SVT ENGINEERING CONSULTANTS

TECHNICAL REPORT - OFFSHORE PETROLEUM FACILITY ACCOMMODATION

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Abbreviations/Acronyms

ABS	*American Bureau of Shipping, classification society*
AC	*Air Conditioning*
AGWG	*Accommodation Guidance Working Group*
AHU	*Air Handling Unit*
AIRAH	*Australian Institute of Refrigeration, Air Conditioning and Heating*
ALARP	*As Low As Reasonably Practicable*
AS	*Australia Standard*
ASCC	*Australian Safety and Compensation Council*
ASHRAE	*American Society of Heating, Refrigerating and Air-Conditioning Engineers*
AVM	*Anti Vibration Mounts*
BS	*British Standards*
CO	*Carbon Monoxide*
CV	*Constant Volume boxes*
dB	*Decibel - units for noise levels*
dB(A)	*A-weighted Decibel*
DP	*Differential Positioning*
ETS	*Environmental Tobacco Smoke*
FAT	*Factory Acceptance Test*
FPSO	*Floating Production, Storage and Offloading vessel*
FSO	*Floating Storage and Offloading vessel*
GRF	*Glass Reinforced Fibre*
HSE	*Health Safety and Environment*
HSR	*Health and Safety Representative*
HVAC	*Heating, Ventilation and Air conditioning*
Hz	*Hertz - units of frequency*
ISO	*International Organization for Standardization*
LQ	*Living Quarters*
MAE	*Major Accident Event*
Min/min	*Minimum value*
MODU	*Mobile Offshore Drilling Units*
m/s^2	*Units of acceleration*
NEPC	*National Environment Protection Council*
NO_2	*Nitrogen dioxide*
NOHSC	*National Occupational Health & Safety Commission*
NOPSA	*National Offshore Petroleum Safety Authority*
NORSOK	*Norsk Sokkels Konkuranseposisjon (Norwegian Standards Organisation)*
NR	*Noise Reduction*
NRC	*Noise Reduction Coefficient*
O&G	*Oil and Gas*
OHS	*Occupational Health and Safety*
OH&SMR	*OH&S Management Resources Pty Ltd*
OPGGSA	*Offshore Petroleum and Greenhouse Gas Storage Act 2006*
Pb	*Lead*
PM10	*Number of particulate matter measuring less than 10µm*
PMV	*Predicted Mean Vote (on the thermal sensation scale) of a large population of people exposed to a certain environment*

POB	*Persons On Board*
PPD	*The Predicted Percentage of Dissatisfied people at each PMV*
ppm	*parts per million by volume*
RMS	*Root Mean Square*
Rw	*Weighted sound reduction index*
SO_2	*Sulphur dioxide*
STC	*Sound Transmission Class*
SVT	*SVT Engineering Consultants*
TV	*Television*
µg/m³	*Micrograms per cubic metre*
WC	*Water Closet*

Key Definitions For This Technical Report

Reasonably Practicable:

The legal definition on this was set out in England by Lord Justice Asquith in Edwards v National Coal Board [1949] who said:

> *'Reasonably practicable' is a narrower term than 'physically possible' and seems to me to imply that a computation must be made by the owner, in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time or trouble) is placed in the other; and that if it be shown that there is a gross disproportion between them — the risk being insignificant in relation to the sacrifice — the defendants discharge the onus on them. Moreover, this computation falls to be made by the owner at a point of time anterior to the accident*.

This English decision has since been confirmed by the Australian High Court[1].

[1] *Slivak v Lurgi (Australia) Pty Ltd* (2001) 205 CLR 304 cited in Bluff & Johnstone (2004) The relationship between Reasonably Practicable and Risk Management (WP 27 ANU National Research Centre for OHS Regulation))

1. INTRODUCTION

Two of the most influential factors for enhancing human performance and reducing human errors are offshore facility design and ambient environmental conditions. Consequently, the quality of the accommodation where offshore facility crews sleep, eat and relax will influence their job and safety performance as well as their overall sense of comfort and well-being.

