INTERNATIONAL STANDARD

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Acoustics — Noise control design procedures for open plant

Acoustique — Modes opératoires de contrôle du bruit dans les installations ouvertes

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 15664 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

Annexes A to I of this International Standard are for information only.

Introduction

This International Standard defines procedures for the noise control design of open plants, including oil refineries, chemical plants, gas plants, unenclosed powerplants, steelworks, gravel washing plants, cement plants, concrete batch plants and other continuous, batch or intermittent operation plants located in the open, in order to achieve optimal environmental, occupational, technical and economic benefits.

This International Standard is applicable to the design of new plants and to the modification/extension of existing plants. It is based on experience in the design, construction, operation and maintenance of such facilities and identifies the major technical and procedural issues that should be addressed in a good plant noise control design.

The users of this International Standard should be familiar with the type of plant involved and have sufficient technical expertise and experience in industrial plant noise control design. This International Standard is intended to be flexible to suit the nature and location of the plant being designed, and the technical abilities of the parties involved.

Where there is any conflict between this International Standard and any local regulations, the requirements of the local regulations should be complied with.

It is specifically intended that the end-user and the contractor agree on the nature and extent of the work to be done and the reporting on the work, and which party carries out what work.

This International Standard is not intended specifically to be a contract document, but it is recognized that annex B and any additional requirements specified separately may form part of a contract between the end-user and the contractor.

This International Standard is not considered suitable for reference in procurements specifications (requisitions) of individual equipment as it addresses issues that are often beyond the scope of an individual equipment item vendor.

A list of standards related to this International Standard is given in the Bibliography.

Acoustics — Noise control design procedures for open plant

1 Scope

This International Standard defines the procedures for noise control of mainly open plants.

It is applicable to the following:

— specification of procedures for noise control during engineering of a new plant and modification/extension of existing plants (construction noise procedures are outside the scope of this International Standard but should be considered);

— definition of responsibilities of parties involved, viz. “end-user”, “engineering contractor” and “equipment supplier”;

— description of general procedures to arrive at noise requirements for individual equipment, on the basis of overall noise requirements for the plant.

A schematic flowchart, reviewing the noise control process, is presented in annex A and a summary of action items is presented in annex B.

NOTE Concerning specific engineering methods for the acoustic design and analysis of plants, use should be made of other standards and textbooks.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 1996-1, *Acoustics — Description and measurement of environmental noise — Part 1: Basic quantities and procedures*

ISO 1996-2, *Acoustics — Description and measurement of environmental noise — Part 2: Acquisition of data pertinent to land use*

ISO 3864, *Safety colours and safety signs*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1 General terms

3.1.1
end-user
party which initiates the project and ultimately owns or operates the plant, or pays for its design and construction

NOTE The end-user will generally specify the technical objectives and/or requirements.

3.1.2
contractor
party which carries out all or part of the design, engineering, procurement, construction and commissioning for the project

3.1.3
manufacturer
supplier
party which manufactures or supplies equipment and services to perform the duties specified by the contractor

3.1.4
work area
any position not less than 1 m from equipment surfaces accessible to personnel, and any position where a worker's ear may be exposed to noise in the normal course of his duty

NOTE The work area includes any platform, walkway or ladder.

3.1.5
project specification
document defining the scope of a project

NOTE It can contain descriptions of the process, project management, responsibilities and engineering requirements. These include safety and environmental requirements.

3.1.6
governing authorities
local, regional, national or other authorities that specify and enforce criteria for environmental and occupational health noise

3.2 Terms specific to noise

3.2.1
noise limit
noise levels not to be exceeded and given as a sound power level, sound pressure level or noise exposure level

3.2.1.1
authority noise limits
noise limits set by governing authorities

3.2.1.3
contractual noise limits
noise limits set by the end-user as part of a legal contract between the end-user and the contractor, considering authority noise limits and company requirements

3.2.1.4
equipment noise limits
noise limits set by an end-user or contractor for a manufacturer/supplier for an individual equipment item

3.2.2
tonal noise
noise which is dominated by one or several clearly distinguishable tone(s)

NOTE See ISO 1996-2.

3.2.3
impulsive noise
noise consisting of one or more bursts of sound energy of duration less than about 1 s

NOTE See ISO 1996-2 (environmental noise), ISO 1999 (in-plant noise) and ISO 12001 (equipment emission).

3.2.4
fluctuating noise
noise whose level varies continuously and to an appreciable extent during the period of observation

[ISO 12001:1996, definition 3.19.1]

3.2.5
intermittent noise
noise whose level abruptly drops to the level of the background noise several times during the period of observation

[ISO 12001:1996; definition 3.19.2]

NOTE The time during which the level remains at a constant value different from that of the ambient is of the order of 1 s or more.

3.2.6
noise emission
airborne sound radiated by well-defined noise source, such as a machine, equipment, part of a plant or an entire plant

NOTE See ISO 12001 and ISO 11690-1.

3.2.7
noise immission
total amount of noise from all contributing sources at a given position

NOTE See ISO 11690-1.

3.2.8
noise exposure
all noises that arrive, over a specific time period, T, at a person's ear in the actual situation

NOTE See ISO 11690-1; for the purposes of this International Standard, this term is also used for specific positions in the environment.

4 General requirements

The control of noise in a plant is necessary for the following reasons:

— to prevent noise-induced hearing loss;

— to reduce work, speech and concentration interference;

— to provide quiet living accommodation for personnel;

— to protect the environment;

— to prevent annoyance to the neighbouring community.

Noise limits can be given for each of the above aspects of noise control, relative to certain areas inside or outside the plant. For the purposes of this International Standard, they are referred to as “general noise limits”. They are specified in clause 5.

