

PETRONAS TECHNICAL STANDARD
DESIGN AND ENGINEERING PRACTICE

TECHNICAL SPECIFICATION

**ACOUSTIC INSULATION FOR PIPING
(AMENDMENT/SUPPLEMENTS TO ISO 15665)**

PTS 31.46.00.31

FEBRUARY 2010



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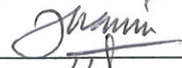
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This revision of PTS **31.46.00.31– Acoustic Insulation For Piping (Amendment/Supplements to ISO 15665)** has been updated incorporating PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. All updates in the document are highlighted in *italic* font.

The previous version of this PTS (**July 1997**) will be removed from PTS binder/ e-repository from herein onwards.

Document Approval

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PREFACE

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TABLE OF CONTENTS

1.	INTRODUCTION	5
1.1	SCOPE	5
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	5
1.3	DEFINITIONS	5
1.4	CROSS-REFERENCES	6
1.5	CHANGES SINCE PREVIOUS EDITION	6
2.	GENERAL	7
3.	NOISE REDUCTION ENGINEERING	8
3.1	REQUIRED ATTENUATION	8
3.2	CHOICE OF ACOUSTIC INSULATION CLASS	10
3.3	IMPLICATIONS FOR PIPING DESIGN	11
4.	CLASSES OF ACOUSTIC INSULATION	13
4.1	DEFINITION OF CLASSES	13
4.2	RESTRICTION IN APPLICATION	13
5.	DIMENSIONS OF ACOUSTIC INSULATION	14
6.	COMPONENTS AND MATERIAL	15
6.1	POROUS LAYER	15
6.2	CLADDING	15
6.3	ANTI-VIBRATION SEALS	15
6.4	SUPPORT OF THE CLADDING	15
6.5	COMBINED THERMAL AND ACOUSTIC INSULATION	16
7.	INSTALLATION	17
7.1	GENERAL	17
7.2	EXTENT OF INSULATION	17
7.3	ANTI-VIBRATION SEALS	17
7.4	END CAPS	17
7.5	ACOUSTIC ENCLOSURES	17
7.6	PREVENTION OF MECHANICAL DAMAGE	18
8.	REFERENCES	19

APPENDICES

APPENDIX 1	GENERAL COMPOSITION OF ACOUSTIC INSULATION	20
APPENDIX 2	TYPICAL ARRANGEMENT OF ACOUSTIC INSULATION SHOWING CLADDING AND END CAP	21
APPENDIX 3	CONSTRUCTION DETAILS - END CAPS	22
APPENDIX 4	TYPICAL ARRANGEMENT FOR BRANCHES AND TEES	23
APPENDIX 5	ARRANGEMENT FOR THE ACOUSTIC INSULATION OF FLANGED JOINTS	24
APPENDIX 6	CONSTRUCTION DETAILS - END CAPS OF BOXES	25
APPENDIX 7	SUPPORT FOR VERTICAL PIPE	26
APPENDIX 8	TYPICAL ARRANGEMENT FOR CLADDING SUPPORTS	27
APPENDIX 9	TYPICAL ARRANGEMENT FOR VIBRATION ISOLATED CLADDING AND INSULATION SUPPORTS IN VERTICAL PIPE	28
APPENDIX 10	DERIVATION OF INSERTION LOSS IN TERMS OF dB(A)	29

1. INTRODUCTION

1.1 SCOPE

This PTS specifies requirements and gives recommendations for the acoustic insulation of pipes, valves and flanges to reduce the noise emitted by these items.

Acoustic insulation of other equipment, such as large vessels and machinery, are excluded from the scope of this PTS. Also excluded are aspects common to thermal insulation, such as cladding, fastening, sealing, surface protection, safety regulations and compatibility of the porous layer materials with the environment. For these aspects, reference is made to PTS 30.46.00.31.

This PTS is a revision of the PTS of the same number dated July 1997.

Sections 3 and 4 of this PTS deal with acoustic aspects and are intended for the noise control engineer responsible for the acoustic design of the plant. Four classes of insulation are included in terms of their required acoustic performance and the choice of class will depend on the expected or measured noise radiated from the pipe and the required noise reduction. A general description is given of how this should be derived from equipment data or from measurements in operating units.

Sections 5, 6 and 7 of this PTS specify materials and installation aspects and are intended for the insulation contractor so that he can achieve the required noise reduction.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to companies forming part of PETRONAS or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them.

This PTS is intended for use in petrochemical facilities, such as oil refineries, chemical plants, gas plants, exploration and production facilities and supply/distribution installations.

When PTS are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regard to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this PTS which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this PTS as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project work and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant, authorized to act for the Principal.

The word **shall** indicates a requirement. The word **should** indicates a recommendation.

1.3.2 Specific definitions

Pipe

Unless the context indicates otherwise, the word pipe also includes other piping components such as valves, fittings and flanges.

