114 – Norwegian Oil and Gas Recommended guidelines for handling noise which may induce hearing loss

Translated version

FOREWORD

These guidelines are recommended by the Norwegian Oil and Gas technical network for occupational hygienists and its Operations Committee. It has also been approved by the director general.

The original guidelines were drawn up in 2008 by a project team comprising acousticians, specialists from the operator companies and a reference group with representatives from the Petroleum Safety Authority Norway, the Norwegian Shipowners Association and the unions.

They were revised in the autumn of 2012 (Rev 1) by a working group composed of representatives from the operator companies.

This version (Rev 2) is a result of work on Noise in the Petroleum Industry, and builds on experience from that project.

The responsible manager at Norwegian Oil and Gas is the manager for HSE, who can be contacted via the Norwegian Oil and Gas switchboard on +47 51 84 65 00.

These guidelines have been developed with the broad-based participation of interested parties in the Norwegian petroleum industry, and are owned by Norwegian Oil and Gas on behalf of the industry. Norwegian Oil and Gas is responsible for their administration.

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1 INTRODUCTION

1.1 Purpose

Hearing loss is the commonest occupational injury reported to the Petroleum Safety Authority Norway (PSA).

Such damage in the form of lost hearing function cannot be reversed, and is therefore a permanent injury. Loss of hearing can lead to a reduced quality of life, with possible loss of the sufferer's medical certificate and exclusion from offshore work as a consequence. Another possible result of exposure to high noise levels is tinnitus, which can also reduce quality of life for the person affected.

These recommended guidelines have been drawn up to meet the oil and gas industry's need for a common standard on handling noise levels which may induce hearing loss (hazardous noise).

The document is intended as guidance for HSE personnel and line managers at the companies, but could provide a guideline for end users as well.

It is also intended for possible use at supply bases and land plants related to the production and processing of oil and gas. In addition, the guidelines can be applied to other activities on land or at sea.

The guidelines primarily address noise as a source of hearing loss, and will not be adequate for dealing with noise as a source of other health problems or increased risk of accidents.

They cover methods for dealing with hazardous noise related to operations and maintenance as well as to modification work on the facilities and in the plants. The document can also provide a basis for work done in the construction phase before a facility has come on stream.

Where planning/design of modifications and newbuildings are concerned, see Norsok S-002 on the working environment.

1.2 Terminology

Noise
Noise is defined as unwanted sound. By sound is meant normal vibrations in the air with frequencies in the audible range from 20 Hz to 20 000 Hz.

Sound is measured in decibels (dB) on a logarithmic scale. This means that every time the sound effect doubles, the decibel level rises by three dB.

Weighting frequency filter
When sound is measured, a weighting frequency filter is often used to express the response by the human ear. Various types of filters are to be found. The A-weighting filter represents the sensitivity of a good ear to different frequencies at levels perceived as embarrassing and posing a risk of hearing loss. In part, it filters out a lot of the low-frequency sound which corresponds roughly with the ear's reduced sensitivity to levels in the 45-70 dB range. At very high levels, the ear's response is less frequency-dependent and a C-weighting filter is used to remove small parts of the lower frequency range in order to measure high levels of impulse sound (see figure 1.1).

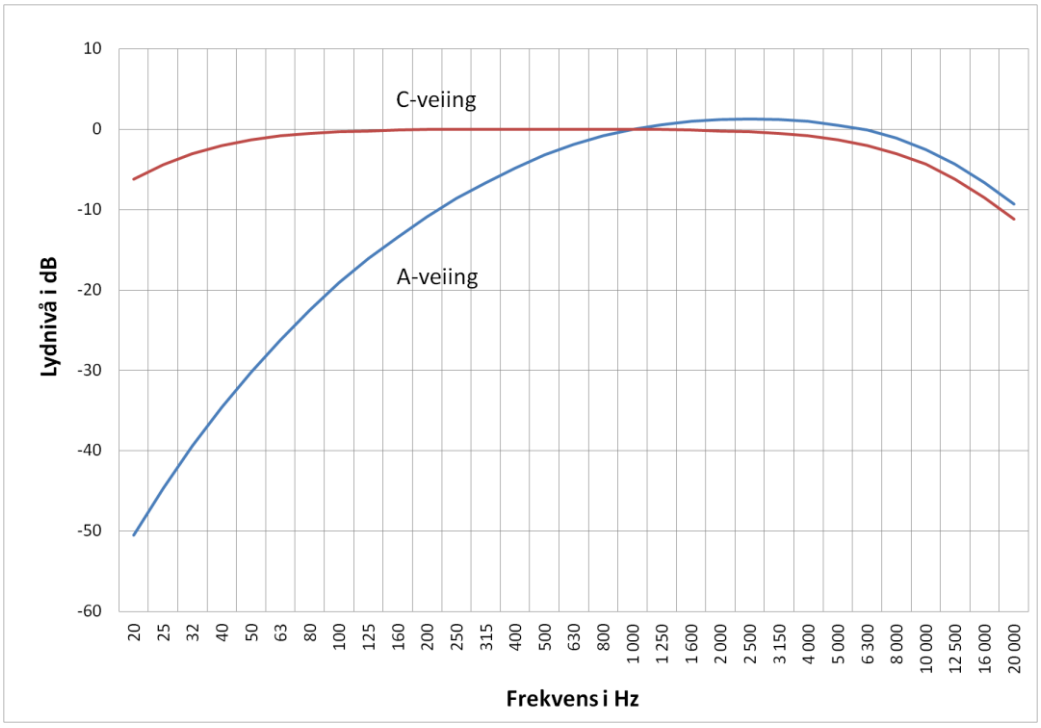

Figure 1.1: Weighted noise curves (A and C)

Low-frequency sound/infrasound

Hearing loss can probably occur at noise levels below the normal limit values for causing harm if the sound contains very low frequencies or infrasound.

Infrasound is defined as sound below the audible level. However, knowledge about this is very limited today.

Some countries have recommended threshold values related to specific low-frequency G-weighted curves (dBG) in order to limit the risk of such conditions as dizziness, discomfort and loss of concentration.

This document gives no further consideration to frequencies which lie outside the normal definition of hazardous noise.

Vibration

Vibration occurs in structures and tools. Low-frequency oscillations in floors, chairs and beds which produce whole-body vibration must be assessed on the basis of separate threshold values. These are not considered in this document.

Structural vibration which produces audible noise can in some cases reach levels which fall within the hazardous noise range.

Hand/arm vibrations from a handheld tool should always be assessed at the same time as noise from the tool. Specific requirements are set for such vibrations and these may, for example, limit permitted working time with the tool rather than its noise level because no damping measures are feasible. No further consideration is given to such vibrations in these guidelines.

> NOTE: Norwegian Oil and Gas has developed a noise and vibration database which also contains an exposure calculator for both noise and vibration. This can be used, for example, to calculate permitted working time for different types of tools.

1.3 Definitions and abbreviations

Abbreviations used in the guidelines are explained below.

