ACOUSTIC PIPE INSULATION : A NEW ISO STANDARD

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1. INTRODUCTION.

ISO/TC 43/SC1/WG48 is engaged in preparing Committee Drafts of two new ISO Standards. These are:

(1) **ISO 15664 " Recommended Practice for Noise Control Procedures in Open Plant during Project Execution**

(2) **ISO 15665 "Acoustic Insulation for pipes valves and flanges"**

The first document has reached FDIS Status and international comments have been received and incorporated.

The second paper **ISO 15665 "Acoustic Insulation for pipes valves and flanges"** will be discussed in more detail.

ISO 15665 "Acoustic Insulation for pipes valves and flanges" sets out to specify three levels of insulation acoustic performance for acoustic insulation applied to piping. Construction methods using common materials that will provide the three levels of insertion loss are described. Insulation constructions using the materials and installed as specified are "deemed" to have the required acoustic performance. The intention is not to exclude other types of pipe insulation, existing or future. However, these other insulation constructions would have to be tested to in order to show that they had a performance comparable with one of the three classes in order to be able to claim compliance with one of the three levels of performance.

A testing method for the insertion loss of piping insulation is included.

2. BACKGROUND.

The insulation of piping systems on piping is a significant issue in the oil and gas industry as piping noise can make up a major part of the noise radiated by process plant and equipment. Many major oil and utility companies have their on noise design procedures that they want to be used during the design of their plants including those for acoustic insulation on piping.

Some of these major oil companies are now questioning if they need to have their own specifications which they will need to update regularly at their own cost.

They would prefer to use an ISO or other standard if it was available and applicable to their needs.

The Dutch Acoustical Society then proposed a new work item to produce an ISO standard for acoustic insulation on pipes and flanges. This was accepted by ISO. ISO Technical Committee TC43/ SC 1 formed Working Group WG48 with Erik Tromp of Shell Global Solutions as convenor. This Working Group has now produced the DIS version of this Standard and has received international comment and incorporated them as appropriate

3. GENERAL ISSUES FOR PIPING ACOUSTIC INSULATION.

Most engineers or consultants in the field have been asked to solve noise problems that should have been eliminated in the design phase. After project start up , it is often difficult and expensive to rectify noise problems in a complex plant. Missing or wrong piping insulation is a case in point.

Acoustic insulation of piping is often an major issue for a large petrochemical plant with severe community noise limits to meet. The total length of piping on large process plants can be measured in kilometres giving a large potential area for the radiation of noise.
While noise from equipment can be controlled by the use of acoustic enclosures or other means, it is not usually practical to apply these techniques to piping systems.

3.1. Valve Noise.

The main source of noise in piping are control valves and the noise from associated machinery.
The noise from valves is controlled by specifying the maximum noise level of the valve in the purchasing requirements. This is addressed in published specifications such as IEC534 Part 8 section 3 (2). The noise of control valves radiated predominantly from the downstream piping rather than the valve itself, as often the valve is a thickwall casting or forging, while the connecting piping is usually thinner. It is always better to reduce noise at source rather than to mitigate the noise by path treatment. Noise levels can be reduced by fitting of low noise trims inside some valves, but significant noise reductions may require that the valve itself needs to be changed as the required low noise trim cannot be fitted inside the existing valve body. An alternative is to insulate the piping downstream of the valve, and sometimes upstream of the valve also, if the pressure drop through the valve is less than a critical drop.

3.2. Rotating Equipment Noise.

The noise from rotating equipment also a significant source of plant noise. Noise radiated directly by the rotating equipment needs often needs to be controlled, but the noise from the connecting piping can be considerably worse.
Rotating equipment often has thick casings more than 25mm thick to ensure the mechanical strength of the equipment as it absorbs the driving power, contains the internal pressure and maintains all of the rotating parts in alignment. This helps to reduce noise also. The connecting piping is often much thinner i.e. 9mm or less
The gas borne noise from the rotating equipment is injected into the connecting piping where it is transmitted and re-radiated with little attenuation along the way. In addition, the vibrations from the machine are transmitted into the pipewall and also travel long distances through the system. The noise in the gas stream and the noise in the pipewall are reputed to link to, and reactivate each other should the noise control engineer be successful in controlling either one.
Mechanical vibration can be isolated by the use of flexible bellows, but these are often ruled out in the oil industry on safety grounds in hydrocarbon service due to the severe consequences of any possible leaks.

Piping noise is thus a significant part of the whole plant noise and the application of acoustic insulation needs some planning. It is often very difficult to apply it retrospectively later.

3.3. Effect of Piping Noise on Plant Design

Published data on compressor piping (2) shows that un-insulated compressor piping has a sound power/ metre of approximately 105 dB. So 100 m of un-insulated piping is equivalent to 125dBAL_W. This value is typically the whole plant sound power level design allowance for a large gas plant in a

remote location. In more developed areas, 5 metres of bare pipe could be equivalent to the whole plant sound power level design allowance.
This illustrates the degree of difficulty in achieving a successful result with acoustic insulation applied as a "fix" after the design is built.