Noise limits for each item of equipment shall be derived from the general noise limits, as applicable for the equipment in its specific position in the plant. These are commonly referred to as “equipment noise limits”. Procedures for deriving equipment noise limits are specified in clause 6.

Each potential noise source shall be subject to the requirements of this International Standard.

Authorities may enforce obligations to reduce noise levels as far as reasonably practicable. Recommendations for noise limits may be found in national or International Standards, e.g. ISO 11690-1 (work place), ISO 9921-1 (speech communication) and ISO 1996 series (environment).

The specified limits shall be met for the design operating conditions of the plant. They shall also hold for other operating conditions which occur occasionally, such as start-up, shutdown, regeneration and maintenance, unless specified otherwise by the end-user and agreed with the contractor. The only requirement for emergency situations (i.e. any conditions other than just described) which can be foreseen or predicted (e.g. relief valve operation) is that the absolute limit specified in 5.1.2 shall not be exceeded.

The end-user may set specific noise limits applicable to the construction phase of the project. These limits may be set to meet environmental requirements.

This International Standard deals with noise from more or less stationary equipment. However, noise radiated from mobile noise sources, such as transportation vehicles (lorries, trucks, railway equipment) or mobile maintenance equipment, in the plant or workshops might have to be taken into consideration. Noise due to mobile sources is more important if relatively high numbers of vehicles are present near the boundaries of the plant, also because noise reduction is often hard to achieve for this type of source. Therefore parties shall investigate whether or not this kind of transportation noise has to be considered as part of the noise control procedures.

The planning for and extent of the noise control engineering for a plant is based heavily on the project specification. It is always vital that all of the noise limits and any other noise requirements specified by the end-user be carefully and completely defined in the project specification. This is particularly true where more than one contractor is involved or where the plant (or part thereof) might be operated by other than the end-user or contractor. In addition to the noise limits, the project specification should include all applicable items from annex C.

This International Standard defines a number of specific tasks that may be performed during a project. These tasks are assigned an action item (A1, A2, A3, etc.). The responsibility for the execution of these action items is assigned to either the end-user or the contractor as stated in annex B, where a summary of the action items is included.

5 General noise limits (immission requirements)

5.1 In-plant noise

5.1.1 General

(A1) The end-user shall investigate all governing authority requirements with respect to noise in the plant, with respect to hearing conservation, speech and work interference, noise levels for accommodation, etc.

Noise limits are often based on noise exposure of workers. In that case work patterns leading to noise exposure shall be agreed by the parties involved. Noise limits may also be based on maximum sound pressure levels for work areas.

(A2) The most stringent noise limits and other requirements shall be determined from the requirements of governing authorities and end-users. The applicable contractual noise limits shall be stated in the project specification.

Where there are no authority limits, the guidelines of ISO 11690-1 and other International Standards should be considered.

5.1.2 Absolute work area noise limit

The absolute limit is the sound pressure level anywhere in the work area that shall not be exceeded in any situation, including emergencies; for example the operation of safety equipment.

The absolute limit is determined in action item (A2).

5.1.3 Work area noise limit

The work area noise limit, which may be different for different areas, defines the noise level that shall not be exceeded in order to comply with the limits as determined in action item (A2).

5.1.4 Restricted area

Restricted areas are those work areas in the plant where, according to the state of the art, it is not reasonably practicable to reduce the noise level at or below the work area limit. The absolute limit remains valid in such areas.

If it is unavoidable that the work area limit will be exceeded around particular equipment, action should be taken to limit the area involved as far as is economically and technically feasible. This may include the erection of an acoustic enclosure. Areas inside acoustic enclosures around such equipment may be restricted areas.

(A3) The contractor shall identify the potential restricted areas to the end-user. Written permission shall be obtained from the end-user to designate an area as a restricted area. The end-user and contractor shall discuss and agree the noise levels that may be permitted in these noise restricted areas, taking into account authority requirements.

(A4) Permanent warning signs to indicate the mandatory use of ear protectors shall be erected at the boundaries of restricted areas. The signs shall be of the type specified in ISO 3864.

5.2 Environmental noise

Limits for environmental noise are often set by governing authorities and may be linked to existing noise levels. The regulations can also include methods for measurement and calculation of environmental noise immission based on the sound power emitted by noise sources. Regulations can include requirements for permits and environmental assessments. See ISO 1996-1 and ISO 1996-2.

(A5) The end-user shall investigate applicable regulations. In order to avoid misunderstandings, it can be useful to discuss the interpretation of the regulations with the authorities.

Environmental noise limits are often different for day, evening and nights, and for week-ends. All of the above requirements shall be taken into account so that all of the requirements are met at all times.

(A6) Where requirements for environmental noise do not exist or are considered insufficient, this aspect of plant design shall still be considered at the project definition stage to anticipate adverse community reactions at some later date.

(A7) Authorities usually specify environmental noise limits for normal and sometimes for emergency operation as a sound pressure level limit at specified locations in the vicinity of the plant or at the plant boundary line. Such limits can be converted into contractual noise limits in terms of sound power level for a number of composing parts of the plant under consideration. In these cases the resultant sound power level limits shall be included in the project specification.

Calculation of environmental noise immission on the basis of source sound power levels and vice versa shall be carried out in accordance with recognized calculation models specified or agreed by authorities and the end-user. Examples of recognized calculation methods (e.g. those in ISO 9613-2) are given in the Bibliography.

NOTE There are many ways to convert sound pressure level limits into sound power level limits for composing parts of a plant or large equipment items. The sound power level limits usually must be specified as octave or one-third-octave spectra and also must include directivity restrictions.