Action value	Exposure value which requires action to be taken to minimise health risk and unfortunate loads.
Alarp	As low as reasonable practicable. See sections 9 and 11 of the framework regulations
BAT	Best available techniques. See sections 9 and 11 of the framework regulations
dB	Decibel, unit for measuring sound
Hazardous noise (which may induce hearing loss)	Lengthy or brief (impulse sound) exposure to noise which may induce permanent hearing loss. High noise levels can also cause other physiological damage
HML	High, medium, low. Method for presenting the theoretical damping effect of hearing protection at different frequencies (based on C-A values)
HSE	Health, safety and the environment
$L_{EX,12h}$	A-weighted noise exposure level normalised to a full 12-hour offshore working day
$L_{p,A,T}$	A-weighted time-averaged (equivalent) sound pressure level – energy-equivalent level (average) of the varying A-weighted sound pressure levels over a time T
$L_{p,Cpeak}$	Peak value of the sound pressure level – highest observed C-weighted sound pressure recorded over the measurement period at the "peak" sound-meter setting.
Limit value	Exposure values which must not be exceeded when taking account of the effect of hearing protection
Niosh	National Institute for Occupational Safety and Health (USA)
NLIA	Norwegian Labour Inspection Authority
NRR	Noise reduction rating (expresses the theoretical damping effect of hearing protection, ref NRR ANSI S12.19-1996(R 2001))
OSHA	Occupational Safety and Health Administration, US Department of Labour
PPE	Personal protective equipment
PSA	Petroleum Safety Authority Norway
RNNP	Trends in risk level in the petroleum activity
SJA	Safe job analysis
SNR	Single number rating (See ISO 4869-2:1994)
U	Expanded uncertainty (ref NS-EN ISO 9612)
Weac	Working environment area chart
Weal	Working environment area limits
WP	Work permit
WRI	Work-related illness

1.4 References

Norwegian Labour Inspection Authority: Working environment regulations, 1 Jan 2013.

Norwegian Labour Inspection Authority: Regulations no 819 on the construction, design and production of personal protective equipment (order no 416)

Norwegian Labour Inspection Authority: Guidelines on hearing tests for workers exposed to noise (order no 416).

Database on noise and vibration – handheld tools
http://www.norskoljeoggass.no/stoy/.

Directive 2003/10/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise).

ISO 1999 - Determination of occupational noise and estimation of noise-induced hearing impairment.

Johnsen, A-K and Morata, T C: "The Nordic Expert Group for Criteria Documentation of Health Risks from Chemicals 142. Occupational exposure to chemicals and hearing impairment". *Arbete och Hälsa*, Nordic Council 2010: 44(4).

Kjuus, H et al: Study for the PSA. Stami report 4 – 2005

Norsok S-002: *Working environment* rev 4 - 2004 (under revision in January 2014)

NS 4814: *Measurement of occupational noise exposure of workers - Area noise measurements and preparation of noise contour line maps*

NS-4815-1 *Measurement of occupational noise exposure of workers - Part 1: Survey metho*d (based on Nordtest method NT ACOU 114)

NS-EN-458: *Hearing protectors - Recommendations for selection, use, care and maintenance - Guidance document*

NS-EN ISO 4869-2:1995: *Acoustics. Hearing protectors. Estimation of effective A-weighted sound pressure levels when hearing protectors are worn* (including HML method)

NS-EN ISO 9612: *Determination of occupational noise exposure. Engineering method*

NS-EN ISO 9614-2: *Acoustics – Determination of Sound Power Levels of Noise Sources Using Sound Intensity Part 2: Measurement by Scanning* (ISO 9614-2:1996)

Norwegian Association of Occupational Medicine: *Oppfølging av ansatte med eksponering for hørselsskadelig støy* – 2013 edition,
http://amv.legehandboka.no/forebygging/helseovervaking-i-forhold-til-eksponering/stoy-985.html.

PSA: Activities, facilities and framework regulations.

Vinnem, J et al. *ALARP-prosesser. En utredning for Petroleumstilsynet. Sluttrapport fase 1. En gjennomgang av selskapenes dokumentasjon og praksis*. Preventor. 2

1.5 Other health effects of noise

Noise can affect health even if it does not cause hearing loss/tinnitus:

- noise can affect the cardiovascular system
- noise can contribute to stress and muscle tension, even at a relatively low level
- noise can be irritating and tiring, as well as reducing the ability to concentrate and being careful
- noise can reduce the ability to rest and the quality of sleep
- noise can affect pregnancy and a foetus.

Noise can also increase the risk of accidents by:

- making communication more difficult
- reducing perception of announcements and alarms given over the public address (PA) system
- contributing to stress
- possibly increasing the risk of making errors
- reducing sleep quality, which reduces the ability to concentrate and take care.

Some chemicals and medications can increase the risk of hearing loss when people are exposed simultaneously to noise and such chemicals. The latter are therefore designated as ototoxic. This effect has been particularly observed with simultaneous exposure to noise and certain solvents. Some chemicals and medications can damage hearing without noise being present. Knowledge about the relationship between exposure to ototoxic chemicals, noise and hearing loss is only partial.

1.6 Limit values, action values and handling uncertainty

Where petroleum activities are concerned, section 11 of the framework regulations sets the parameters for risk reduction work by the companies. In addition to being cut to the mandatory level specified by regulatory requirements, risk must be further reduced to a level as low as reasonably practicable (Alarp) – including by using the best available technologies (the BAT principle)

The requirements for managing and organising work are described in sections 33 and 38 of the activities regulations. Pursuant to sections 23 of the facilities regulations and 23 of the activities regulations, facilities must be designed and work organised so that no worker is exposed to hazardous noise.

The regulations concerning organisation, management and employee participation from the Norwegian Labour Inspection Authority (NLIA), which also apply to the petroleum industry, specify that "the measurement methods used shall be representative for the individual employee's personal exposure, and *account shall be taken of measurement uncertainty in the assessment of risk*."

A distinction is made between assessments during operation – in other words, operational assessments – and when designing newbuilds or conversions. The limits, tailored to the NLIA regulations on land and the EU directive, are then applied as follows:

Limit value
Mandatory requirements where account can be taken of the use of hearing protection with real-world attenuation.

Upper action value
Exceeding this value in normal operation entails requirements that action should be assessed without taking the effect of hearing protection into account.

Lower action value
Efforts must be made to meet this value for newbuilds or major modifications without taking the effect of hearing protection into account.

Expanded uncertainty, U
Value which specifies how large a divergence can occur in calculated noise exposure – in other words, in the expectation value $\mathbf{L_{EX,12h}}$. The recommendation is that this should be represented by the 95th percentile, but it must be based on the 90th percentile as the minimum.

Limit and action values are given in the table below.

Table 1.1: Limit and action values

Limit and action values	Requirement
Limit value and upper action value	$\mathbf{L_{EX,12h}}$ + U $\leq$ 83 dB
Lower action value	$\mathbf{L_{EX,12h}}$ + U $\leq$ 78 dB
Peak value for maximum levels	$\mathbf{L_{pC,Peak}}$ < 130 dB

Comment 1: Hearing protection cannot be regarded as an action for fulfilling the action values.

Comment 2: The same set of noise limits are applied in order to reconcile requirements for a 12-hour working day offshore with those for an eight-hour day on land**.** These are also defined in the EU directive. When the expectation value plus uncertainty are assessed in relation to an upper action limit of 83 dB, the risk is handled as well as it was in earlier assessments based on the "old" limit value of 80 dB. This fulfils the intentions in section 38 of the activities regulations.

