West Germany.
- In 1985, the Russian design Viscodamper was invented, which differs from the original design in the presence of additional internal elements and a special silicone based high viscous liquid as working grease. These design variations allow to expand the dynamic and thermal range of the damper's characteristics. Since that time VD type Viscodampers have been widely used worldwide at NPPs with VVER, BWR, PWR and Fast–Breed reactors as seismic and vibration protection dynamic supports and restraints.
- Nowadays dampers of both types - VES and VD are manufactured by GERB GmbH under strict quality control by German TUF.
- Since early 90s more than **10 000 units** of viscoelastic dampers have been installed around the world at nuclear and conventional power plants and industrial facilities.

Codes and Standards approval

Dampers have been successfully used for many years for vibration reduction of piping systems and components in different installations:

- nuclear power plants
- conventional power plants
- chemical, petrochemical and industrial plants
- offshore facilities

- HVD has been added to the types of dynamic restraints (November 2007) covered by ASME B&PVC Section III - Subsection NF. Hence, they are an acceptable type of dynamic restraint for piping and nuclear components in accordance with ASME B&PVC Section III.
- HVD are covered by German Nuclear Code KTA and European Nuclear Code for Light Water Reactors.
- HVD are accepted by Nuclear Authorities of all Nuclear States in Europe, Asia, and America including US, Russia, Japan, China and India, etc.
- HVD are considered by International Atomic Energy Agency (IAEA) as a tool for seismic and vibration protection and seismic upgrading of NPPs.
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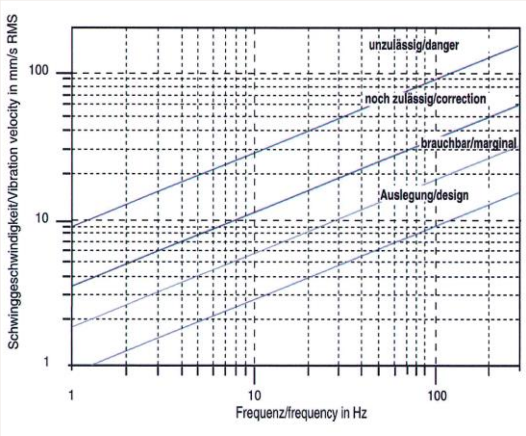
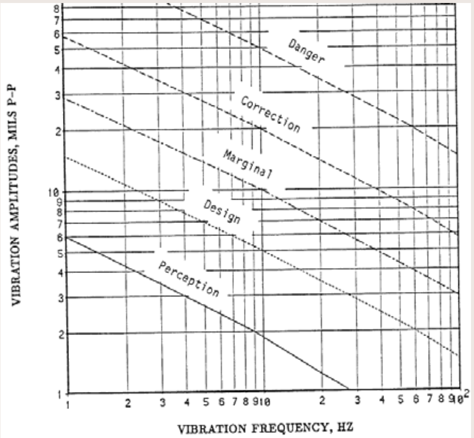
Piping vibration criteria variety

- The most comprehensive European guideline for piping vibration is VDI 3842 that provides some screening criteria for piping vibrovelocities against dominant frequencies of vibration based on rearranged J.C. Wachel allowables: for piping safety

VDI





J.C. Wachel

- According to the VDI 3842 vibro-velocities from 6.0 to 20 mm/s RMS in the frequency range 3 to 30 Hz recognized as “Required corrections” and from16 to 50 mm/s RMS as dangerous.
- ASME OMa S/G-2000 Standard Part 3 installs guaranteed fatigue limit of 12.7 mm/sec peak.
- EDF, France NPP & Gas Industry piping criterion in 12 mm/s RMS.
- Russian Boiler Standard RD 10-249-98 criteria (peak): less than 15.0 mm/s is excellent; 15.0-25.0 mm/s requires additional measurements and analysis to confirm safety; more than 25.0 mm/s recommends improving vibration state of the system.
- Loviisa NPP (approved by STUK): RMS vibro-velocity should be less than 7.5 mm/s (primary criterion), Peak vibro-velocity less than 20mm/s (secondary one criteria).