5.3 Exceptional or emergency operating conditions

(A8) It shall be ensured that any allowances for occasional higher noise levels that may be acceptable to governing authorities (such as for emergencies, start-up, shutdown and maintenance activities) are included in the project specification.

(A9) Any noise limits applicable during construction of the plant shall be stated separately in the project specification.

5.4 Additional restrictions for tonal or impulsive noise

Further restrictions may apply if the noise contains tonal or impulsive components and these shall be taken into account when specifying equipment noise limits (see 6.3.5).

6 Equipment noise limits (emission requirements)

6.1 General

Equipment noise limits shall be derived from the noise immission or exposure limits of the work area (A2) and the sound power level limits obtained from 5.2 (A7), or any other limits that may be stated in the project specification.

If the results of the investigation indicate that one or more of the limits will be exceeded, consideration should be given to replacing the equipment concerned by equipment emitting less noise or, if this is not reasonably practicable, noise control measures such as insulation or acoustic enclosures should be installed. The extent of noise control measures to be taken shall be in accordance with the severity of the requirements.

6.2 Sound power level limit for equipment

For plants where no other limit than the work area limit (see 5.1.3) is applicable and not many significant noise sources are located near each other, the equipment sound power level limit need not to be determined.

The sound power level limit for individual equipment shall be determined at an early stage of the project in order to comply with the noise limits of the plant.

The allocation of sound power level limits to individual equipment items at an early stage of a project can best be performed using vendor data, noise declarations (see, for example, ISO 4871), databases and experience, taking into account the type, size and operating conditions of the equipment. However, where actual sound power levels are known, they should be used. They may also be calculated from equipment sound pressure levels, assuming that the requirements of 6.3 will just be met.

The derivation of the sound power level limit for each item of equipment is an iterative process. If a sound power level limit for a plant, or a number of parts of a plant, is specified (5.2), it is only required that the sum of the sound power limits for equipment items in that plant does not exceed the overall limit. If the environmental limit is not provided as a sound power level limit, the total environmental immission sound pressure level at the locations where the environmental limits apply shall be computed (predicted). The sound pressure levels due to each noise-producing item at the community location of interest can be added together. Noise propagation calculations shall be carried out in accordance with recognized calculation models specified or agreed by the authorities and end-users (see, for example, ISO 9613-2). It can then be decided if individual equipment sound power level limits can be increased or decreased so that the community sound pressure level limit is met. The allocation of any safety

margin between the calculated sound pressure level and this community sound pressure level limit at the same point shall be considered. The reliability of the sound power levels used, and an allowance for items that may have been omitted from the calculation, should also be considered.

It is more cost effective to allocate higher sound power level limits to large or high-powered equipment than to simply allocate the same sound power level limit to each item of equipment.

The noise control engineer shall also consider other aspects when predicted community sound pressure levels exceed the limits. These aspects could be the relocation of items of equipment to increase the distance to the community point, the use of screening by natural or man-made obstacles (such as hills or buildings), the use of sound barriers, or the use of noise-reducing acoustic enclosures.

In most cases, it is better to reduce noise at source.

6.3 Sound pressure level limit for equipment

6.3.1 General

For equipment where no other limit than the work area limit (see 5.1.3) is applicable, the emission sound pressure limits given in 6.3.2 to 6.3.6 shall apply.

Where more or less (e.g. restricted area) stringent work area noise limits apply, the equipment noise limits given below shall be adapted accordingly.

Equipment sound pressure level limits shall not be exceeded anywhere at a distance of 1 m from the equipment surface or at the operator position.

Some equipment in what is generally “open” plant can be located in buildings or shelters. Then sound pressure levels inside buildings or shelters shall be calculated, taking into account both the noise from equipment in the building and the noise from outside. Calculation of the attenuation of noise from outside to within a building shall be based on accepted acoustic principles.

6.3.2 Equipment emitting continuous noise

The maximum value for the equipment noise limit (sound pressure level) shall comply with the work area limit (see 5.1.3).

If equipment consists of components (e.g. a driver and a driven part), the above limits applied to each component separately will **not** ensure that the assembled equipment meets the work area limit. For such equipment, more stringent limits shall be specified on the data/requisition sheets for the separate components. The noise limit per component shall be based on acoustic calculations.

A further reduction of the equipment noise limit shall be made when several items of equipment or equipment trains are to be mounted close together, or when the equipment is located in a reverberant area. The equipment noise limit shall be based on acoustic calculations (see, for example, ISO/TR 11690-3).

6.3.3 Equipment emitting intermittent or fluctuating noise

Where the general noise limits of 5.1 and 5.2 are complied with, but equipment emits an intermittent or fluctuating noise (e.g. depressuring, boiler blow-down, sump pump), the estimated equivalent continuous sound level, L_{eq}, shall not exceed the equipment limits specified in 6.3.2. A maximum instantaneous level may be set by the end-user or authorities (see clause 5).

NOTE Some regulations require a 5 dB exchange rate for halving the worker exposure instead of the 3 dB exchange rate implicit in the use of an equivalent continuous sound pressure level.

6.3.4 Equipment located outside the work area

The equipment noise limit is normally set at 1 m from the equipment. Where the nearest accessible position is more than 1 m away, an equipment noise limit for 1 m may be set higher and should be calculated. This could be the case for vent stacks and certain control valves.

Although from the work area limit point of view this increase might be permissible, it might conflict with the environmental noise limit. This can be the case with flare noise, for instance. The most stringent requirement based on the work area limit and the environmental noise limit shall be applied.