Comment 3:
When using the protection regime described in section 3.5, uncertainty will be handled as follows:

1. the requirements specifications will come into play at a noise exposure above $L_{EX,12h}$ = 80 dB
2. viewed overall, grouping in five-dB steps provides a good safety margin against exceeding the limit value for noise exposure.

Comment 4:
An example of using the limits in a work operation is provided below.

An electrician is doing a job in an area with a high noise level. A noise assessment made using NS 4815-1 shows an expected noise exposure of $\mathbf{L_{EX,12h}}$ = 99 dB. The uncertainty, U, is assessed to be four dB by using the table in annex C of the same standard. Thereby $\mathbf{L_{EX,12h}}$ + U = 103 dB.

The electrician is to use double hearing protection, which gives an 18 dB reduction. The risk of hearing loss is assessed by checking whether the noise exposure in the hearing protection is below the *limit value*: ($\mathbf{L_{EX,12h}}$ + U) – 18dB = 85 dB. This shows that the *limit value* is exceeded by two dB. On that basis, the decision is taken to reduce working time spent subject to the high noise level by 40 per cent, so that the noise exposure, including uncertainty and the effect of hearing protection, becomes 83 dB. The work can thereby continue.

Even with a shorter working time, $L_{EX,12h}$ + U = 101 dB without the hearing protection – in other words, far above the *action value*. Other measures must therefore be assessed in any event if this work is to be repeated many times. A simple temporary technical measure could be to deploy noise-reduction curtains as movable screens. Such action should be assessed if the noise level without hearing protection fails to meet the *limit value.* It could, for example, make single hearing protection sufficient. That also has other benefits, such as reducing the threat of over-damping and simplifying communication with work colleagues. Such screens could also be an alternative to reduced working hours.

1.7 Handling hazardous noise in operations

Protecting employees from hazardous noise is the employer's responsibility, while the employee is duty-bound to comply with the measures implemented to reduce exposure to noise.

The employer must ensure that employees and safety delegates receive continuous information and training on the current risk associated with noise if employees are exposed to levels exceeding the lower action value – in other words, $L_{EX,12h}$= 78 dB. The same also applies for $L_{p,Cpeak}$ above 125 dB.

Necessary mapping and risk assessments of noise must be documented. If the action values described in section 1.6 are exceeded, scheduled plans must be drawn up for reducing the noise exposure. This assumes systematic work in the companies covering activities related to mapping, risk assessment, action, follow-up and verification. See figure 1.2. The protection regime can be regarded as part of the risk assessment.

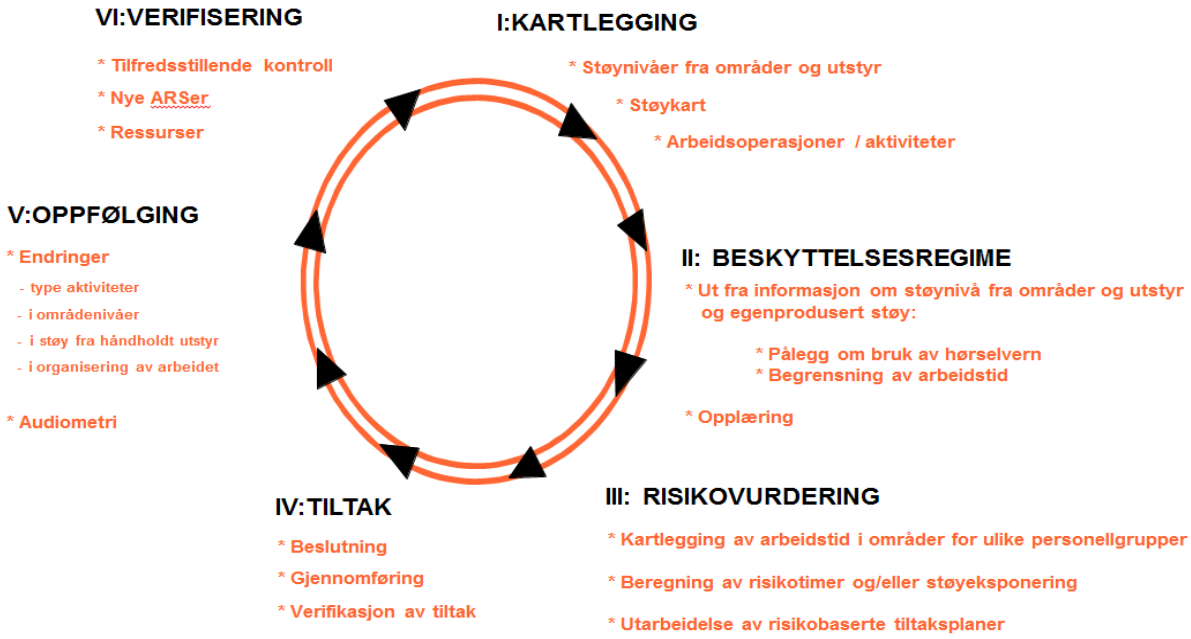

Figure 1.2 Systematic follow-up of hazardous noise.

The six key elements in the management circle above are covered in sections 2-4 and 6.

Establishing a work group which can work on systematic follow-up of noise exposure is recommended. This should comprise relevant personnel such as the offshore installation manager, the operations and maintenance supervisor, safety delegates, HSE personnel and occupational hygienists.

2 MAPPING THE NOISE LEVEL

2.1 Measuring and documenting noise from areas and fixed equipment

Area mapping of noise levels must provide a representative picture of the total noise exposure which personnel are subject to. All areas expected to have an A-weighted noise level above 80 dB must be mapped, whether they are manned or unmanned. When making measurements as a basis for risk assessments, measuring methods and instruments must be tailored to the environment and the type of noise exposure encountered. The standard/method utilised for the measurements must be documented.

The operational circumstances in which measurements are made must be described. In areas where the noise level varies by more than five dB with normal variations in operating conditions, levels for the various conditions should be mapped separately. In addition to noise exposure from the areas, all stationary sources of impulse sound above $L_{p,\mathrm{Cpeak}}$ 125 dB must be identified.

Results from the area mapping should be registered in the relevant working environment area chart (Weac). In addition to measurement results expressed as A- and C-weighted sound levels in dB, it is recommended that the measurements are registered as one-third of octave-band values in the 25-10 000 Hz frequency range. Other factors which can explain the results should also be described, such as the size of the area, absorbents and other noise sources.

The area data must be updated in the event of significant changes to the area noise level (change in area noise greater than three dB) or at least every four years. If no significant changes with an effect on the noise level have occurred in the area, its data can be verified with simple point measurements.

2.2 Noise map

On the basis of mapped noise levels from areas and identified stationary sources for impulse sound, preparing a noise map for the relevant areas is recommended. See appendix C for a description of creating such maps.

An example of a noise map is provided in figure 2.1.