Acoustic insulation

Acoustic insulation consists of one or more layers of a sound-absorbing material (the 'porous layer(s)') and one or more impermeable layers (the 'cladding'). It is applied to reduce the noise radiated from the pipe.

Flow resistivity

The flow resistivity of a porous material is defined as the pressure drop per unit thickness of the material for an air flow of unit velocity through the material.

It may be expressed as:

Flow resistivity = pressure drop / (air velocity * thickness of sample)

The dimension of flow resistivity is $\text{Ns/m}^4 = \text{Pa.s/m}^2$ (also referred to as Rayl/m)

NOTE: Procedures for determining the flow resistivity are described in ISO 9053.

Insertion loss

Insertion loss (IL) is the difference in the sound pressure level at a given fixed point anywhere outside the influence range of noise sources other than the pipe, before and after the acoustic insulation has been fitted. It is not appropriate to express insertion loss as a single number such as dB(A) because it varies with frequency. It shall therefore be quoted as decibels in octave bands (minimum range 125 Hz to 8 KHz).

1.4 CROSS-REFERENCES

Where cross-references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced in this PTS are listed in (8).

1.5 CHANGES SINCE PREVIOUS EDITION

Only minor changes have been made to the previous revision, mainly on general updating of references.

2. GENERAL

General requirements with respect to noise control are specified in PTS 31.10.00.31 which specifies the procedures for controlling noise and the maximum allowable noise levels.

The noise radiated by the wall of a pipe is usually generated by equipment connected to the pipe, such as compressors, pumps, valves or ejectors. These noise sources may cause long sections of pipe to radiate noise because noise will travel inside the pipe with little attenuation. Noise radiation should be reduced by using low noise equipment. If this is not reasonably practicable, the noise radiation may be reduced by incorporating in-line silencers or by applying acoustic insulation in accordance with this PTS.

In many respects acoustic insulation is similar to thermal insulation and is frequently installed by a sub-contractor specialised in thermal insulation. However, some aspects of acoustic insulation are different and the purpose of this PTS is to draw the attention of both the installer and the noise control engineer to these aspects.

It is emphasised that the ultimate success of acoustic insulation depends on the quality of installation; small gaps or bridging effects can have a far greater effect on the acoustic properties than on the thermal properties and may completely negate the acoustic performance. Thorough inspection shall therefore be performed during installation.

3. NOISE REDUCTION ENGINEERING

3.1 REQUIRED ATTENUATION

3.1.1 Plant Design Phase

The following considerations may be used to estimate the required attenuation in the design phase of a plant:

Firstly, determine the sound pressure level at a distance of 1 metre from the bare pipe wall. Piping upstream and downstream of the source shall be considered separately. The method to be applied depends on the pipe noise source in question (many valve manufacturers, for example, provide calculated dB (A) levels downstream of their valves). Both the octave band sound pressure levels and the overall A-weighted level should be determined. Appendix 10 gives typical octave band spectra for the most common sources of pipe noise.

3.1.1.1 Work area noise

If the pipe is the only source of noise in the area and is radiating under free-field conditions, the sound pressure level determined for the area in question can be compared directly with the area's noise limit, see PTS 31.10.00.31, and any excess noise obtained by subtraction.

If other noise sources are also present the total noise level should be determined before comparing it with the work area noise limit. The most economical means of eliminating excess noise should then be considered; either by reducing the pipe noise or by reducing the other sources.

3.1.1.2 Environmental noise or reverberant space

- (i) If the pipe is in a reverberant space or is subject to environmental noise limits, its sound power level should be determined. The sound power level L_w of the pipe is derived from:

$$L_w(s) = L_p(x, r) + 10 \log(2\pi r s) \quad (\text{dB}) \quad (1)$$

in which: s = the length of the pipe ($s \gg r$), m
 D = diameter of the pipe, m
 r = distance from the pipe axis, m
 (r normally = $(1 + \frac{1}{2}D)$, which is 1 m from pipe wall)
 $L_p(x, r)$ = the sound pressure level at a distance r from the axis of the pipe, at a distance x from the source, counted along the pipe
 $\log$ = logarithm to base 10

NOTE: Preferred value for x is 1 m; where attenuation along the pipe is considered negligible, other values of x may also be used.