NOPSA (National Offshore Petroleum Safety Authority) recognises the positive impact that appropriate accommodation conditions and design practices can have on the productivity, morale, overall well-being, health and safety of offshore facility workers. Offshore regulatory bodies from various countries also recognise this and there is sufficient suitable good practice material available globally that NOPSA need not conduct original research or investigations.

This technical report was developed under the auspices of the Accommodation Guidance Working Group (AGWG); a tripartite working group comprising of representatives from industry, the workforce and NOPSA. It identifies current good industry practices and goals in areas where the provision and management of accommodation will affect the health, safety and welfare of members of the offshore workforce on offshore facilities. This technical report also provides operators with some practical steps for achieving these goals. The technical information material contained in this report was collated by SVT Engineering Consultants, at NOPSA's request, from industry standards and guidelines, previous NOPSA publications, SVT's experience and contributions of specialist subcontractors.

1.1 Purpose Of This Technical Report

The purpose of this technical report is to provide the Australian offshore petroleum industry with information in the form of:

- High level goals that encompass current international offshore petroleum industry good practice; and
- Practical information to assist operators to achieve these goals.

This technical report is for information purposes only, and summarises global industry good practice and research. It is not an exhaustive summary of such practices. Where possible, references have been provided throughout.

It should be noted that this document is not intended to act as a standard, code of practice or regulation in any sense.

1.2 Scope

The scope of this document refers only to the provision of accommodation on offshore facilities. For the purposes of this report, accommodation includes sleeping, recreational areas and mess rooms (see Section 1.2.2). Accommodation blocks more often will contain workshops, control rooms and offices, but these areas are not within the scope of this report. Occupational Health and Safety was also excluded from the scope of this report.

In particular, this technical report provides an outline of current good industry practices in the areas of:

- Layout of living quarters;

- Noise;
- Whole-body vibration;
- Indoor air quality; and
- Lighting.

A number of these topics relate to ensuring offshore workers get adequate rest and sleep. The factors involved in getting adequate rest and sleep are much broader topics in their own right and are outside the scope of this report. For example, fatigue is covered, but only in so far as the design and criteria for sleeping facilities or other accommodation influence a worker's ability to sleep well. Fatigue at work is also a wider topic in itself and requires separate information to that provided here.

There are a number of publications available in Australia covering fatigue and working hours that comprehensively apply a risk management approach to the management of fatigue. Information on these publications can be found in the bibliography. Welfare issues such as physiology and psycho-social are also not within the scope of this report.

1.2.1 Facilities

In general terms, this document applies to vessels and structures undertaking construction, installation, maintenance, production, operation and decommissioning activities associated with offshore facilities in Australian Commonwealth waters. A facility is defined in the Offshore Petroleum and Greenhouse Gas Storage Act 2006 Schedule 3 Clause 4, and the listing given here in Section 1.2.1 should be used as a general guide only, not as a definitive listing. The scope of this document does not extend to facilities in transit or to transportation vessels. Facility types included in the scope of this document are:

- Fixed permanently manned, intermittently manned and normally unmanned production and/or processing platforms with or without drilling capability;
- Mobile Offshore Drilling Units (MODUs) including drill ships, jack-up drilling rigs and semi-submersible drilling rigs;
- Pipe lay barges and construction vessels;
- Floating Production Storage and Offloading (FPSO) vessels, Floating Storage and Offloading (FSO) vessels; and
- Accommodation vessels ('Floatels').

1.2.2 Areas

This report only relates to the living quarters of offshore facilities. In general the living quarters include:

- Sleeping cabins;
- Quiet lounge;
- Cinema;
- Games room;
- TV lounge;
- Coffee bar / tea preparation;

- Shop / kiosk;
- Phone booths;
- Prayer room;
- Music room;
- Computer room;
- Gymnasium;
- Outdoor exercise area;
- Corridors;
- Recreation areas;
- Library (when used for recreational activities only);
- Mess;
- Temporary accommodation; and
- Emergency accommodation.

The report provided also applies to multi-use areas where these are used for recreation or accommodation purposes (eg helicopter muster areas which are also used as cinemas or TV rooms).