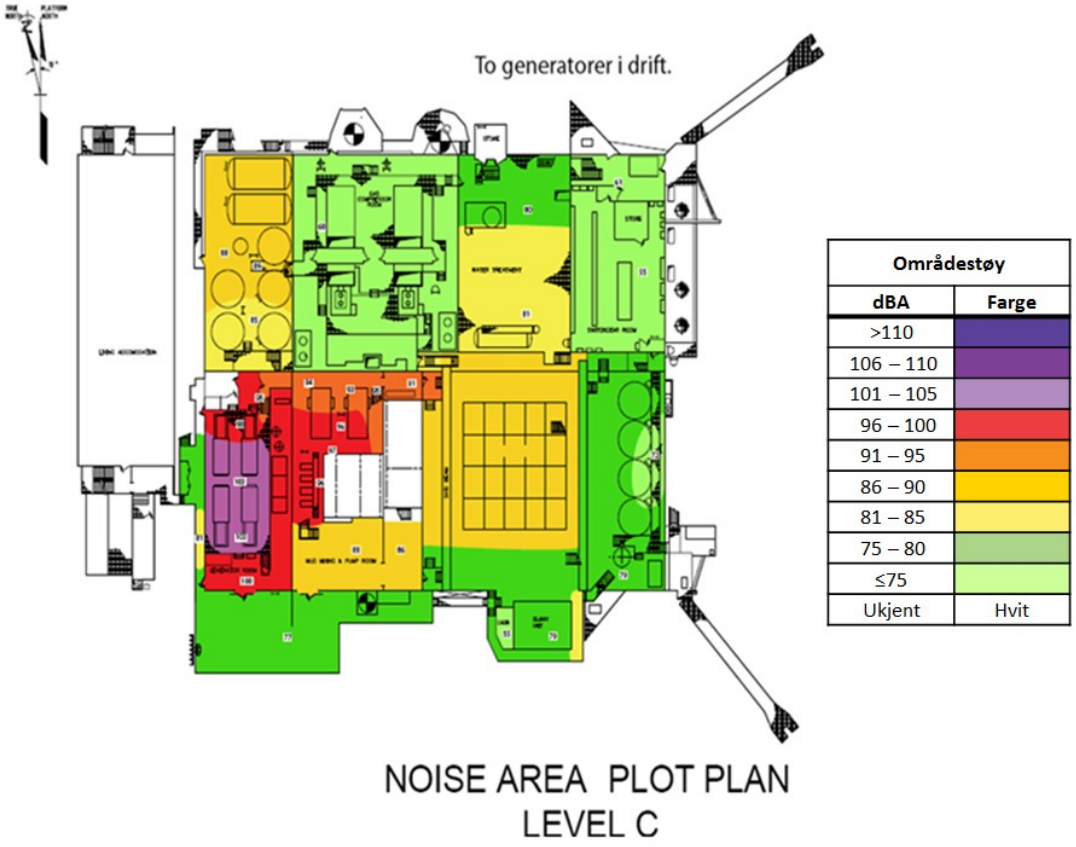

Figure 2.1: Example of a noise map.

Description of varying operating conditions in the map

- For each area, the colour code will be based on the highest "normal" noise level
- The background for this is specified in a note on the map.
- Should brief periods with high noise levels occur, this is shown by stripes in the relevant colour code and a note on the map which describes the relevant operating condition/noise source.

Description of impulse sound in the map

- The risk of impulse sound is shown by stripes and a note on the map which describes the noise source. Areas where peak values above $L_{p,\mathrm{Cpeak}}$ > 125 dB may occur are shown with orange stripes (see the 91-95 dB interval).
- It is also recommended that areas with the risk of extremely high peak values ($L_{p,\mathrm{Cpeak}}$ >140 dB) are shown by dark purple stripes (see the > 110 dB interval).

In complex cases, with big variations in operating conditions and noise levels, it could be appropriate to create more than one noise map.

2.3 Signage

All areas with permanent or periodic noise levels above 80 dBA must be provided with signs specifying mandatory use of hearing protection as described in table 2.1. Sources which periodically generate noise levels above 80 dBA must be indicated by a sign with a descriptive sub-text.

Table 2.1: Signing of areas

A-weighted time-averaged sound pressure level ($L_{p,A,T}$)	**Peak values of sound pressure level ($L_{p,Cpeak}$)**	**Sign**
>110	> 140	
106-110		
101-105		
96-100		
91-95	125-140	
86-90		
81-85		
76-80		No signage unless peak values above $L_{p,Cpeak}$ >=125 dB are possible
<= 75		

Note: the intervals in the table apply from and including/to and including. This means, for example, that a requirement for signage from and including 81 dB corresponds to a requirement for signage above 80 dB.

Access to areas with an A-weighted L_{eq} level above 110 dB and C-weighted peak levels above 140 dB must be confined to personnel with special training. It is assumed that single hearing protection gives a minimum 15 dB damping for C-weighted peak levels.

3 RISK ASSESSMENT

Risk assessment of work-related exposure to hazardous noise levels involves an evaluation of two considerations:

- risk that a worker will suffer hearing loss over time
- risk that a worker will suffer hearing loss from exposure to peak values for sound pressure levels.

3.1 Noise exposure

Noise exposure is defined as $L_{EX,12h}$ and represents the mean noise level at the ear averaged over the working day. This normally means a typical or normalised working day, which is representative for the noise load personnel may be exposed to. Alternatively, noise exposure can be calculated for a typical average day based on all activities over the course of a week or 14 days. If some working days deviate by more than three dB from the typical level, noise exposure on these days must also be assessed.

Noise from helicopter transport to/from the facility and shuttling must be included in the calculation of noise exposure.

Mapping of noise exposure must be done by personnel with adequate expertise.

The overall noise exposure experienced by a worker during a typical working day must lie below the limit values for hazardous noise.

Where work operations with moderate to high noise exposure are concerned, a qualified assessment will be needed and – if necessary – periodic monitoring of exposure levels with the aid of measurements. More detailed descriptions of measuring methods are provided in:

- NS 4814: *Measurement of occupational noise exposure of workers - Area noise measurements and preparation of noise maps*
- NS-4815-1 *Measurement of occupational noise exposure of workers - Part 1: Survey metho*d
- NS-EN ISO 9612: *Determination of occupational noise exposure. Engineering method*

3.2 Determination of noise exposure when present in an area

Mapping of activities and their scope covers registration in areas with a threat of exposure to hazardous noise.

As a minimum, the mapping must involve the registration of

- job categories
- areas where the various categories are present
- types of activities conducted in the area
- duration and frequency of times present in noisy areas and noisy self-activity
- utilisation of hearing protection and its type.

Activities can be mapped either through interviews with personnel groups or by assessing the area, as shown in table 3.1.

Table 3.1: Mapping of activities – data acquisition

Interviews with personnel groups	Through direct interviews with or questionnaires to workers, asking them to describe their normal working day (pursuant to appendix A) and the day/14-day period with the highest exposure.
Area assessment	Through interviews with the area authority, map all annual activities (including description of personnel groups and time present) in areas with noise levels above 80 dB. In addition to normal activities, emphasis will be given to identification and mapping of periodic and/or infrequent maintenance activities.

3.3 Determination of noise exposure from handheld tools.

The worker's own activity and work with handheld tools can involve high levels of both noise exposure and hand/arm vibration. Measuring and mapping such incidents should be conducted by personnel with expertise in making such measurements.