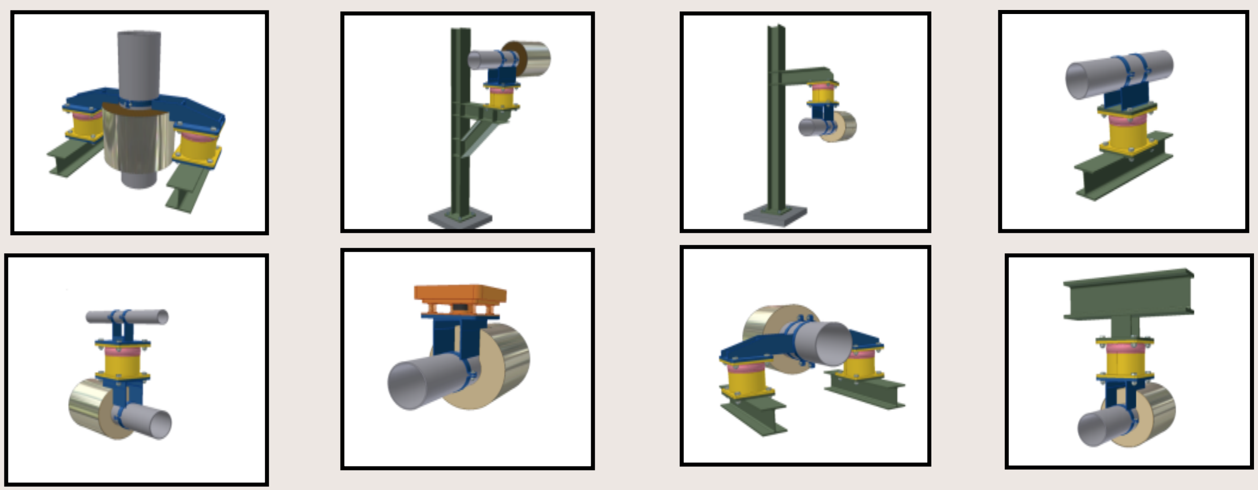
Damper supports (simple clamp installation)

VD (VES type) at the Feed-water piping in a high radiation zone

VDs at the main steam vertical run piping

Inverse installation of the VD at the piping

Connection of two piping by VD in the open air using their different dynamic properties



Different possible approaches for VD piping installation

Analytical model of VDs based on the comprehensive experimental test program since early 80s