6.3.5 Additional restrictions for tonal or impulsive noise

Further restrictions can apply when the noise of an equipment item contains tonal and/or impulsive components and the relevant sound source contributes significantly.

6.3.6 Specific equipment

Some additional information on the noise aspects of specific equipment is listed in annex D.

6.4 Equipment noise data sheets

(A10) Equipment noise data sheets shall be prepared for all relevant items of equipment or an equipment train, if such a train will be provided by a single supplier, specifying the limits as given in 6.2 and/or 6.3. If the components of a train will be provided by different suppliers, separate equipment noise data sheets shall be prepared.

The equipment noise limits shall be given as an overall A-weighted value in decibels or, where considered more appropriate, the corresponding 63 Hz to 8 kHz octave-band spectrum may be specified in addition.

An equipment noise data sheet (such as the model given in annex E or similar) shall be used to specify either a sound pressure level limit at a specified distance, usually 1 m, from the equipment surface (or operator position) or a sound power level limit, or both.

The supplier is obliged to state noise guarantees for the equipment to be provided, for any of the conditions of operation for which the equipment can be expected to be used.

The equipment noise data sheet shall contain all the information that the equipment supplier requires to understand, comply with and measure compliance with, and the noise limits for the equipment to be supplied. It is not intended that this International Standard and the end-user/contractor agreements be sent to the equipment supplier.

The equipment noise data sheet shall be returned with the tender, with its guarantee section completed by the supplier, giving the following information:

a) unsilenced sound power and sound pressure levels in octave bands, and the A-weighted overall levels of the equipment;

b) sound power and sound pressure levels in octave-bands, and the A-weighted overall levels of the equipment, together with details of any silencing measures that are necessary to meet the specified noise limits;

c) the minimum attainable sound power and sound pressure levels in octave bands, and the A-weighted overall levels, if the specified limits cannot be met;

d) details of any tonal, impulsive, intermittent or fluctuating noise levels.

Additionally the following information shall be given, where applicable:

e) completed data/requisition sheets of any silencers and/or acoustic enclosures, if the tender comprises such silencing equipment.

Data based on measurements shall be determined according to accepted standards. International Standards, for instance the ISO 11200-series and ISO 3740-series, are recommended.

All guaranteed noise levels quoted shall include upper measuring tolerances. The noise control engineer should consider the test method tolerances when setting the noise limits for individual equipment items.

If guarantees have been provided in some other way, specification of equipment noise limits on individual data/requisition sheets is not required. For example, where a supplier provides all the pumps or motors in a project, a list of guaranteed equipment noise levels and spectra per item will be acceptable.

NOTE 1 The sound power level limit and sound pressure level limit need not be related or equivalent since they can originate from different general limits; i.e. the sound power limit can originate from the “environmental” noise limit and the sound pressure limit from the “work area” noise limit.

NOTE 2 An example of declaring noise emission values of machinery and equipment that includes measuring and production tolerances in this way is given in ISO 4871.

NOTE 3 Octave-band spectra are needed for further acoustic calculations. However unless otherwise specified, the overall A-weighted value in decibels will be evaluated against the noise limit.

6.5 Equipment selection

(A14) It shall be ensured that suppliers have provided in their tenders all the information required in accordance with 6.4.

If the noise measurement method used by the supplier differs from the method required or recommended on the data sheet, the influence of such a difference shall be evaluated.

(A15) Bid comparison shall be made, including the cost of all the options required to meet the specified noise limits. Where a choice can be made between equipment with low noise emission by design and equipment with external noise abatement measures (path-treatment), the estimated extra cost in operation and maintenance that could result from path treatment shall be taken into account in the ultimate selection. Generally, preference should be given to equipment of low noise emission by design.

For equipment emitting fluctuating or intermittent noise, temporary excursions above the equipment noise limit might be permissible, see 6.2 and 6.3.3. If such excursions can be avoided by selecting a less noisy and otherwise acceptable alternative, then this shall be preferred. Where a higher extra expenditure would seem justified, the end-user shall be consulted.

7 Silencing equipment

(A16) Silencing equipment, such as silencers and acoustic enclosures, may be included in the tenders for noisy process equipment (6.4). When the supplier has been selected, details of such silencing equipment shall be agreed upon between the supplier and the contractor. It is often useful for an equipment supplier to provide silencers for that equipment, so that the source of the noise and the control of the noise are in one scope of supply. However, the contractor may choose to order silencing equipment separately from the process equipment.

Noise emission from certain silencing equipment (e.g. silencers on vent stacks, acoustic insulation on pipes) is not always the responsibility of any particular equipment supplier, and is the responsibility of the contractor. It shall be ensured that such silencing equipment is incorporated in the design and that the relevant data/requisition sheets are prepared.

Where required, sound-absorbing materials or constructions shall be incorporated in the design of potentially reverberant spaces for noisy equipment. For example, for minimum absorption, ISO 11690-1 deals with recommended acoustic properties of work rooms.

(A17) For some equipment, calculations or measurements can indicate that the noise limits will be exceeded, but with a margin of uncertainty extending down to levels below the limit (i.e. there is a possibility that the limits

might be met). For such equipment, the conceptual design of adequate noise control measures shall not be postponed until actual noise levels have been obtained after start-up. If application of the noise control measures may be delayed until after start-up, this shall be specifically agreed with the end-user, if acceptable to governing authorities. Services such as electrical and instrumentation and any necessary other requirements shall be provided in advance of start-up. The consequences arising from the late application of noise control measures, such as a change in electrical classification, shall be considered in the design.