Measurement data must be analysed and normalised in order to represent noise exposure over a whole work cycle. A working day could include noise contributions from several different tools over periods of varying length. The normalised 12-hours-equivalent level must also include natural breaks in connection with adjustments, inspections and so forth when performing the work operations.

Comment: A database for handheld tools where typical values can be found for noise and vibration is available on the Norwegian Oil and Gas website at http://www.norskoljeoggass.no/stoy/). The database also has a programme for calculating noise and vibration exposure. This database and the associated programme make it possible to acquire rough estimates and detailed assessments of noise and vibration exposure from self-activity.

3.4 Protection regime

The protection regime in table 3-2 below describes immediate measures for use in high-noise areas to ensure that the limit values for noise exposure are being met. See section 1.6. These cover restrictions on time present and the use of hearing protection. The regime can be applied in the short term if the risk cannot be controlled in an alternative manner through technical and administrative measures.

Table 3.2: Protection regime expressed as recommended limits on time present and the use of hearing protection in high-noise areas.

Area noise level dB(A)	Max presence in area	Hearing protection
> 110	Presence not recommended	Presence on special terms, such as using hearing protection with integrated noise dosimeter.
106-110	30 min per shift	Double hearing protection (both ear defenders and plugs for presence beyond 10 minutes[1]). Single protection for shorter presence.
101-105	Two hours per shift	
96-100	Six hours per shift	
91-95	Six hours per shift	Single hearing protection (ear defenders or plugs).
86-90	12 hours per shift	
81-85	No restrictions	
76-80		No requirements.
<=75		

The working day must be planned to ensure that time spent in an area does not exceed the limits in table 3.2. If parts of the day, either alone or collectively, consume the permitted working time, the worker must spend the rest of the day in areas with a sound level below 75 dB. “No restrictions” under 85 dB apply only if all work during the relevant day takes place at such levels.

Self-generated noise can make a substantial contribution to noise exposure and must be assessed in the same way as area noise with regard to restrictions on time present and use of hearing protection. Where self-generated noise is concerned, better damping values from hearing protection can be assumed in some cases (see chapter 5).

It is recommended that measures in the protection regime are implemented in the company’s operations-related working environment procedures as a first step in assessing and controlling exposure.

A noise calculator can be a practical aid in estimating the noise dose and permitted exposure times for a mixed working day. Area and self-generated noise are elements which should be covered by such a calculator.

Measures protecting against impulse sound are not included in the protection regime. This must therefore be assessed separately. In some cases, high peak values for sound level could reflect false contributions such as mechanical stress on the dosimeter. Observed measurements will therefore be needed in many cases to find the real levels.

If impulsive sounds cannot be dampened by organisational or physical measures, hearing protection must be used. The effectiveness of such protection can be considered the same for impulsive sounds as for area noise.

[1] Other solutions which provide documented protection corresponding to double hearing protection, either through better damping or improved control in use, can also be utilised.

Only noise exposure has been taken into account when calculating restrictions on time present. Other working environment factors such as chemicals, vibration and so forth have not been assessed.

Using the protection regime assumes that noise levels in the relevant work areas are known. Active use of the a noise map together with the regime is recommended when planning work – through a safe job analysis (SJA), for example. Maps should therefore be readily available and placed at least where work permits are handled (such as the WP office).

Ear-plug stations are recommended outside areas with levels above $L_{p,A,T}$ = 95 dB.

Deviations from the protection regime is permissible on the basis of results from detailed risk assessments performed by an acoustician or occupational hygienist.

3.5 Detailed risk assessment

The protection regime provides a theoretical barrier against hearing loss, based on simple assessments of area noise. In certain circumstances with more complex noise conditions, however, detailed risk assessments will be needed. These could also be required in order to determine whether margins which might exist in the structure of the protection regime could be exploited. This must be done by people with adequate expertise (such as an acoustician or occupational hygienist) and the results must be documented.

> COMMENT: Detailed assessments could be made, for example, on the basis of calculations of measurement and noise exposure pursuant to NS-EN ISO 9612. The database developed for Norwegian Oil and Gas could be an aid in this context. Each company must decide the terms on which a detailed risk assessment is to be based.

The detailed risk assessment must conclude whether the relevant work operation is executable during the working day and, if so, what corrective measures are needed.

A detailed risk assessment of noise exposure must also take account of the type of jobs involved, the need for communication and concentration, the real effect of hearing protection, impulse sound, area and self-generated noise, and noise outside normal working hours which is the employer's responsibility.

3.6 Risk based action plans

Risk-based action plans should be prepared to reduce noise exposure and thereby the dependence on hearing protection,

Exposure conditions which could cause hearing loss or substantial impairment must be given the highest priority. Prioritisation of measures must be based on an assessment of which personnel groups are most exposed and which areas contribute to their noise dose. The duration of all activities should be assessed, including low-frequency activities in areas with high noise levels.

4 MEASURES AND FOLLOW-UP

4.1 Measures

To meet the action values, measures must be implemented with the following priorities:

1. removal/elimination
2. technical measures
3. organisational measures.

To meet the limit values, the effect of hearing protection can also be taken into account.

Examples of various measures are provided below.

Removal/elimination

- Removing the source is the most effective solution, and must always be assessed when planning new workplaces and procuring new equipment. With procurement, the strategy should be to secure the purchase of low-noise equipment and/or the selection of quieter processes.

Technical measures

Noise-reducing measures can be divided into categories depending on distance from the source – the closer to the source the measure is located, the larger the affected area.

- Select other, quieter processes/equipment –
  gas engines rather than diesel, larger fans with slower speed, replacing valves, good maintenance etc.

- Measures inside the equipment between source and surface –
  stronger engine frame, increased damping of engine frame, etc.

- Surface measures –
  cladding made of mineral wool and sheet metal, viscoelastic damping materials, etc

- Reducing vibration –
  stabilising, insulation, neutralisation, insulation for structural sound, etc.

- Encapsulation

- Damping reverberation in the room –
  additional acoustic cassettes, microperforated panels.

- Noise –
  noise-reduction curtains, fixed and moveable noise-absorbing screens/walls.

- Noise-insulated operator room with a view of the equipment –
  reduced time spent beside the equipment.

- Remote control of work operations and remote reading of operational data for engines and other equipment.

Organisational measures

- Customise work by choosing working methods and times which reduce noise exposure (maximum possible automation and video monitoring).
- Where and how equipment is installed and positioned can make a big difference.
- Employees must be informed of noise risk and adequately trained in preventive measures.
- Noise maps must be created and posted on warning signs at entrances to rooms, zones or operator positions where hearing protection is mandatory.
- Restrictions on time present pursuant to the protection regime or checks of permitted working hours with the aid of the noise database and calculator.

Personal protective equipment (PPE)

- Ear defenders and plugs are only temporary measures (except for helideck personnel and in unmanned engine rooms).
- The quality of hearing protection must accord with section 5.2 as well as satisfying the requirements in the NLIA's regulations on construction, design and production of PPE (NLIA order no 523 - in Norwegian only).
- A range of hearing protection must be offered to ensure individual customisation – several sizes of ear plugs.
- Training in the correct use and maintenance of hearing protection is mandatory.
- The effect of single/double hearing protection (12/18 dB) can be increased by correct training for some types of noise sources.
- Where sources with a lot of low-frequency noise are concerned, the effect of hearing protection can be drastically reduced.