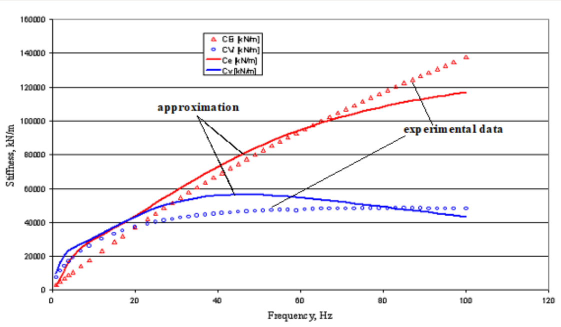
Italy, Eucentre

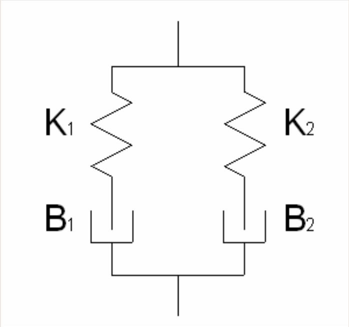
Russia SIST

German TUF approval

Japan, 1989 to 2014

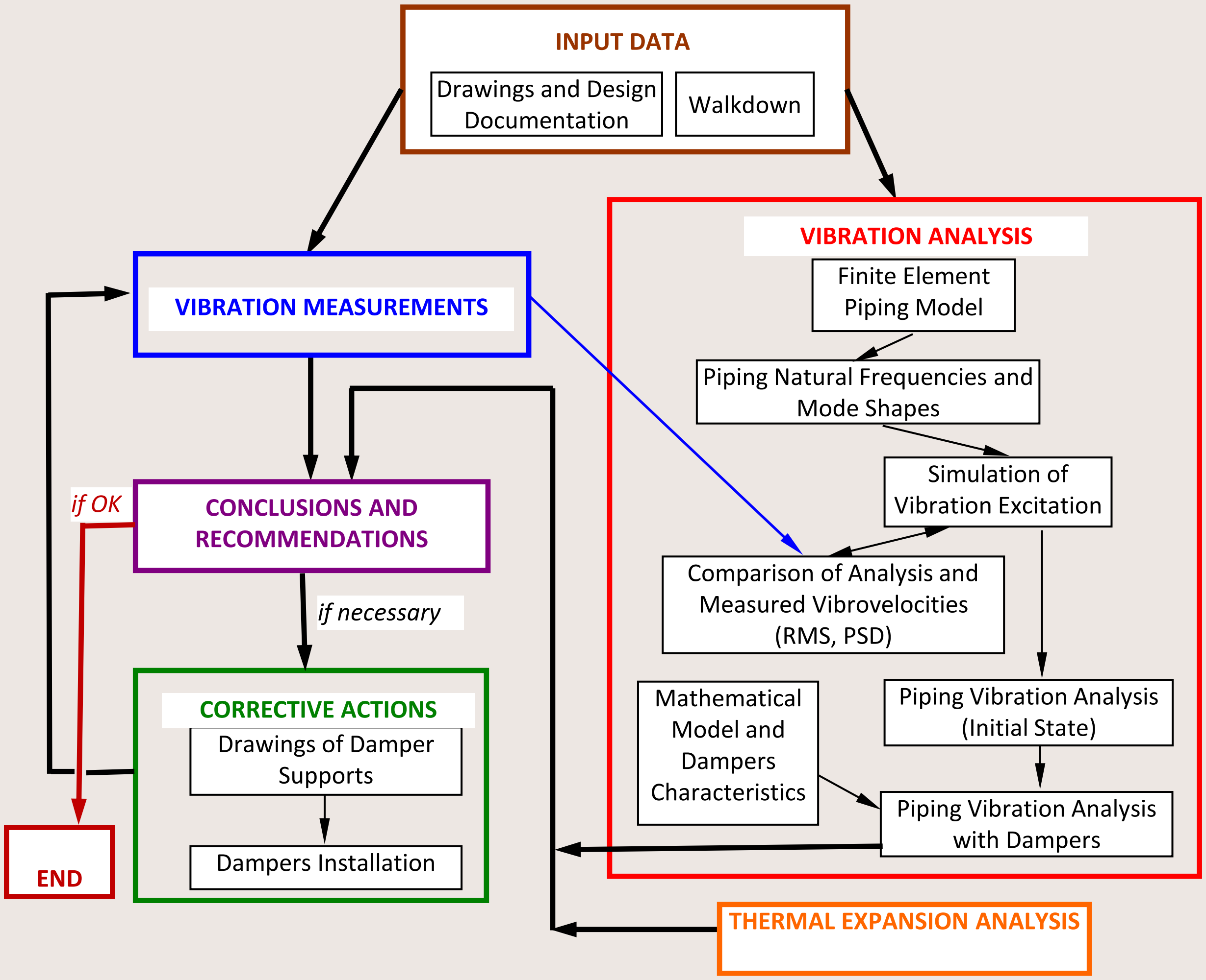
Germany





Maxwell model based on natural scale experiments

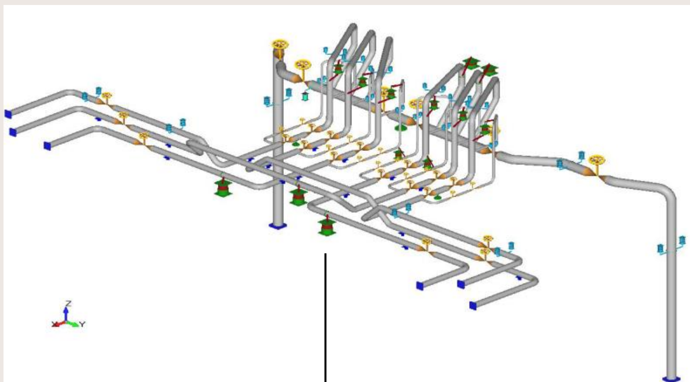
Main stages and flow chart of works for resolving vibration matter of piping using viscodamper's technology