The report does not extend to any working areas, such as:

- Galley / kitchen;
- Laundry;
- Offices;
- Conference room;
- Technical library;
- Control room;
- Medical Facilities;
- Heli-admin;
- Bridge;
- Radio room; etc.

Furthermore, this report does not extend to areas containing machinery or equipment, such as:

- Process areas;
- Propulsion (engine) rooms;
- Pump rooms;
- HVAC plant rooms;
- Winches / anchor chains; etc.

1.2.3 Previous Work Undertaken

In 2007, NOPSA published a Discussion Paper on "Offshore Accommodation Standards", which was prepared by OH&S Management Resources Pty Ltd (OH&SMR) and NOPSA. The discussion paper provided a review of relevant international and Australian standards and information as they relate to offshore accommodation. Comments were sought and received from a number of parties. Based on those comments, a revised draft document "Guidance Note - Offshore Petroleum Facility Accommodation, N-09000-GN0807" was prepared by SVT Engineering Consultants, and issued by NOPSA for further comment in February 2011. This technical report incorporates the text and comments from that draft Guidance Note.

1.3 About This Document

1.3.1 Input Provided

The goals have been identified by the AGWG to recognise there are three distinct situations applying to offshore facilities and the reasonable practicability of achieving the goals will vary for these different situations. The different situations are:

- New build facilities;
- Facilities coming into Australia – new entrants; and
- Existing facilities.

For facilities that do not currently meet the goals described, this report provides operators with examples of steps that may be reasonably practicable to undertake as part of an operator's continual improvement processes. It is emphasised that this technical report provides information as to current good practice and it is recognised that for existing facilities and new entrants' compliance with a number of the targets in this report will be subject to a "reasonably practicable" examination.

1.3.2 Intended Users

This technical report is intended to be used as a reference document by personnel involved in the design of new facilities or modifications to existing facilities. Such personnel will generally be professionals and technical specialists, and may include:

- Project engineers and managers;
- Architects;
- Ergonomists;
- Industrial hygienists;
- Health and safety advisers; and
- Health and Safety Representatives (HSRs).

1.4 Clarification Of Terms

Manned	Carrying or operated by one or more persons.
Permanently manned	A work area or workplace manned at least 8 hours a day for at least 50% of the facility's operation time.
Intermittently manned	A work area or workplace where inspection, maintenance or other work is planned to last at least 2 hours a day for at least 50% of the facility's operation time.
Normally unmanned	A work area or workplace that is not permanently or intermittently manned.
Should	An action or specification that is recommended and regarded as good practice.
Shall	An action or specification that is mandatory and regarded as the minimum acceptable standard (not used in this document).

2. ACCOMMODATION LAYOUT

2.1 Background

The relationship between adequate quality sleep and human performance is well documented. The impact of the physical environment on a person's ability to achieve adequate quality sleep is widely understood and accepted.

The contribution that a functional, comfortable, and pleasant living environment can make to people's motivation and enjoyment of work, while less widely researched and documented, should not be discounted by facility operators in considering optimisation of human performance and productivity; improvements in occupational health and safety outcomes; and factors such as staff retention.

The intent of this report is to assist facility operators with determining key requirements in provision of an adequate sleeping and recreational environment and identifying areas where improvements may be achievable.

2.2 Goals

The goal is to ensure an accommodation layout that provides suitable areas and environment for rest, restitution and recreation for all personnel on board (POB) throughout the facility operational lifecycle.

The following general design considerations are noted:

- The primary goal of layout design should be the safety of personnel in the event of a process upset or internal fire; however this aspect of layout design is outside the scope of this document.
- The layout for communal and recreational areas should be designed to avoid isolation and promote interaction and communication.
- Communal areas, including dining facilities and recreation rooms, should be equipped with windows where possible.
- The design and layout of accommodation should ensure the needs for individual privacy are met. This must include visual and auditory privacy for rest, ablutions, and internal and external private communication requirements.
- The accommodation design and layout should consider personnel movement and communication requirements during the full range of operating conditions.
- The design should adopt a logical and consistent approach to layout, location and operation of equipment, items, labelling and signage. The approach adopted should reflect cultural expectations and ease of use.
- The design should address the safety and efficiency of cleaning, replenishment, and routine and non-routine maintenance of areas, equipment, and services. Considerations should include safe access, working postures, and materials handling requirements. Manual handling tasks should be designed in accordance with authoritative sources of good practice such as the Australian Safety and Compensation Council requirements (Section 2.9), or similar international guidance and standards.