4.2 Hearing monitoring

Monitoring the hearing of workers exposed to noise forms part of risk management, and provides a way to identify hazardous noise and to follow up the effects of measures adopted. It is nevertheless worth noting that noise tolerance varies greatly. Audiometric results are part of risk mapping, but changes to the hearing threshold are often a late and very unspecific indicator of noise-induced hearing loss.

Employers must conduct regular hearing tests of everyone exposed during their work to noise measured without hearing protection ($L_{EX,12h}$) at 78 dBA or higher, individual daily doses above 95 dB A-weighted, or a C-weighted peak level over 125 dB. Use of hearing protection does not make such tests unnecessary. Unless otherwise documented by noise mapping, exposure to helicopter noise means that all offshore workers must be included in the monitoring programme.

The hearing threshold must be established with the initial test, no later than six months after being hired. Follow-up tests must be conducted within a year and thereafter at intervals tailored to the risk of hearing loss but not longer than three years. Repeating audiometric measurements every other year is recommended.

Where implementing audiological testing is concerned, see the guidelines on hearing tests of workers exposed to noise (NLIA order no 416 – in Norwegian only).

Results of the hearing test must be made known to the worker. Summary findings of hearing monitoring must be made available to the employer and the safety delegate service. It must be possible to follow up results over time and summarise them for exposed personnel groups.

Audiometric results must be assessed by a qualified physician. See the latest edition of the occupational medicine guideline on follow-up of employees exposed to hazardous noise as well as the NLIA's guidelines on hearing tests of workers exposed to noise.

See appendix B, which summarises the principles for hearing monitoring and reporting noise damage.

4.3 Follow-up of particularly exposed workers

Establishing a special follow-up programme is recommended for personnel who work regularly with an exposure potential (average time-weighted noise exposure without hearing protection over a 12-hour working day) of more than 95 dB. This will improve management of their actual noise exposure by ensuring and documenting the quality and properties of hearing protection so that a minimum real protection is achieved in normal operation. Teaching, training, motivation and follow-up of the individual worker are assessed on the basis of noise type, time present and actual exposure in real work conditions. Establishing the follow-up programme in consultation with experts on the subject is recommended.

As a minimum, a special follow-up programme should include the following.

1. Periodic noise dose measurements.
2. Need for more frequent audiometry.
3. Offer of individual customisation of hearing protection, both ear defenders and plugs. This must cover a number of approved products with documented damping properties from use in real conditions.
4. Customisation of safety goggles and other equipment which could cause leakage in ear defenders to ensure that products which produce minimum leakage are utilised.

Where extreme work is concerned, the use of hearing protection with an integrated noise dosimeter is recommended. Extreme levels mean $L_{p,\mathrm{A},T}$ above 110 dB and repeated peak values of $L_{p,\mathrm{Cpeak}}$ above 130 dB.

An example of a checklist for evaluating programmes to follow up and preserve hearing for particularly exposed people is presented in appendix B. This checklist provides a number of examples of what can be included in such a programme.

5 DAMPING EFFECT OF HEARING PROTECTION

5.1 Introduction

If action values cannot be satisfied by measures like those described in points 1-3 in section 4.1, the limit values must in all cases be satisfied with the use of hearing protection and/or working time restrictions.

This chapter describes damping values which can be expected to be attainable with the use of hearing protection, which factors could reduce the effect, and which measures should be implemented to keep control over hearing protection.

5.2 Real-world attenuation

Hearing protection manufacturers express damping values in different ways. NRR and SNR describe damping data presented as a single numerical value. Manufacturers can also specify damping effects on the basis of the HML. This gives three values for the effect with high-, medium- or low-frequency noise respectively. The common feature of these values is that they present the damping effect under ideal conditions. The estimated real-world attenuation will therefore be lower than the manufacturer's figure.

Real-world attenuation is estimated to be 12 dB for single hearing protection (defenders or plugs) and 18 dB for double protection (defenders and plugs) (see the OSHA). These values can be used providing the hearing protection has a minimum single number rating (SNR) value specified by the manufacturer of 30 dB for defenders, 28 dB for single-use plugs and 25 dB for moulded plugs. These minimum values are recommended unless a detailed assessment has been made of the type of protection, its customisation and the frequency distribution of the noise.

5.3 Factors reducing the real-world attenuation

Several factors may reduce the effectiveness of hearing protection. The loss is greatest in rooms with low-frequency noise. Single hearing protection can have an effectiveness as low as five dB if the leakage is not adequately restricted. Table 5.1 provides an overview of these factors as well as proposed measures for reducing the loss of damping effect.

Table 5.1. Factors reducing the effect of hearing protection.

Factor	Description	Measures
Safety goggles	In most cases, safety goggles will reduce the effect of ear defenders because the sound seal between defender and skin is broken. Thick temples or ones which are not tight to the skin cause the biggest seal loss. That also applies to temples (arms) which stick out behind the ears.	Goggles causing the smallest possible leakage should be used. Workers should be able to choose between different types and sizes. Protective goggles attaching directly to the hard hat without temples should have priority.
Goggles and tight-fitting respirator	Goggles and tight-fitting respirator could reduce the damping effect of ear defenders if they are positioned so that the strap covers part of the earlobe or comes between defender and skin.	Goggles and tight-fitting respirator with a narrow strap which does not conflict with earlobe or defender are to be preferred.
Balaclava, hazmat suit/ raingear hood, hat and other headgear	Balaclava, hazmat suit/raingear hood, hat and other headgear could reduce the damping effect of ear defenders when the head covering comes between defenders and skin. A balaclava with zip or thick material at the ears could cause a very big reduction in damping effect.	Choose a head covering designed for use with ear defenders or produced in a thin material.
Incorrect use of ear plugs	Ear plugs of the wrong size or incorrectly inserted will reduce the damping effect substantially.	Various types and sizes of ear plugs must be available at the work site. Training must also be given in choosing and using hearing protection.
Incorrect use and maintenance of ear defenders	Ear defenders positioned on top of the earlobes or hard-hat lining have a reduced damping effect. After lengthy use, cushions and head-bands on the defenders will become worn.	Different hard-hat types and sizes must be available at the workplace. Training must also be given in choosing and using hearing protection. Defender manufacturers recommend that cushions are changed twice a year. If other faults are suspected, the whole set should be replaced.

Other factors which can influence the damping effect of ear defenders are head shape, hard-hat size and thick hair. An oversized hard-hat can reduce the damping effect for people with small/narrow heads.

5.4 Adjusting the real-world attenuation

An upward adjustment of the damping effect on hearing protection is permissible providing a detailed risk assessment of the operation has been conducted before work begins. This assumes that several of the following measures are in place:

- the frequency distribution of the noise is known (see table 5.2)
- the assessment is conducted by an occupational hygienist, acoustician or a person with corresponding expertise
- the hearing protection is used at all times when in the noise zone
- ear defenders are in good condition (good undamaged cushions with firm strength in the headband)
- spectacles/goggles have narrow, pliant temples which do not stick out too far behind the ear, so that minimal leakage occurs when combined with ear defenders
- other PPE to be used is compatible with the ear defenders, and in good condition
- ear plugs used provide a documented individual damping effect of at least 15 dB at 500 Hz
- the noise level is checked regularly as long as the work operation lasts
- individual training in the use and insertion of plugs has been provided for the workers involved.