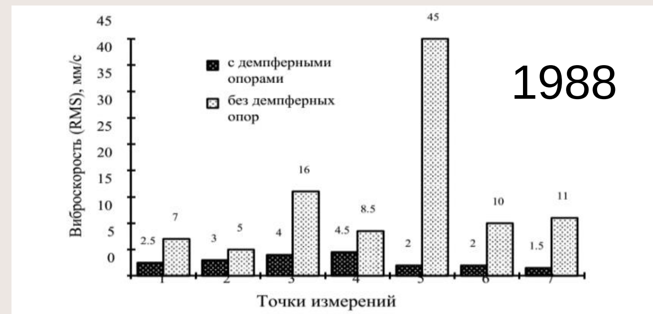
VDs application and efficiency

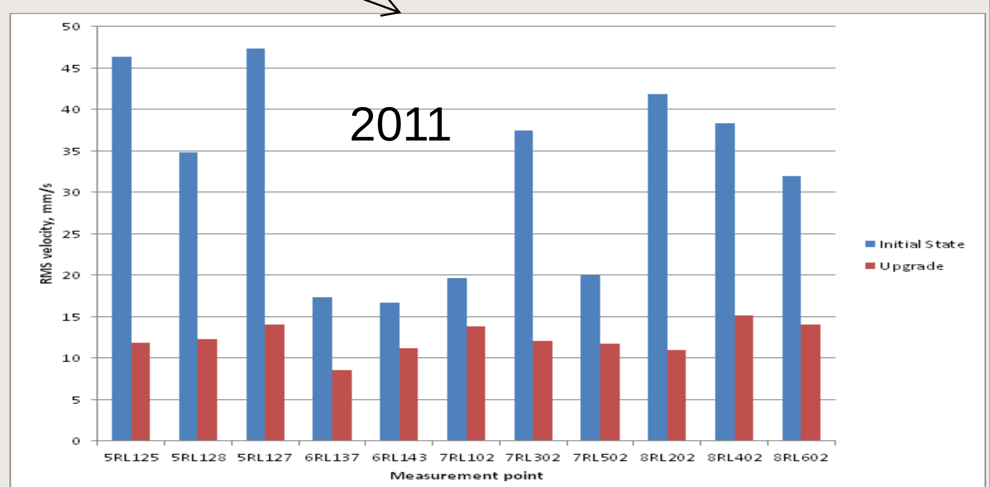
More than 10 000 Viscodampers are installed at NPPs and FPPs at all continents and all nuclear states around the world