- The design should consider personnel wellbeing aspects and should provide a functional, comfortable and pleasant living environment.

2.3 Scope

The scope of this technical report in relation to accommodation layout is limited to sleeping and recreation areas only. It is emphasised that all work areas including offices, control rooms, workshops, bridge, communication and equipment rooms, medical facilities, galleys, laundries, housekeeping and general ablution facilities are specifically excluded. Dining / mess rooms are considered but all associated work areas including food storage, preparation, and serving facilities are excluded.

The importance of addressing functional relationships between the various work, rest and restitution areas, and ensuring these relationships are appropriately represented in accommodation design and layout, is acknowledged. These fundamental aspects of accommodation design and layout are not within the remit of this document.

Safety critical aspects of accommodation design and layout, including requirements for emergency egress, are not within the scope of this document.

The information in this section relates to the operational phase of a facility's lifecycle. Whilst construction, installation, commissioning, and decommissioning phases are not specifically addressed, the report should be considered wherever and whenever people are required to live and work on the facility. The report is considered applicable to intensive work programs such as major maintenance campaigns and facility upgrades - particularly in cases where such programs are conducted within an operational environment.

It should be noted that the information in this section is focussed primarily on normally manned and intermittently manned facilities. Facilities which are not-normally-manned should consider the report and implement key recommendations - particularly for sleeping areas - where these are achievable. Similarly, operators of mobile facilities, temporarily in Australian waters, whose accommodation standards are compliant with international shipping regulations and codes are encouraged to consider and adopt the recommendations contained in this report where it is reasonably practicable to do so.

It is further emphasised that the information in this section is aimed primarily at new build facilities, but application is also encouraged for existing facilities where practicable.

In determining aspects such as minimum clearances, reference to recognised ergonomic standards such as ASTM F1166 Standard Practice for Human Engineering Design for Marine Systems, Equipment and Facilities [Ref. 6] and SAA HB59-1994 Ergonomics – The human factor – A practical approach to work systems design [Ref. 7] is recommended.

2.4 Cabins/Sleeping Areas

2.4.1 General

Cabins should be grouped together on dedicated floor levels or in separate corridors away from traffic areas and noisy activities.

Cabins should be arranged to provide a basis for uninterrupted sleep, rest, quietness and personal hygiene needs. Each cabin should be furnished to include storage for required safety and survival gear, clothing and personal belongings. It should provide opportunity for reading, writing and relaxation. Beds in cabins where there is more than one bunk should be fitted with bed curtains to enable privacy and protection from light and direct view.

All berths should be immediately adjacent to an aisle or access-way leading directly to an escape route from the accommodation.

2.4.2 Occupancy

In determining appropriate cabin occupancy for an individual facility, the goal is to ensure all personnel can get adequate quality sleep. In addition to number of people per cabin, factors such as shift patterns must be properly considered to ensure the risk of sleep disruption (eg through effects of people entering and leaving the room) is minimised.

Two-berth cabins with en-suite shower, toilet, and washroom facilities shared between two cabins is considered the typical arrangement or norm for the design of new intermittently-manned and normally-manned facilities.

Single berth cabins are recommended where space allows because they provide optimal privacy and comfort.

Four-berth cabins, in most circumstances, will not provide reasonable privacy and comfort. This arrangement is considered below standard for new facilities, or for existing facilities undergoing accommodation refurbishment in which upgrade to a two-berth, or single-berth cabin arrangement is reasonably practicable.

Four-berth cabins are acceptable on existing facilities where it is not reasonably practicable for them to be upgraded because of lack of space or other technical or severe economic limitations. Ideally, no more than two beds should be occupied during any particular shift.