3.4. Rectification Difficulties.

After construction is completed there is often not enough space between pipes for effective insulation thickness to be applied. Piping designers often leave only 75mm spacing between pipes and 30mm between pipe flanges. This is to allow access for pipe welding and pipe guide installation during construction and pipe movement during operation due to mechanical and thermal stress. Sometimes this clearance can be used for insulation, but then access and movement tolerances are lost.
The piping for large compressors is often subject to elaborate flexibility analysis to ensure that the compressor to which it is attached is not overstressed by the weight of the attached pipe. Adding insulation increases the weight and requires that the pipework system flexibility and compressor nozzle leads be re-analysed.This is unpopular after the construction of the project is complete.

Another issue is the use of support shoes under insulated pipes.
These gives clearance between the pipe and any supporting steelwork to allow the insulation to fully wrap around the pipe and to be properly weatherproof and to be fully effective acoustically. When this is not possible there is often contact between the pipe and supporting steelwork allowing noise to be re-radiated by the supporting steel. In addition it is often difficult to seal the insulation around the pipes / support interface. Poor weatherproofing leads to moisture becoming trapped in the acoustic insulation. This leads to corrosion of the piping and is a real safety issue on some plants.

The ISO 15665 Standard will not solve any of these problems, but it does provide a basis for achieving a reasonable acoustic insertion loss from an acoustic insulation system.
The investigation, measurement and selection of an acoustic solution will remain with the acoustic design engineer to resolve.
What should be easier in future is the implementation of an acoustic insulation system that should achieve a specified performance if applied correctly.

4. FEATURES OF ISO 15665 "ACOUSTIC INSULATION FOR PIPES VALVES AND FLANGES".

The ISO specifies three "standard "types of acoustic insulation with matching acoustic performance. These three "standard" acoustic insulation systems use common materials that are commonly available within the insulation trades.
The use of other acoustic insulation system is of course permissible, but there is a standard method set out to evaluate the performance of an insulation system and to rate it against the ISO insulation performance bands.
The issue of the relative performance of an insulation system when applied to different pipe sizes is also addressed.
This has been addressed previously only in German publications such as VDI3733 (3).
In addition, a lot of useful diagrams are attached which show how successful acoustic insulation could be applied.

4.1. Scope of the ISO

The International Standard is applicable to the acoustic insulation of cylindrical pipe and to their piping components. It is valid for pipe up to one metre in diameter and a minimum wall thickness of

4.2 mm for diameters below 300 mm and 6.3 mm for diameters from 300 mm and above. The Standard is not applicable to the acoustic insulation of vessels or machinery.
The ISO is specifically not applicable to rectangular ductwork. Rectangular ducting has appreciably less stiffness than piping and in some cases the weight of the insulation system can be more than the weight of the duct for the same length. The upper limit is based only on the range of the test data available and not for any reason of underlying acoustics.

This International Standard covers both design and installation aspects of acoustic insulation and provides guidance to assist noise control engineers in determining the required class and extent of insulation required for a particular application.
The International Standard emphasises the aspects of acoustic insulation that are different to those of thermal insulation, serving to guide both the installer and the noise control engineer. Specific attention is paid to the successful isolation of the cladding material from the pipewall to prevent noise being transmitted to the cladding and re-radiated by the cladding.

4.2. Definitions.

Most of the definitions will be familiar, but in ISO 15665." Acoustics - Acoustic Insulation for Pipes Valves and Flanges" the term "End-user (or owner or operator)" is used. This is defined as:
"The party which initiates the project and ultimately owns or operates the project, or pays for its design and construction. The end-user will generally specify the technical objectives and/or requirements. The end-user may also be an agent or consultant, authorised to act for the end-user."
The standard also uses:
Dw , insertion loss, sound power insulation defined as the difference in the sound power level radiated from a noise source before and after the application of the acoustic insulation
Dp **, sound pressure insulation** defined as the reduction in the sound pressure level, expressed in decibels, at a specified position, obtained due to the acoustic insulation, in one-third-octave or octave bands

4.3. Acoustic Performance of "Standard" insulation Systems.

ISO15665 defines the acoustic performance of three levels of acoustic performance . This is shown in Table 1. The negative insertion loss characteristic of acoustic insulation systems is also show.

		Octave band centre frequency in Hz						
		125	250	500	1K	2K	4K	8K
Class	**Nominal Diameter range**	**Minimum insertion loss in dB**						
A1&2	diameter < 650 mm	-4	-4	2	9	16	22	29
A3	650 mm≤ diameter < 1000 mm	-4	2	7	13	19	24	30
B1	diameter < 300 mm	-9	-3	3	11	19	27	35
B2	300 mm ≤diameter < 650 mm	-9	-3	6	15	24	33	42
B3	650 mm ≤diameter < 1000 mm	-7	2	11	20	29	36	42
C1	diameter < 300 mm	-5	-1	11	23	34	38	42
C2	300 mm ≤diameter < 650 mm	-7	4	14	24	24	38	42
C3	650 mm ≤diameter < 1000 mm	1	9	17	26	34	38	42

Table 1 The Performance Of "Standard" Insulation Systems As Per ISO15665

As the performance of acoustic insulation systems is non linear, the noise control engineer needs to know the acoustic characteristics of particular noise sources. Table 2 provides typical frequency characteristics of noise sources to assist with this.