For large plants, the cost of downtime or lost production to fit noise control equipment after start-up will often exceed the cost of the noise control equipment itself.

Silencers to suppress noise during the commissioning phase may be of a movable and temporary type.

Silencers to reduce noise in transient operations such as start-up, shutdown, etc., shall be permanent.

For the selection of silencers, information can be obtained from ISO 14163. The design of silencers shall ensure that any internal parts that could inadvertently break loose do not partly or completely block the silencer outlet or damage downstream equipment (e.g. compressors).

Acoustic enclosures (see, for example, ISO 15667) may be either of the close-fitting or walk-in (large) type. Large enclosures shall be designed in such a way that operating/maintenance personnel can conduct their work without being hampered in their movements.

Some authorities require that field-installed noise control measures, such as acoustic insulation, be inspected by a suitably experienced noise control engineer during the installation process.

8 Project control

8.1 Noise control documentation

(A18) Annex F lists documents that are required by the noise control engineer of the contractor and which can be made available to the end-user if close guidance is required during the design and procurement phase of a project. The extent of reporting detailed noise information to the end-user shall be agreed.

8.2 Engineering phase reports

(A19) Where environmental noise limits or a plant sound power limit are specified, a noise allocation report shall be prepared to show how sound power levels are allocated to various equipment items. The report, with figures based on manufacturer's information, experience or data bases, serves to set equipment noise limits and to anticipate noise abatement measures. The report shall be submitted to the end-user for approval before data/requisition sheets are released for tendering.

(A20) The contractor shall prepare a noise control report for approval by the end-user after the major part of the equipment selection has taken place. The report shall give sufficient data and calculations to demonstrate to the satisfaction of the end-user that the acoustic design of the plant will meet the requirements.

(A21) The model formats given in annexes G and H may be used for these reports and the contents shall be agreed between the end-user and contractor.

In both reports (action items A19 and A20), due attention shall be given to the prediction of piping noise (see annex D).

8.3 Noise test runs

(A22) The contractor or end-user shall decide which equipment shall have a noise test run at the supplier's works.

Test runs at the supplier's works may not reproduce the in-service conditions. The end-user, contractor and supplier shall agree corrections to be applied to tests at the supplier's works to estimate noise levels of the equipment in service.

Where acceptance of individual equipment items is conditional on satisfactory conclusion of noise test runs at the supplier's works, the test run shall reflect the *in-situ* arrangement and a suitable test procedure shall be agreed between the contractor, end-user and supplier.

8.4 Acceptance test

(A23) At the start of the project, the end-user and contractor shall agree on the plant noise acceptance test procedure, including measurement and calculation methods and tolerances. Any requirements of governing authorities involved shall be considered.

The possible range of surveys could include, for example,

— measurement of the sound pressure levels from the plant at specified points,

— identification of areas where noise limits exceed specified values, and which are possible hearing protection areas, on the basis of a tour of the plant,

— derivation of worker noise exposure levels,

— determination of the sound power level of the whole or part of a plant (ISO 8297 may be used) and the resultant sound pressure levels at community points.

Accordingly the format of the model noise verification report may need to be varied in line with the project requirements.

(A24) A final plant acceptance test shall be performed and reported in a noise verification report by the end-user or contractor, or by an independent party according to the test procedures agreed under action item A23. Some authorities require certified or accredited organizations to be involved.

The report may be prepared in accordance with the format shown in annex I. The verification report usually includes a noise survey of the plant. The results of the survey will be compared with the project requirements. The comparison of required and determined noise levels completes the verification process.

The model noise verification report provides a framework that may be used for a typical plant noise survey and verification report. It may also be used as a reminder of the things that could or should be recorded while carrying out a noise survey.

A noise survey carried out before site work commences on a project is usually carried out to establish pre-existing noise conditions on site (zero measurement). Noise surveys after start-up are usually to verify compliance with the noise limits set for the project.