Four-berth cabins may provide a practicable solution for temporary and emergency accommodation on not-normally manned facilities. However, where stays of extended duration are anticipated, eg for maintenance campaigns and modifications, the benefits of two-berth or single berth cabin arrangements should be given proper consideration by the facility operator.

Hot bunking is not considered acceptable for any facility.

In all cases, separate sleeping accommodation (cabins and bathroom facilities) for men and women should be provided.

2.4.3 Cabin Size

Cabin sizing should be based on the facilities provided and adequate free circulation space for occupants.

The following sections (2.4.3 – 2.4.7) provide a guide to the minimum requirements for cabin and furniture sizes quoted in internationally accepted standards and available information. Note that it is the operator’s duty to be able to demonstrate that cabin sizing and clearances are adequate. The minimum sizes and clearances quoted here may not be adequate in many circumstances, and will not be considered adequate where it can be demonstrated that it is reasonably practicable to provide cabin sizing and clearances which are greater than the minimum.

It is recommended that net internal cabin area (excluding entrance lobby, bathrooms, bunks, lockers and desks) for single and two-berth cabins should be not less than 4 m^2.

The minimum recommended clearances are given in Section 2.4.5.

2.4.4 Cabin Design

Cabin design should preferably be standardised across the facility. For new and refurbished facilities, modular 'prefabricated' cabins are recommended for consistency, acoustic performance, ease of cleaning, and ease of replacement over the life of the facility.

Cabin layout and furniture should be of an ergonomic design, simplifying fabrication, housekeeping, and maintenance, and enhancing comfort and usability for personnel. The layout should provide for unrestricted access to bunks, desks and lockers. Outside corners of berthing bulkheads, doors or edges that personnel may contact incidentally should be radiused to reduce risk of injury.

Where possible, berths should be facing fore and aft and not port and starboard, regardless of cabin orientation, to assist in reducing movement and motion induced sickness, for floating facilities where the length that is much greater than the beam.

Berths should be designed such that making beds and changing linen is easy to do and does not expose housekeeping personnel to risk of injury through prolonged poor postures, excessive mattress handling or contact with sharp edges when tucking in sheets.

Wherever possible, beds should be placed on the floor for ease and safety of access and use. Beds should be sized to comfortably accommodate a 95th percentile male (minimum dimensions not less than 900 mm wide by 2100 mm long are suggested). The top of the mattress should generally be between 550 mm to 600 mm above the floor for ease of access and to allow personnel to sit comfortably. If there is a requirement for upper level bunks then the top bunk should have a dust-proof bottom constructed of suitable material. Robust ladders, grab bars and safety rails should be provided for access to upper berths. Proprietary pull-down bunks may be considered where these are required temporarily for peak manning periods.

2.4.5 Clearances

Head clearance between the top of a bunk and any overhead obstruction should be sufficient to allow a 95th percentile male to sit up without bumping his head (eg 900 mm is currently considered a minimum clearance by some sources).

In sleeping areas, a clear ceiling height not less than 2400 mm should be considered, and in washrooms, not less than 2200 mm.

Aisle widths in sleeping areas should be at least:

- 600 mm between a single berth and the nearest obstruction;
- 900 mm between facing berths; and
- 1000 mm when joining two or more aisles.

2.4.6 Storage Space

Each cabin should have sufficient, identifiable storage space for the occupants' bag or holdall, clothes, personal items, and valuables (lockable storage space).

Storage provision should also consider the need to minimise requirements for people to enter multiple-occupancy rooms while others are sleeping.

Drawers and doors should be arranged to prevent inadvertent opening and closing due to movement on floating facilities.

A kick space of at least 100 mm high by 100 mm deep should be provided around accessible faces of cabin furniture including lockers and berths.

2.4.7 Cabin Doors

Cabin doors should have a clear opening of at least 1980 mm high by 660 mm wide and be capable of being operated by a single person, from either side, in both light and dark conditions. However, the opening should be sized for all foreseeable operational circumstances which may be greater than the minimum quoted here.