	Octave band centre frequency in Hz						
	125	250	500	1K	2K	4K	8K

Source	Difference between A-weighted overall and A-weighted octave band level in decibels						
Control valve (1)	36	25	20	9	5	4	8
Centrifugal compressor (2)	31	21	12	7	2	9	13
Centrifugal pump	20	11	7	5	6	8	13
Reciprocating compressor	19	13	8	6	7	7	9
Centrifugal fan	18	10	5	6	8	11	15

Table 2 Acoustic Characteristics Of Noise Sources

In addition , ISO15665 provides calculation methods to assist the noise control engineer in establishing the nature and extent of the acoustic insulation that has to be applied.

4.4. Construction of typical insulation systems.

The general construction of piping insulation systems is described in some detail in this section. The cladding, porous layer, damping materials acoustic seals and cladding support systems are addressed.
The recommended practice proposes three standard construction methods of acoustic insulation that will provide the acoustic insertion loss of the three insertion loss classes.
A range of suitable materials for the cladding and porous layers are described in Table 3.

Class A	Porous layer :50 mm (min) +cladding 4.5 kg/m^2 min (e.g. 0,6 mm steel plate)
Class B	Porous layer :100 mm (min)+cladding 6.0 kg/m^2 min (e.g. 0,8 mm steel plate)
Class C	Porous layer [mm] :100 mm (min) + cladding below
	Cladding for pipe diameters < 300 mm :7.8kg/m^2(e.g. 1,0 mm steel plate)
	Cladding for pipe diameters >= 300 mm :10.0kg/m^2 (e.g. 1.3 mm steel plate)

Table 3 Classes of standard acoustic insulation construction

While the term porous layer is used, the airflow resistivity of the porous layer is specified, so that suitable materials must be used.

5. Testing method for other insulation constructions

The ISO specifies a method whereby any acoustic insulation system can be tested to demonstrate compliance with any particular class of acoustic performance. The method is broadly similar to ASTM E1222. The ISO can also be used at a standard way of testing acoustic insulation so that it's performance can be claimed to be "as tested to ISO 15665 Section 10". The acoustic performance has to be related to the size of pipe on which it was tested in the laboratory.
If for example the performance was in excess of class C then the performance can be stated "as tested to ISO 15665 Section 10."
This will give a degree of conformity to testing regimes.
The testing method is in a reverberation chamber with a loudspeaker noise source that is vibration isolated from the reverberation room and the pipe under test as shown in figure 3 of ISO 15665

6.0 Implications of ISO 15665

The implications of ISO 15665 will take some time to work themselves into the world of acoustics. Initially it will be easier for the acoustic engineer to specify the required performance for acoustic insulation. For example, the engineer may be able to specify "insulate pipe A with type B acoustic insulation for C metres." This will avoid the necessity of specifying the acoustic insulation in detail.

This will allow a wide range of competitive bids for acoustic insulation supply and installation to be evaluated more easily, as the acoustic performance will be a known quantity.

Installation practices for inexperienced acoustic insulation installers should improve as the ISO provides 17 illustrations of good practice in the installation of acoustic insulation
The ISO also calls for vibration isolation under the supports of pipes where noise re-radiation by the structure supporting the pipes is an issue. Vibration isolators with a 1mm deflection are required. This gives a theoretical 90% isolation to vibration frequencies above 50 Hz.
The re-radiation of piping noise by supporting steelwork is a real problem in oil and gas plants. In some cases, support steelwork has had to be acoustically insulated to rectify piping noise problems.

There may be a perception that only insulation constructions as described above are acceptable.
This is not the case. The ISO makes no limitation on any form of construction. However, in order to claim that an insulation system has a specific level of performance, the insulation system has to be tested to ISO 15665

7. Conclusions.

The publishing of ISO 15665 "Acoustic Insulation for pipes valves and flanges" will provide three standard of acoustic performance that the noise control engineer can use when specifying acoustic insulation. Three construction methods are specified which will give the claimed performance.
In addition, a test method is provided that will allow any existing or future insulation system to be tested and the acoustic insulation performance can be clearly stated.
This should help encourage competitiveness in the supply and installation of acoustic insulation,.

8. References

(1) IEC 534 Industrial-Process Control Valves, (Part 8 -) Noise Considerations, (Section 3 -) Control Valve Noise Prediction Method.
(2) Effective control of Environmental Noise by Colin D. Lyle . Gas Engineering 1990.
(3) VDI3733: Noise at Pipes, Verein Deutscher Ingenieure (available in English)