Cola NPP



Kostroma FPP 1200 MWt MSL, P=24 MPa, T=565C

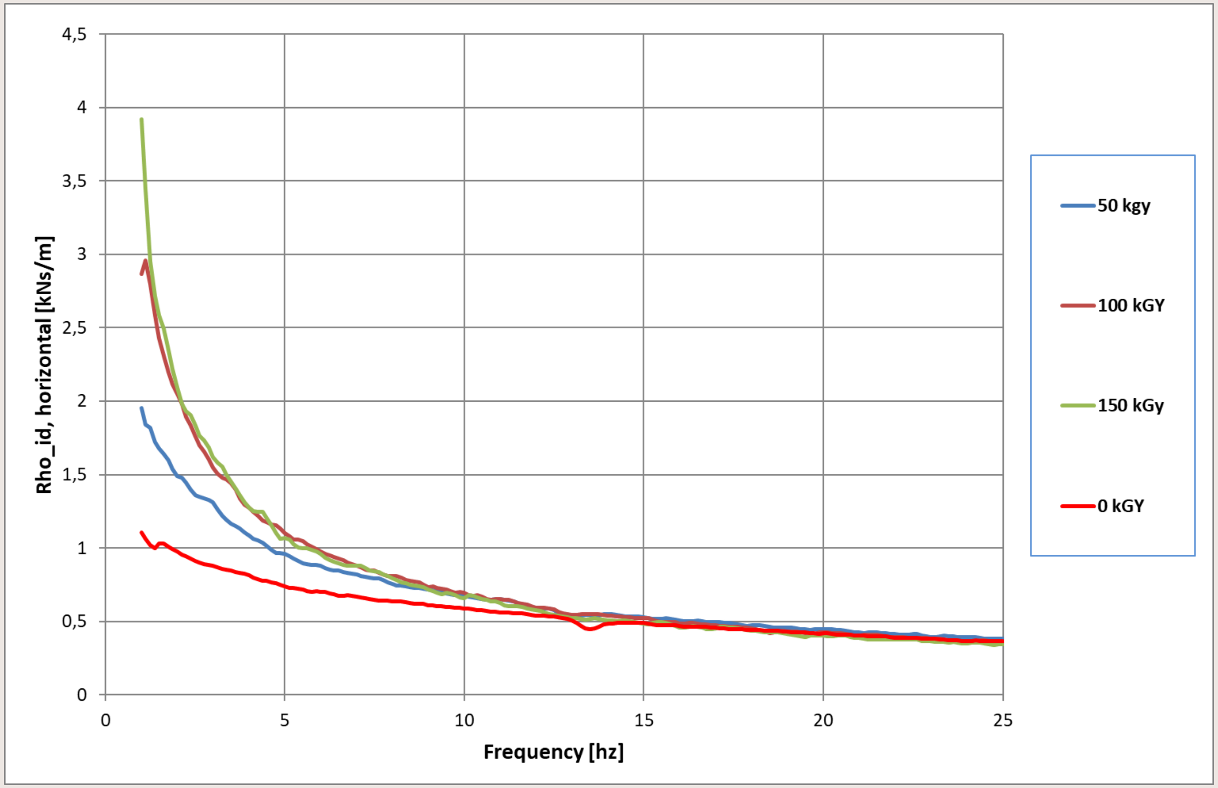




Blue column before VDs installation
Red Columns after VDs installation

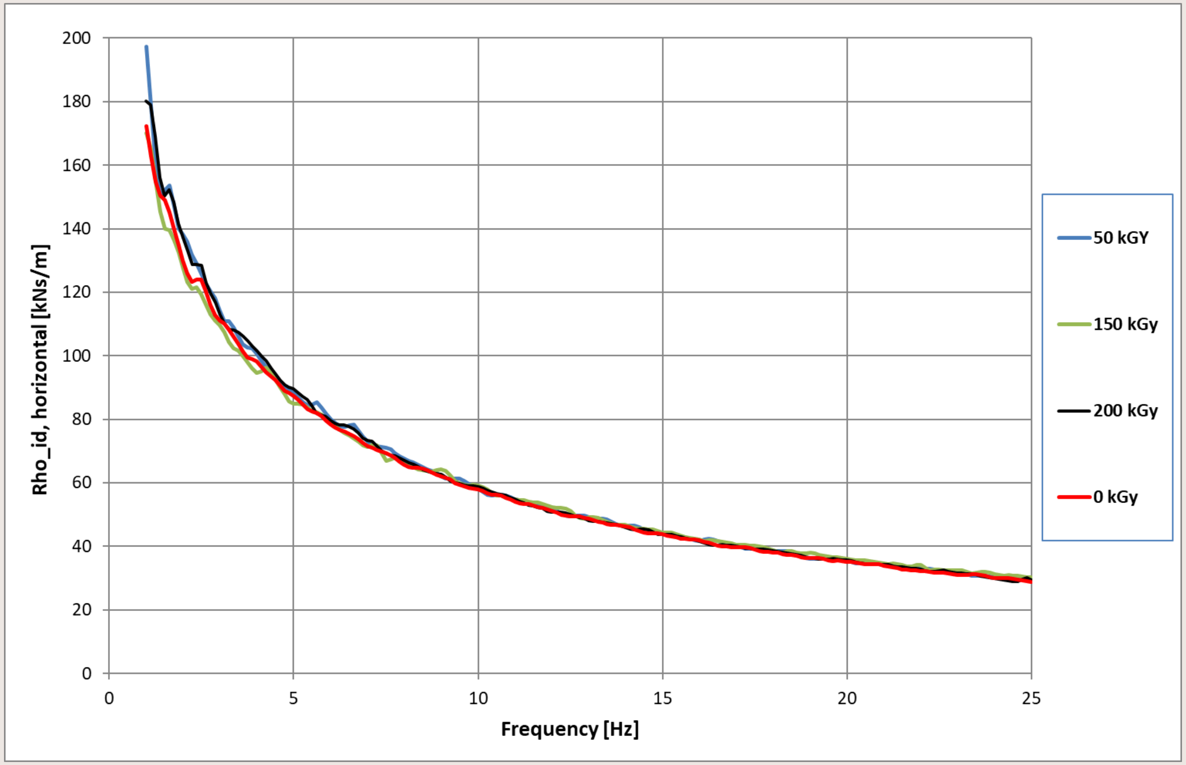
Special radiation tests confirmed possibility for VDs installation in high radiation zones of NPP's containment area in close proximity of reactor