An individual identifier (eg letter or number) should be clearly visible from outside the room to identify each cabin.

A means of switching on/off lighting should be provided near the door so that occupants are not required to enter a darkened room.

2.5 Sanitary Facilities

The provision of ensuite bathroom facilities is preferred and is considered the norm for the design of new intermittently-manned and normally-manned facilities (see Section 2.4.2). For existing facilities where provision of ensuite bathrooms is not reasonably practicable, access to sanitary facilities from the bedrooms should not require access via 'public' areas.

Table 2-1 : Sanitary facility information

Item	Reference	Relevant Section
1	ABS Guide - Crew Habitability on Offshore Installations May 2002	Appendix 3 – Accommodation Criteria – Sanitary Spaces
2	Australian Government – Marine Orders Part 14 Accommodation Issue 1 Compilation No. 1	Appendix 1, Part 6. Sanitary Accommodation and Part 7. Washing and Change Rooms.
3	NORSOK Standard C-002 2006 Architectural components and equipment	Section 17 – Prefabricated Bathroom Units

2.6 Corridors

The goal is to provide adequate access and egress to and from all usable areas of the accommodation in normal, abnormal, and emergency conditions.

Rooms located on the same level should be interconnected by corridors connected vertically by staircases (and lifts). Corridors should link directly to designated internal and external escape routes. Dead end corridors should be avoided and should never be more than 5 metres in length [Ref. 4].

Corridors must be designed in accordance with the facility's safety standards. Dimensions provided in this section are considered minimums based on ergonomic criteria. The more onerous standards required for compliance with escape, evacuation and rescue design criteria shall be applied wherever applicable.

Frequently used corridors or those which require 2 persons to pass comfortably should have a minimum 1200 mm clear width [Refs 4, 7] and minimum 2300 mm clear height (including fire detector heads). Additional clearances should be provided as required for identified activities and tasks (eg to enable a stretcher to be manoeuvred around corners; to allow for equipment removal and materials handling clearances, to allow for fire fighting appliances and detector heads etc).

Equipment in corridors should be recessed so that it does not obstruct access or egress nor pose a knock hazard to personnel. Maintainability of corridor equipment (eg light fittings) and impact on access should be considered in design.

For ease of orientation, it is important to locate corridors, stairways, connection doors, emergency exits, etc for each level consistently in the same position and direction where possible.

2.7 Dining/Mess Rooms

The dining room should be on the same level and vicinity as the galley with immediate proximity to galley servery areas.

Consideration should be given to workflow patterns and the dining room entrance, exit, fixtures, and dining furniture, arranged to provide adequate personnel circulation and facilitate a logical flow. Ease of access should be provided to servery and beverage counters and sufficient space allocated for queuing adjacent the servery. The waste, dirty return and wash-up areas should be located en-route to the dining room exit where possible.

Dining room capacity is typically sized to accommodate approximately 50% POB at any one time. The dining room should be of adequate size to allow personnel to sit comfortably while having their meals and to move freely between tables and self-service areas.

The following information is included to assist in determining space requirements:

- Recommended table space required for each diner is at least 750 mm wide;
- Recommended table depth for facing diners is at least 900mm (450 mm for each diner);
- Distance between tables with back to back seating should be sufficient to allow for personnel movement (minimum 1500 mm clearance recommended); and
- Distance between the seating side of a table and the nearest obstruction should be sufficient to allow for personnel movement (minimum 1000 mm recommended for a fixed non-accessible obstruction such as a wall; greater clearance is required for accessible obstructions such as self-service counters and cabinets).

Dining room interior fixtures, furnishings, and finishes should be of durable quality, and easy to clean.

Tables, and other loose furniture items as necessary, should be capable of being secured on mobile facilities.

Consideration should be given to manual handling tasks in relation to regular cleaning requirements and practical provisions made to improve efficiencies and reduce risks (eg proximity of janitor room; table brackets for securing chairs off the floor for mopping, etc).

2.8 Recreation and Exercise Facilities

2.8.1 Goal

The goal is to provide adequate spaces for the health and welfare needs of personnel on board in terms of recreation, leisure, social interaction, and exercise.