Table 5.2 Frequency distribution and damping value for double hearing protection.

Frequency distribution		Damping value [dB]
Low frequency:	$C - A \geq 5$	20*
Medium frequency:	$0 < C - A < 5$	22
High frequency:	$C - A \leq 0$	24

* Note that ear defenders used in areas with very low-frequency noise ($C - A \geq 10$), particularly when combined with safety spectacles or possibly a balaclava, can give a very reduced damping effect. In such cases, the real-world attenuation must be documented – by measuring on the inside of the hearing protection, for example.

6 VERIFICATION

Systematic handling of hazardous noise calls for continuous follow-up and assessment of how far the established management system (noise regime) provides adequate control of hazardous noise in the business. This activity also involves a systematic follow-up of work-related illness (WRI) with the aim of identifying improvements.

6.1 Verification of noise-reduction measures

The effect of all noise-reduction measures should be verified as part of the systematic follow-up of work to combat noise.

Administrative barriers cover such aspects as procedures for using moveable noise screens, restrictions on time present, training and hearing protection. Verification should be obtained that these are functioning through such methods as interviews, reviews of procedure documents (work permits and so forth), and methods or inspections in the field.

The effect of established technical noise-control measures (such as encapsulation, acoustic insulation or absorbents) can be verified with the following methods.

- Comparing measurements before the measure was implemented with subsequent measurements. Repeating measurements at intervals such as a year should be considered in order to check whether the effect is diminishing.
- Visual inspection to check whether the noise barrier has suffered mechanical wear or damage which reduces the noise-damping effect.
- Physical measurements to verify the noise-damping effect. Preference is to be given to determining the sound effect through sound-intensity measurements (ISO 9614-2).

7 REVISION HISTORY

7.1 Summary

The latest revision of this document has emphasised bringing the guidelines into step with new regulations and standards. Partial changes have been made to the document structure (including moving some text). A number of clarifications and simplifications have also been made, while some shortening of the previous version has been achieved.

The following main changers have been made in the revision.

- Chapter 1- introduction. This has been significantly expanded. Special mention must be made of the following.
    - Section 1.2 Terminology changed to bring the conceptual structure into line with applicable standards. Low-frequency sound/infrasound and vibration mentioned.
    - Section 1.3 Some definitions and abbreviations have been revised.
    - Section 1.4 References. Revised. Reference is now made, for example to the NLIA's new working environment regulations of 1 January 2013.
    - Section 1.6 Limit values and action values are rewritten and the concepts clarified in line with the regulations. Handling uncertainty is included.
    - Section 1.7 Handling hazardous noise in operations – figure 1. 2 on systematic follow-up of hazardous noise has been revised.
- Chapter 2 Coverage now confined to mapping noise levels.
- Chapter 3: Risk assessment, structure revised and contains sections from the "old" chapter 2 on noise exposure as well as new/revised sections.
    - Section 3.1 Noise exposure – formulas removed (part of the standard).
    - Section 3.3 New provision on noise exposure from handheld tools.
    - Section 3.4 Qualitative designation of noise exposure removed. Subsequent sections in chapter 3 have thereby been renumbered.
    - Section 3.5 Protection regime – new name (previously rough risk assessment), new number 3.4 and some textual amendments.
    - Section 3.6 Detailed risk assessment – recommendation incorporated on using noise calculator for estimating noise dose. New number 3.5.
- Chapter 4: Measures and follow-up.
    - Section 4.1 Alternative measures. Title changed to Measures. Substantially expanded, particularly for technical measures and use of PPE (removed from hierarchy of measures).
    - Section 4.2 Audiometry is revised and the title changed to hearing monitoring.

- Chapter 5: Damping effect of hearing protection. Based on former section 3.3, but by and large new.

- Chapter 6: Verification.

    - Section 6.1 Verification of noise-reduction measures.
      Formerly placed in chapter 4.

- Former appendix B: Overview of noise levels related to self-generated noise has been removed. The document refers to the use of the noise and vibration database for handheld tools (see sections 3.3 and 3.6).

- Former appendix C (now appendix B): Evaluation of programme for following up and preserving the hearing of people exposed to noise. The title and introduction have been reformulated with a view to using the content for general prevention.

- Former appendix D: Damping data hearing protection has been removed and replaced by a new chapter 5: Damping effect of hearing protection.

- Former appendix E (now appendix C): Colour codes for preparing a noise map. Some text has been moved to section 2.2 Noise map. Consistency has been ensured between the colours used in figure 3.1 and this appendix.

APPENDIX A: MAPPING ACTIVITIES AND WORK OPERATIONS

Example of a form to acquire input for assessing noise exposure.

Vurdering av oppholdstid i aktuelle arbeidsområder for en typisk arbeidsdag ("gjennomsnittsdag")			
Før du skriver noe i dette skjemaet bør du lese gjennom veiledningen.			
Skjemaet gjelder for :			
Navn:		Dato:	
Arbeidsområde	Fordeling av arbeidstid		**Typisk arbeidssted.**
	%	Timer pr.dag	Hvor i området arbeider du og hva gjør du?
Generelle, relativt stille områder på hele plattformen			
Kont.rom, Verksted, L.E.R, Tavlerom Samlet tid for alle rom av denne typen.			
Kontor / Stille områder (kontor, møter, lager, pauser etc.			
Gangveier, landing og mønstring			
Aktuelle arbeidsområder med middels til mye støy			
M-50 -Drillfloor			
M-30 Pipe deck			
M-30 Laydown Area *Angi kun opphold med generator i drift			
M32-Shaker Area			
M32/M31 Mudtank and BOParea			
M32-Sackstore			
M32-Mudpit area			
M31-Mud Pump Area			
M31-Mudmix &-transfere Area			
M31 Cement Unit room			
M31 HPU Area			
C45 - Wellbay Area			
Andre aktuelle arbeidsområder som ikke er nevnt ovenfor			
(spesifiser)			
Totalt (100 % eller 12 timer)			

Verktøybruk omtrentlig brukstid per dag					
Beskrivelse av verktøy:	**Tidsbruk (minutter per dag)**		**Beskrivelse av verktøy:**	**Tidsbruk (minutter per dag)**	
	% av dag	Minutter pr. dag		% av dag	Minutter per dag

APPENDIX B: EVALUATING PROGRAMME FOR FOLLOWING UP AND PROTECTING THE HEARING OF PEOPLE EXPOSED TO NOISE

Checklist

This checklist will provide a good basis for establishing routines which can prevent and combat the risk of noise-induced hearing loss.

Education and training

Inadequate implementation of programmes for hearing preservation (programme for preventing hearing loss) can often be traced back to inadequate education and training for workers exposed to noise and those responsible for programme implementation.

1. Has the educational programme been given at least once a year?
2. Was the educational programme given by a qualified instructor?
3. Was the quality of each educational programme evaluated?
4. Is the content reviewed periodically?
5. Is management at all levels directly involved?
6. Is the programme reflected in procedures, and are newsletter, posters and so forth used to provide information on key elements/activities in the programme?
7. Do employees receive personal advice if they have problems using hearing protection or show signs of hearing loss?