- **Damping resistance for the VDs with silicon based medium**



Special radiation tests confirmed possibility for VDs installation in high radiation zones of NPP's containment area in close proximity of reactor

- **Damping resistance for VDs (VES type) with bitumen based medium**



SOME SPECIFIC CASES OF PIPING VIBRATION MITIGATION BY HVD APPLICATION AT POWER PLANTS AND INDUSTRIAL FACILITIES (BESIDE SEISMIC UPGRADING BY HVD's)

VRF – Maximum Vibration Reduction Factor achieved at the facilities' systems.

No	Facility	Country	Year	Number and type of HVD		Systems	VRF	Notes
				VD	VES			
1	Kostroma FPP 1200 Mwt Unit Conventional Power Plant	USSR/ Russia	1988 - 1990	96		Main Steam Line, 24 MPa, 565 C	22.5 10.0 !	1
2	Ignalina NPP RBMK (BWR) 1500 MWt	Lithuania	1991 - 1994	34		Main steam piping in the Turbine hall and Confinement	6.0	
3	Lenenergo FPP No. 14	Russia, St. Petersburg	1992	11		Condensate drain water piping	7.0	
4	Leningrad NPP (LAES-1) RBMK (BWR) 1000 MWt	Russia	1993 - 1994	38		Drain water and Recirculation turbines piping	4.0	
5	Lenenergo, Yuzhnaya FPP UTMZ 300 MWt	Russia, Saint Petersburg	1993	4		Main steam lines to the HP turbine inlet, 24MPa, 560 C	3.0	
6	Lenenergo, FPP No. 15	Russia, St. Petersburg	1993	2		Deaerator manifold. Drain line	7.0	
7	Kola NPP VVER (PWR)-440	Russia	1993 - 1995	20		TQ, TH coolant injection lines	3.0	
8	WNP-2 (WAPP) BWR	USA, WA	1994	8		Heater Bay Area Feed&Drain lines	Good	2
9	Kola NPP VVER (PWR)-440	Russia	1994	6		Coolant makeup system	5.0	
10	Leningrad NPP (LAES-1) RBMK (BWR) 1000 MWt	Russia	1995	24		Primary loop in the Confinement	Good	3
11	Temelin NPP	Czech Republic	1995 - 2006		62	Primary and secondary systems	Good	
12	Kozloduy NPP VVER (PWR)-1000	Bulgaria	1997	5		Main steam line. Emergency loops	1.1-3.0	4
13	Loviisa NPP VVER (PWR)-440	Finland	1999 - 2002	39	58	Main steam lines, Feed-water lines in the Turbine hall and the Containment	3.8	5
14	Mochovze NPP	Slovakia	1999 - 2002		27	Primary and secondary systems	Good	
15	Angra NPP	Brazil	1999 - 2003		39	Primary and secondary systems	Good	
16	Balakovo NPP VVER (PWR)-1000	Russia	2000 - 2002	12	11	Main steam line. Emergency valves loops	1.2-2.0	See Note 4
17	Chernobyl NPP RBMK (BWR) 1000 MWt	Ukraine	2000		6	Main steam line. SEBIB safety valves.	3.0	6
18	RAO Acron Chemical Plant	Russia	2002	8		Waste heat boiler lines of methanol workshop	up to 16.0	
19	Ignalina NPP RBMK (BWR) 1500 MWt	Lithuania	2005	6		Condenser line to the condenser pump	1.2	7
20	Temelin NPP VVER (PWR) 1000	Czech	2006 - 2007	4		Main steam line. Emergency loops	1.5	See Note 4
21	RAO Acron Chemical Plant	Russia	2007 - 2012	33		Compressors inter-stage piping of methanol workshop	2.4	
22	Kola NPP VVER (PWR)-440	Russia	2008 - 2012	24		Recirculation lines of high and low pressure injection	2.0	
23	Narva Power Plant, EEsti PP	Estonia	2008	9		Oil piping lines to turbine's bearing	3.3	8
24	Kola NPP VVER (PWR)-440	Russia	2008	8		Main steam lines inside Confinement	3.7	
25	Kola NPP VVER (PWR)-440	Russia	2009	42		Feed-water and mix- flow condensate manifold lines	2.6	
26	Kola NPP VVER (PWR)-440	Russia	2010	4		Main steam lines' bypasses	3.9	
27	Kola NPP VVER (PWR)-440	Russia	2011	14		Emergency feed-water lines	1.7	
28	Cooper NPS BWR 950Mwt	USA, NB	2010 - 2012	18		Main Steam Lines Heater Bay Area	Full Power	9
29	Brown Ferry NPP BWR 1300 MWt	USA, AL	2019 - 2020 Ongoing Project	16		Main Steam Lines Heater Bay Area		See Notes 9, 10