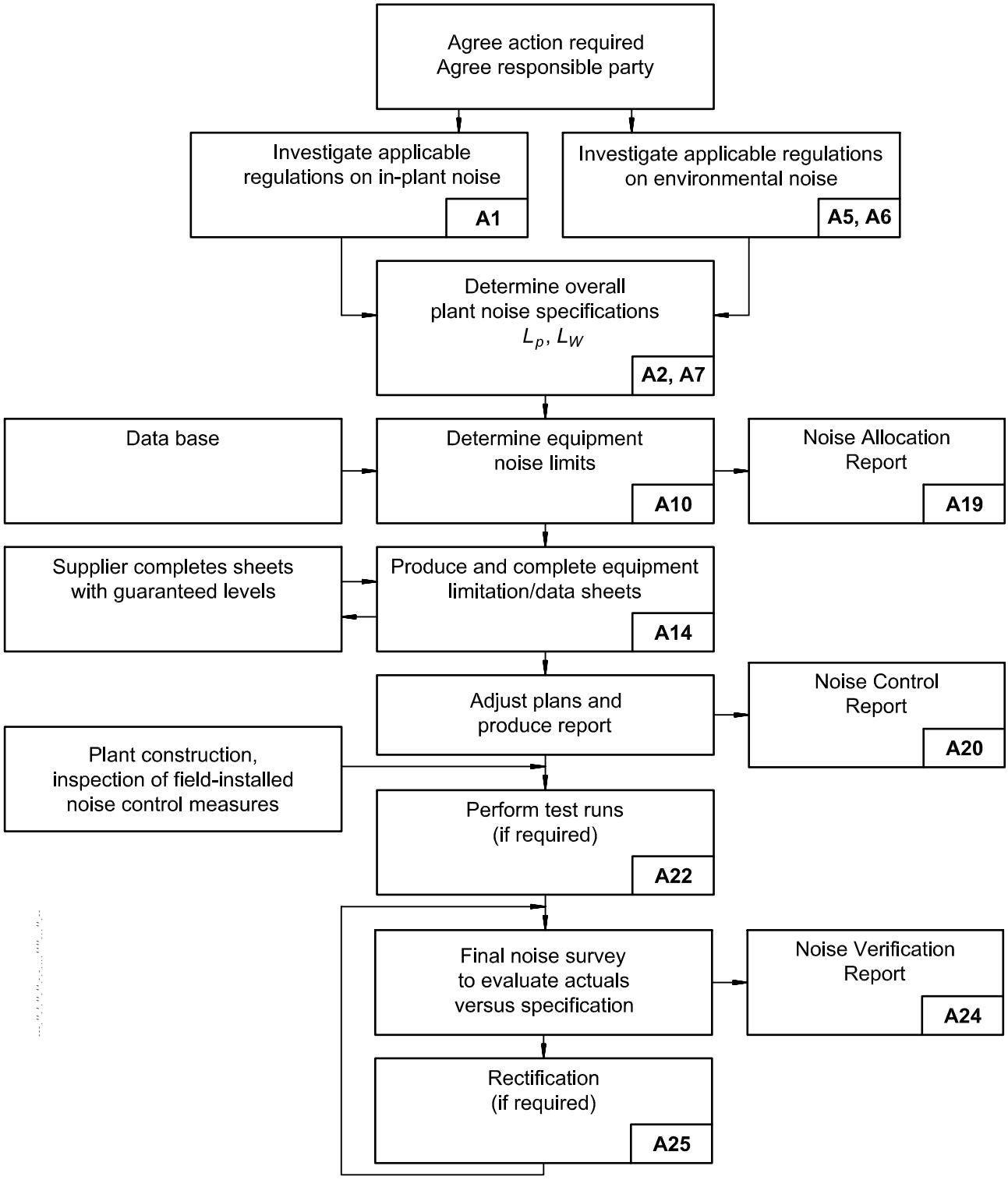
The model noise survey report is not specifically intended to describe the measurement of sound pressure levels of individual items of equipment and the derivation of their sound power levels. However, while such activities may be part of the objectives of a verification report, such noise measurements are described in detail in other relevant International Standards.

8.5 Remedial action

(A25) Corrective action shall be taken if actual sound pressure or power levels or levels calculated from measurements made in the acceptance test exceed the specified limit. The responsibility for rectification shall be agreed in the contract between the end-user and the contractor. After rectification, compliance with the specification shall be verified.

Annex A
(informative)

Noise control flowchart



NOTE Numbers **A1**, **A2**, etc. refer to action items, see annex B.

Annex B
(informative)

Summary of action items and allocation of responsibility

The action items defined in this International Standard are summarized in Table B.1; the allocation of the responsible party should be agreed before the start of a project.

Note that the action items given in Table B.1 are not in the chronological order in which they occur in a project.

Table B.1

Action item No.	Task description	Reference clause	Action required/Responsible party [a]	
			end-user	contractor
A1	Investigate applicable regulations for in-plant noise	5.1.1	x	
A2	State in-plant noise limits in project specification	5.1.1	x	
A3	Obtain end-user's permission for restricted areas; set limits for those areas	5.1.4		x
A4	Erect signs indicating hearing protection zones	5.1.4		x
A5	Investigate applicable regulations on environmental noise and discuss the interpretation with authorities	5.2	x	
A6	Consider environmental noise aspect (where no regulations exist or are considered insufficient)	5.2	x	
A7	Incorporate sound power limit in project specification	5.2	x	
A8	Set noise limits for occasional operating conditions, viz. start-up, shutdown, maintenance and emergencies	5.3	x	
A9	Set special noise limits during plant construction	5.3	x	
A10	Specify equipment noise limits, including additional restrictions	6.4		x
A11	Determine pipe noise; assess insulation and silencer requirements	D.3		x
A12	Determine the need for vent silencers	D.4		x
A13	Evaluate the need for special requirements for flare	D.5		x
A14	Obtain noise limitation sheet with guaranteed power/ pressure level from supplier, incl. silencers/enclosures	6.5		x
A15	Select least noisy equipment	6.5	(x)	x
A16	Agree on details of silencers/enclosures	7	(x)	x
A17	Agree on postponing the decision to apply noise control measures until after start-up	7	(x)	x
A18	Prepare noise control (background) information	8.1	(x)	x
A19	Submit noise allocation report	8.2		x
A20	Submit noise control report	8.2		x
A21	Agree format for noise control reports	8.2	x	x
A22	Decide which equipment shall have a noise test run	8.3		x
A23	Agree on acceptance test procedure	8.4	x	x
A24	Perform final plant acceptance test – Noise verification report	8.4		x
A25	Take corrective action where required	8.5		x

[a] Indicated responsibilities are given as an example, they can deviate from project to project.

Annex C
(informative)

Information for inclusion in Project Specification

The definition of responsibilities in the Project Specification should include, but not be limited to, the following:

a) all noise limits and other requirements;

b) any end-user requirements for specific noise-control engineering efforts, such as noise contours;

c) any end-user requirements for specific equipment noise limits, calculation methodology, measurement procedures or reporting requirements;

d) the extent to which the end-user has the option of reviewing and approving contractor noise-control engineering methodology, noise prediction model and noise controls;

e) requirements for practicality, maintenance, maintainability and life expectancy of noise-control measures and the extent to which they need to be approved by the end-user;

f) responsibility for writing a noise measurement protocol for verifying whether noise limits have been met;

g) definition of specific operating conditions or background noise levels during verification measurements (as specified by the protocol);

h) responsibility for making any measurements needed to verify that vendor and/or project noise limits have been met;

i) the extent to which the end-user will monitor and inspect noise control measures as they are being installed.