- (ii) If the pipe is long (see below) it may be worth taking into account the attenuation along the length of the pipe, which is expressed by the formula:

$$L_p(x, r) = L_p(1, r) - \beta x / D \quad (\text{dB}) \quad (2)$$

in which: $L_p(x, r)$ = see equation (1)
 $L_p(1, r)$ = the sound pressure level at a distance of 1 m away from the noise source, at the same distance r from pipe axis as in $L_p(x, r)$
 β = attenuation factor, (dB)

The value of β shall be 0.06 dB for pipes carrying gas or vapour and 0.017 dB for pipes carrying liquid, except that other values may be used if sufficient data is available. The length of pipe should exceed $(3D/\beta)$ before attenuation should be taken into account. On the basis of equation (2) the sound power level L_w of a long pipe can be shown to be:

$$L_w(s \rightarrow \infty) = L_p(1, r) + 10 \log \frac{rD}{\beta} + 14.4 \quad (\text{dB}) \quad (3)$$

NOTE: The complete equation for the relation between L_w and $L_p(1)$ is:

$$L_w(s) = L_p(1, r) + 10 \log \frac{2\pi r D}{0.1 \beta \ln 10} + 10 \log (1 - 10^{-0.1 \beta s / D}) \quad (\text{dB}) \quad (4)$$

in which $\ln$ = logarithm to base e

For small values of $(\beta s/D)$, equation (4) can be shown to simplify into equation (1) and into equation (3) for very long pipes. The errors involved in applying equation (1) to pipes longer than $(3D/\beta)$ and in applying equation (3) to shorter pipes can be shown to be less than 3 dB.

- (iii) If the sound pressure level near to a source or the sound power level of a pipe section connected to that source is known and the pressure or power level has to be determined of another section under different conditions but connected to the same source, the following formula can be used to determine the difference in level due to those other conditions:

$$\Delta L = 10 \log t/t_k - 30 \log D/D_k - 10 \log P/P_k \quad (\text{dB}) \quad (5)$$

in which: ΔL = difference in (sound pressure or power) level, dB
 t = pipe wall thickness, m
 D = pipe diameter, m
 P = internal static pressure in pipe, Pa
 Subscript k refers to the conditions of the known level

The contribution of the pipe to the noise in a reverberant space is calculated from its sound power level and should be added to the contributions from other sources.

For environmental noise the contribution of the pipe to the total sound power level of the plant or to the sound pressure level at the adjacent point should be calculated.

If allowable limits are exceeded by the combined effect of noise sources, the most economical method of reducing noise should be found.

3.1.2 Plants in operation

In operating units the assessment of pipe noise should be based on measurements, and where the pipe noise is significantly higher than the background noise it may be measured directly as airborne noise.

If background noise is significant, pipe noise can be determined with sound intensity measurements. These measurements require special equipment and qualified personnel.

A third, less preferred option is to assess the pipe noise by measuring the vibratory velocity level as follows:

$$L_p(x, r) = L_v + 10 \log \sigma + 10 \log (D/2r) \quad (\text{dB}) \quad (6)$$

in which: L_v = the vibratory velocity level in the pipe = $10 \log (v/v_0)$
 v_0 = 5×10^{-8} , m/s
 $10 \log \sigma$ = radiation efficiency ($10 \log \sigma$ is negative, as $0 < \sigma < 1$)

The symbols D and r are pipe diameter and radial distance, as before. For practical purposes the value of σ can be derived from:

$$\sigma = \frac{1}{1 + \left(\frac{c}{4Df}\right)^3} \quad (7)$$

in which c = velocity of sound in air, m/s
 f = octave band mid-frequency, Hz

This method also requires special equipment and qualified personnel.

3.2 CHOICE OF ACOUSTIC INSULATION CLASS

Where pipe noise is to be reduced, the various alternatives should be considered:

- equipment designed for low noise;
- silencers;
- acoustic insulation.

If the assessment concludes that acoustic insulation of a pipe is required, the necessary reduction of pipe noise should be tabulated in octave bands. Reference to (4.1, Table 1) will then indicate which class of insulation is required; see also (4.2) for the limits of application.

Pipes will usually have to be insulated from the source up to (and sometimes including) the next silencer, vessel, heat exchanger, filter, etc., unless it can be shown that attenuation along the pipe has reduced the noise sufficiently at some point upstream or downstream of the source to render further insulation unnecessary.

This may be the point where the contribution of the pipe to the work area noise level is below the specified value, as according to equation (2). Alternatively, if the sound power level of a pipe is to be reduced, the length of the pipe, L , to be insulated can be derived as follows:

$$L = \frac{10D}{\beta} \log\left(\frac{1-a}{R-a}\right) \quad (m) \quad (8)$$

in which R = the reduction factor required for the radiated sound power level
 = antilog $\{(L_{w,after} - L_{w,before}) / 10\}$
 and a = the insertion loss factor of the acoustic insulation
 = antilog $\{(L_{p,after} - L_{p,before}) / 10\}$
 = antilog $(-IL/10)$
 IL = the insertion loss of the insulation (see Section 8)

NOTE: antilog (x) means 'ten to the power x '

The relation between the variables in equation (8) is illustrated in Figure 1, with the attenuation factor β taken as 0.06. This figure shows that reductions in sound power are limited by the performance (insertion loss) of the acoustic insulation, i.e. R shall be larger than a . It also illustrates that in some cases it may be more economical to choose a class of cladding with higher insertion loss, because the required length is (much) shorter.

NOTE: Both equation (8) and Figure 1 can be used for either octave band or overall dB(A) values.