Involvement of supervisors

Studies indicate that employees who fail to use hearing protection have supervisors who are not fully involved in the programme for hearing preservation.

1. Does the supervisor have the knowledge required to ensure that their subordinates use and maintain hearing protection?
2. Does the supervisor themself use hearing protection where this is required?
3. Is the supervisor informed if an employee fails to use hearing protection?
4. Are disciplinary sanctions implemented if an employee consciously fails to use hearing protection on repeated occasions in noisy zones?

Noise measurements

Noise measurements should be related to assessments of exposure risk or made in connection with the implementation/prioritisation of noise-reducing measures. Results from noise measurements must always be communicated to all personnel involved, particularly if such measurements trigger measures.

1. Has adequate noise mapping been conducted?
2. Was the purpose of each noise mapping clearly defined? Have those exposed to noise been informed of their exposure level and risk of hearing loss?
3. Are the results routinely communicated to line management and other key people?
4. Are the results transferred to the health record for each person exposed to noise?
5. Are the results communicated to the relevant workshop/area via information brochures/folders?
6. Are noise maps produced, and are these used by the right personnel?
7. Are noise measurement results taken into account when assessing the procurement of new equipment, modification of plants and redeployment of personnel?
8. Has noise exposure been altered by changes to layout, equipment or processes? Have follow-up noise measurements been carried out?
9. Are employees who have experienced a significant change in exposure included in/ excluded from the hearing-loss prevention programme?

Technical and administrative barriers

Reducing/removing the noise source with the aid of new technical solutions or by introducing administrative decisions/procedures is often the most effective way of lowering or eliminating risk of hearing loss.

1. Has the need to introduce noise-reduction measures been prioritised?
2. Have cost/benefit assessments of different options been carried out?
3. Have employees and supervisors been informed of plans for noise-reduction measures? Will they have an opportunity to comment on prioritisation of measures?
4. Is the work being done by internal or external resources with adequate noise expertise?
5. Have employees or supervisors been consulted on the operation and maintenance of noise-reduction installations?

6. Is the implementation of noise-reduction programmes followed up continuously to ensure completion at the agreed time?

7. Has the potential for implementing administrative barriers been fully exploited? Have restrictions been imposed on the time present in noise zones? Are noisy operations conducted at times when few workers are present? Are lunch and break areas protected against noise?

8. Are specialists with noise expertise involved in planning noisy work?

Monitoring of audiometry and document archiving

The expertise of personnel conducting hearing tests (audiometry), the quality/condition of audiometers and localities for doing the testing, and the quality of archived records of such tests are crucial for the success of the hearing preservation programme.

1. Do the people conducting hearing tests have documented and approved expertise?

2. Do on-the-job observations of people conducting hearing tests indicate that their work is thorough and reliable, that they have acquired sufficient information from employees and that data are recorded in an appropriate way?

3. Are the records complete?

4. Are follow-up measures documented?

5. Are the hearing threshold levels reasonably consistent from test to test? If not, is the reason for the inconsistency quickly investigated?

6. Are the annual test results compared with the base line to identify changes (threshold shift)?

7. Does the occurrence of noise damage show a rising or falling trend? Assess preventive measures if the trend is rising.

8. Is it possible to document that the right procedures for audiometric calibration have been observed?

9. Is documentation available which shows that levels of background noise in the audiometry room were low enough to permit valid testing?

10. Are the results from audiometric testing communicated to supervisors and managers as well as to the employees?

11. Have corrective measures been implemented if the frequency of missed appointments for audiometric testing exceeds about five per cent?

12. Have employees with a change in hearing threshold been notified in writing within a minimum of 21 days? (Niosh recommends an immediate warning if a re-test shows a significant threshold change of 15 dB, same ear, same frequency.)

13. Are hearing tests always evaluated by the company health service/personnel with specialist education in occupational medicine/company nursing?

14. Can satisfactory procedures be documented for conducting hearing tests and verifications which confirm that the tests are conducted as specified in the procedure?

Hearing protection

Until noise-reduction measures have been established, and where such measures cannot be implemented or fail to reduce noise exposure adequately, hearing protection must be used to prevent hearing loss. To ensure that hearing protection is actually being used effectively, continuous attention must be paid to this subject by supervisors, those responsible for implementing the programme and those exposed to noise themselves.

1. Is hearing protection made available to all employees?

2. Are employees able to choose between different types of hearing protection?

3. Is emphasis given to considerations of employee comfort (and therefore the likelihood of using the protection) when allocating hearing protection?

4. Do all employees, and not just new recruits, receive detailed education at least once a year?

5. Is hearing protection checked regularly for wear or faults, and replaced immediately if necessary?

6. Are disposable ear plugs easily available in several sizes?

7. Do employees understand the purpose of the hygiene requirements?

8. Have any of the employees developed ear infections or irritation associated with the use of hearing protection? Are any employees unable to use hearing protection for medical reasons? Have these conditions been treated quickly and with good results?

9. Have other types of hearing protection been considered if some employees have experienced problems with the type they are using?

10. Do employees with hearing loss receive advice on their health afflictions/problems?

11. Do those who allocate and follow up the use of hearing protection have sufficient expertise to tackle the various problems which might arise?

12. Do workers complain that the hearing protection obstructs them in their work? Does it obstruct communication or perception of PA announcements? Are possible complaints followed up immediately in terms of advice on using alternative types of hearing protection, assessing noise-reduction measures and so forth.

13. Are employees encouraged to use hearing protection in their private lives if they are exposed to hazardous noise in their free time?

14. Are new types of hearing protection on the market continuously assessed?

15. Are assessments made of how far routines for allocating and utilising hearing protection function as intended?

16. Has the actual dampening (at the ear) provided by hearing protection been evaluated to ensure that it gives sufficient protection in relation to the relevant noise levels which the employee is exposed to?

17. Are routines in place to ensure that hearing protection users actually understand how it is to be used and looked after? Are the findings documented?

Administrative routines

Successful implementation of the programme depends on administrative routines functioning as intended.

1. Have regulatory requirements changed? Have the programme's policy/goals been amended to reflect these changes?

2. Does correspondence exist between the company's HSE policy and the hearing preservation programme? Is the latter known to top management?

3. Do procurement routines function so that hearing protection and other requirements related to the hearing preservation programme are delivered at the right time? If sufficient priority occasionally fails to be assigned, is corrective action taken?

4. Is the commitment of key personnel evaluated periodically? Is corrective action taken if this work is not given sufficient priority?

5. Safety – have undesirable incidents occurred because hearing protection has obstructed communication or prevented PA announcements or other messages from being perceived? Has corrective action been taken if this is the case?

(Source: Niosh)

APPENDIX C: COLOUR CODES FOR PREPARING NOISE MAPS

Table E.1: Colour table for preparing noise maps with 5 dB intervals

Area noise		Colour code			PMS
dB (A)	Colour	R	G	B	
>110		90	64	153	266C
106-110		127	64	152	2592C
101-105		178	140	193	2592C CMYK 60%
96-100		239	62	66	185C
91-95		247	143	30	021C
86-90		255	210	0	116C
81-85		255	239	111	106C
75-80		172	213	138	802C
≤75					
Unknown	White				

PMS: Pantone matching system.