Annex D
(informative)

Noise aspects of specific equipment

D.1 Control valves

For each control valve and its associated pipe work, the requirements of 6.3.2 to 6.3.5 should apply.

Control valve noise should be determined for three operating conditions, viz. minimum, normal and maximum throughput. Noise limits should not be exceeded for any of these three conditions.

D.2 Safety/relief valves

The noise from safety/relief valves (and their piping) which blow under emergency conditions only, should not exceed the absolute limit (see 5.1.2) in any work area.

D.3 Piping

(A11) Noise emitting from piping is of major importance in plant noise control and should be subject to the same restrictions as equipment (6.3). Such noise usually has its origin in equipment such as a valve or compressor.

The prediction of noise from piping, which is normally the responsibilty of the contractor, is difficult. Noise radiation from structures supporting piping can be significant, especially for acoustically insulated piping. Suitable references are listed in the Bibliography (e.g. VDI 3733).

The noise should be controlled by selecting low-noise equipment (by design) or, when this is not reasonably practicable, by incorporating in-line silencers or acoustic insulation. Guidance on the assessment and reduction of noise emitting from piping by the use of acoustic insulation is given in ISO 15665. The use of in-line silencers in the suction line of compressors often requires approval by the end-user.

D.4 Vents

(A12) All vents incorporated in the design to meet operational requirements should be subject to the same restrictions as the equipment (6.3). Where necessary, vent or blow-down silencers should be incorporated in the design. Vents intended for emergency use only should be subject to the same requirements as safety/relief valves (D.2).

NOTE An acceptable method of calculating vent noise is given in API RP 521, see Bibliography.

D.5 Flares

D.5.1 (A13) Elevated flares under emergency conditions

The noise level at the base of the stack should not exceed the absolute limit (see 5.1.2).

If the plant to which the flare is allocated is subject to environmental noise requirements, the noise levels produced during emergency conditions should be evaluated against authority requirements.

D.5.2 (A13) Elevated flares under normal operating conditions (including start-up and shutdown)

Noise levels at the perimeter of the safety area (at least 60 m from the flare base) should not exceed the work area limit (see 5.1.3) when operating at flow rates up to 15 % of maximum flaring capacity or at the maximum relief rate that can occur during normal operation (including start-up and shutdown), whichever is the higher.

If there are environmental noise limits, then the sound power level generated during normal operation should be taken into account when assigning sound power levels to noise sources (see 6.2).

Ground flares should not exceed the work area limit outside the windscreen or louvre wall.

Annex E
(informative)

Example of equipment noise data sheet

EQUIPMENT NOISE DATA SHEET	
Type of equipment:	Mechanical power (kW):
Supplier/manufacturer:	Speed (r/min):
Type No.:	Size $l \times b \times h$ (m):

1. GENERAL

This data sheet covers the noise limits of the equipment, given below.

2. NOISE LIMITS TO BE MET BY THE EQUIPMENT

The noise generated by the equipment shall not exceed the more stringent of the noise limits given in the table below, for any of the conditions of operation for which the equipment may normally be expected to be used.

L_p is the maximum sound pressure level, re 20 μPa in dB, for the mode of operation indicated at any location at 1 m from the equipment surface or operator position, if specified.

L_W is the maximum sound power level, ref. 1 pW, in dB, for the mode of operation indicated.

If the equipment generates noise with tonal or impulsive components, this shall be indicated.

Noise levels will be verified according to the following standards: ISO 3740 series, ISO 11200 series, ISO 9614 or International Standards or methods required or recommended by the authorities.

3. INFORMATION TO BE SUBMITTED WITH THE TENDER

This noise data sheet shall be returned with the tender and with guaranteed noise data filled in.

The supplier shall state which add-on silencing measures were taken to meet the noise requirements.

Equipment items/Locations	**a**		Sound pressure/power levels guaranteed by supplier dB									**b**	Remarks
			Un-weighted octave-band levels										
			63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	Total A-weighted	Noise limit	Silencing measures
		L_p											
		L_W											
		L_p											
		L_W											
		L_p											
		L_W											
		L_p											
		L_W											
		L_p											
		L_W											
		L_p											
		L_W											
		L_p											
		L_W											
		L_p											
		L_W											

Purchaser shall indicate:
in column “b”, the A-weighted sound pressure/power limit
in column “a” using the appropriate number, which of the following applies to the required noise levels:

1) without acoustic provisions
2) with acoustic provisions
3) special low-noise design
4) suppliers best estimate, not necessarily guaranteed
5) …………………………………………………………..

Information on special operating conditions:

Annex F
(informative)

Documents to be made available to the noise control engineers

For major projects in the design and engineering phase and the procurement phase, the following documents should be submitted to the noise control engineer as they become available.

a) Project specification.

b) Site lay-out drawing, showing equipment, buildings and traffic ways.

c) Plan of local area.

d) Basis of plant design.

e) Process flow diagram.

f) Equipment list.

g) Process description, indicating all modes of operation of the plant.

h) Equipment data requisitions for all relevant noise sources, amongst others:

- air-cooler fans;
- furnaces, burners;
- mechanical handling equipment;
- extruders, ejectors;
- pumps, compressors, incl. drives;
- valves;
- flare and vent stacks;
- external insulation, sound proofing only;
- transformers, generators;
- electric motors;
- cooling towers;
- fired steam generators;
- silencing equipment (silencers, enclosures, screens);
- mobile noise sources, such as lorries, cranes or loading equipment.

i) Data on the acoustic properties of buildings (in special cases only).

j) Piping arrangement data.

k) Piping and instrumentation diagram.