Some aspects of technical and cost benefits of the 3D VD technology against 1D linear dampers and snubbers

Hydraulic and mechanical linear 1D dampers and snubbers

3D-Viscodampers (VDs)

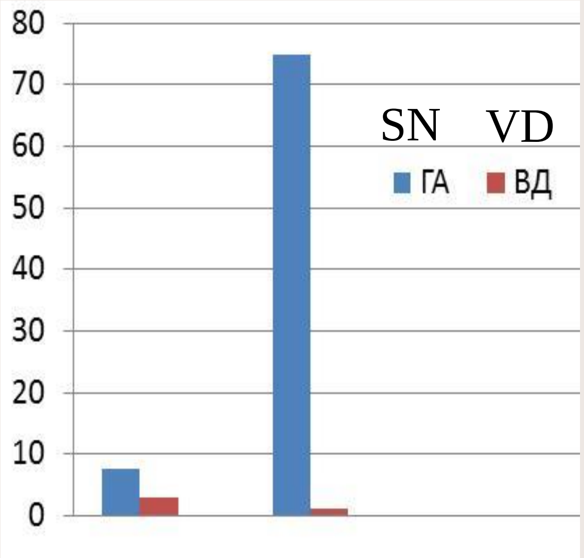
3D High Viscous Damper (VD Type).

3D High Viscous Damper (VES Type).

Application of 3D VDs instead of 1D dampers and snubbers

Evaluation is performed for the 1200 MWt Nuclear Power Plant located in a high seismicity zone with Peak Ground Acceleration > 0.4g

Cost $, mln



Primary Cost

Maintenance Cost for the 10-20 years period

Required number of devices to achieve necessary seismic capacity and vibration protection for the 1200 MWt NPP Unit:

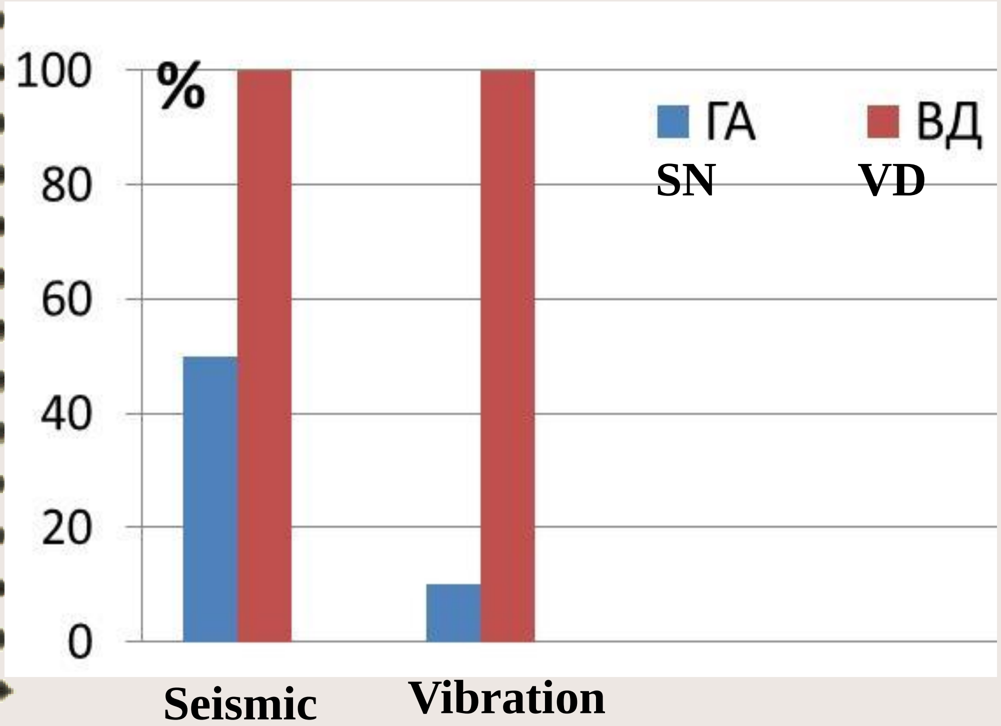
Snubbers – 750 units.
VD - 300 units.

Cost savings as the primary cost by using HVDs is more than: 4.5 mln. USD

Expected maintenance operation costs by using HVDs in the first 10 -20 years will decrease on: App. 70 mln. USD

Reference:
"Guidelines for Reducing Snubbers on Nuclear Piping Systems", Quadrex Corporation, NSAC/104, EPRI

Comparison of Efficiency of Snubbers and VDs against seismic excitation and operational vibrations



VDs efficiency against Snubbers demonstrate:

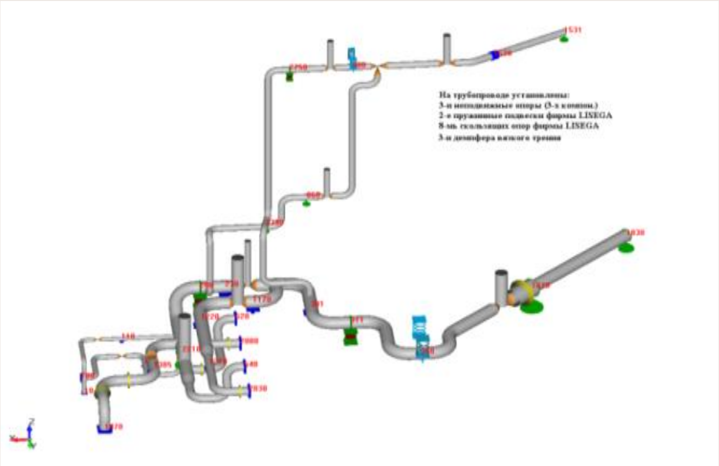
2 times for seismic event

10 times for operational vibration (flow induced vibration, water and steam hammers, etc.)

A comparative study of the JNG NPP's safety piping. Seismic analysis using Snubbers and VDs. PWR/VVER NPP 1200 MWt

SNUBBERS		
Fn, kN	Type Lisega	Devices Number
350	308216	1
100	306216	2
46	305213	5
Total snubbers number:		**8**

3D Viscodampers (VDs)		
Fn, kN	VD Type	Devices Number
80	VD-426/325-7	2
46	VD-325/219-7	1
Total VDs number:		**3**



The task in getting equal piping seismic capacity could be achieved by 3 VDs units against 8 snubbers units with additional vibration protection and dramatic reducing of the operational costs

Final Remark

In general, on basis of comprehensive analysis and experimental experience it could be concluded that using 3D-Viscodamper technology is the best option for piping vibration mitigation and seismic protection in comparison to all other existing approaches.

Thank you so much for your kind attention.