Annex G
(informative)

Example of format for the Noise Allocation Report

The report specified in 8.2 and nominated as action item A19 may be prepared in accordance with the following format.

a)	Specified limits - quote the original requirements and make any comments necessary.
b)	A list of equipment items (including valves, piping, buildings etc.) with the following information:
	1) tag number
	2) short description (e.g. centrifugal pump, recip. compressor)
	3) typical description of duty (e.g. 3 000 r/min, 150 kW)
	4) allocated sound pressure level in decibels, A-weighted
	5) allocated sound power level in decibels, A-weighted
	6) total allocated sound power level per plant unit in decibels, A-weighted
	7) total allocated sound power level for project in decibels, A-weighted
c)	Description of anticipated restricted areas
d)	Indication of areas of maximum uncertainty of noise data

Annex H
(informative)

Example of format for the Noise Control Report

The report specified in 8.2 and nominated as action item A20 may be prepared in accordance with the following format.

	Required
1. Summary showing to what extent	
• the acoustic design of the plant has been completed	☐
• guaranteed noise data has been obtained from suppliers	☐
• the specified noise limits have been met	☐
2. Specified limits — quote the original requirements and make any comments necessary	☐
3. Supplier noise data	
• tables of octave-band sound power, sound pressure and overall levels of all potentially noisy equipment per plant unit; the origin of the data shall be indicated (guarantee from supplier, estimate from supplier, test data from contractor, estimate from contractor, etc.).	☐
• the results of “noise” test runs, if available [a]	☐
4. Noise control measures	
• a list of silencers and acoustic enclosures	☐
• the detail and extent of any acoustic insulation	☐
5. Calculations	
• in-plant noise contour maps, showing A-weighted sound pressure level contours of for instance 75 dB, 80 dB and 85 dB and higher.	☐
• evaluation of the sound power level of the plant or sections of it, even in the case that no plant sound power limit is required	☐
• immission noise levels at discrete points	☐
• environmental noise contour maps, showing A-weighted sound pressure level contours	☐
• separate evaluation of plant pipe noise	☐
• calculations of expected sound pressure levels inside buildings and shelters	☐
6. Restricted areas	☐
7. Outstanding items	☐

[a] A list of control valves with an A-weighted sound pressure level above 80 dB with an indication where low-noise control valves or other noise reduction measures will be applied.

Annex I
(informative)

Example of format for the Noise Verification Report

The report specified in 8.4 and nominated as action item A24 may be prepared in accordance with the following format.

		Required
1.	The objective of the noise verification report.	☐
2.	The survey or calculation methods to be used (i.e. refs. [11], [30], [32], [33]). In some countries the environmental authorities have supplementary or different requirements for noise verification reports.	☐
3.	The name of the end-user, the name and location of the plant.	☐
4.	The date and time of the noise survey.	☐
5.	The names and/or affiliations of the personnel participating in the noise survey.	☐
6.	The noise limits set for the project.	☐
7.	A map or drawing of the area to be surveyed. [a]	☐
8.	A description of the plant and a description of the type of noise being generated.	☐
9.	The plant operating conditions at the time of survey, including production configuration, percent throughput, whether in normal operation, abnormal operation, start-up or shutdown mode.	☐
10.	The weather conditions at the time of the measurements (if relevant), in particular wind speed and direction, relative humidity and air temperature.	☐
11.	The type, model, serial number and calibration and method of calibration of all instrumentation used. [b]	☐
12.	Operator work patterns where noise exposure per shift is required to be verified.	☐
13.	Sound pressure measurements and octave band levels recorded at agreed immission points. The bottom octave band will usually be 63 Hz.	☐
14.	Report on any locations at which measurements could not be taken or omitted for other reasons.	☐
15.	A qualitative but brief assessment of neighbouring noise sources (other plants, road noise, etc.) likely to affect the measured sound pressure readings.	☐
16.	Report the corrections for background noise, if any, and microphone positions at which the background noise could not be measured.	☐
17.	The calculated plant A-weighted sound power levels per octave band and A-weighted overall sound power level.	☐
18.	Report any deviations from the survey requirements due to the site environment.	☐
19.	Prepare environmental noise contour maps.	☐
20.	Preparation of an in-plant noise contour plot, showing A-weighted contours of for instance 75 dB and higher, with incremental steps of 5 dB.	☐

	Verification	
21.	Compare the noise survey results with the requirements.	☐
22.	Identify whether any of the project requirements are exceeded (if at all).	☐
23.	Identify causes for the noise requirements being exceeded in any location, if possible.	☐
	Attachments	
24.	Octave-band measurements. The height of the microphone position should be reported.[c]	☐
25.	Corrections made for background noise.	☐
26.	Sound power levels.	☐
27.	All input data for computer calculations	☐

[a] If community noise verification is required, include a map or drawing of the surrounding area of concern. The map or drawing should show all the measurement locations used in the survey. If applicable, the positions of noise sources outside of the plant, and the measurement locations which could be affected as a result should be documented. Where a noise contour map is required, then use sufficient measurement points to allow a noise contour map to be drawn. Describe any significant noise screens or reflectors on the plant.

[b] The calibration of the instruments should be checked at the beginning and end of the noise survey.

[c] The determination of sound power level according to ISO 8297 requires elevated measurement positions. However practical limits may restrict microphone height.

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