Separate areas should be provided for quiet and noisy activities.

2.8.2 Scope

Recreation and exercise facilities may include:

- Quiet lounge;
- Cinema;
- Games room;
- TV lounge;
- Coffee bar / tea prep;
- Shop / kiosk;
- Phone booths;
- Prayer room;
- Music room;
- Computer room;
- Gymnasium;
- Outdoor exercise area;
- Recreation areas; and
- Library (when used for recreational activities only).

2.8.3 Recreation Areas

Recreation areas should be grouped and located adjacent to dining areas where possible and arranged so that a logical flow is established between the recreation facilities and the dining room.

Interconnecting doors and glazed partitioning should be used where appropriate to promote social interaction and reduce isolation, particularly in periods with low manning.

Corridors linking dining room, stairway, coffee bar/tea prep, shop, rest rooms, and recreation rooms should be designed to promote free circulation and avoid congestion.

Recreation room entrances and exits (eg TV lounge / cinema) should be arranged to allow personnel to join or leave activities without unnecessary disruption to other participants.

Furnishings, fittings, and finishes should be aesthetically attractive; of durable quality; and easy to clean. Loose furniture should be compliant with ergonomic design criteria and should be easy to handle and manoeuvre for cleaning purposes.

Dining rooms, lounges, TV rooms and cinemas often have dual functions and can be designed and adapted for multipurpose use including:

- Muster rooms;
- Triage / Emergency medical treatment;
- Meetings, briefings, seminars, training sessions;
- Films and videos;
- Live shows / concerts / entertainment;
- Games / quiz / card nights; and
- Group exercise.

2.8.4 Games Rooms

If provided, games rooms should preferably be positioned in reasonably close proximity to other communal recreational areas however care must be taken to ensure suitable location (eg near gymnasium) and adequate acoustic isolation, as these tend to be relatively noisy areas. Facilities provided may include pool table, tennis table, dartboards etc. Proximity to refreshments and rest rooms should also be considered.

2.8.5 Gymnasium and Exercise Areas

All facilities should provide suitable area(s) and equipment for physical exercise.

A gymnasium should contain professional quality equipment and should be provided with outlets for television and audio-visual equipment. The gym should preferably be located in reasonable proximity to other communal and recreation rooms but the overriding requirement is that it is located away from quiet areas to avoid nuisance noise.

Suitable wall and floor insulation should be provided to minimise the transmission of sound from exercise areas. In particular treadmills should be located in separate rooms or alcoves to reduce noise transmission. Free weights are best avoided due to noise and safety issues.

Floors in exercise areas should also be shock absorbent to reduce risk of injury.

Means of fixing equipment should be provided on mobile facilities.

Where practicable, exercise areas should have changing rooms adjacent to them with showers, toilets and washbasins for separate male / female use.

2.8.6 External Communication Facilities and Computer Rooms

The ability to contact home and hold a private conversation is an important aspect of maintaining satisfactory personal relationships for people working offshore.

Adequate provision of communication facilities for private use by personnel on board should be considered as the norm. Clear definition of adequate provision is a subject for further research; however some information sources recommend at least one phone for every 35 POB.

Communication facilities should include computer rooms for private use including email correspondence. Such facilities should consider webcams and acoustic booths to allow more personal contact with family.

As a minimum, phone booths / hoods offering visual and acoustic privacy to allow personnel to conduct private external conversations should be provided where possible. Some of these phone(s) should be located in close proximity to communal and recreational areas to allow personnel to read, watch TV etc while awaiting their turn in peak use periods.

2.9 References

1) ABS Guide for Crew Habitability on Offshore Installations 2002

2) ABS Guide for Crew Habitability on Ships 2001

3) Australian Maritime Safety Authority, Marine Orders 14 – Accommodation.

4) NORSOK Standard C-001 2006 Living Quarters Area

5) NORSOK Standard C-002 2006 Architectural components and equipment

6) ASTM F1166 Standard Practice for Human Engineering Design for Marine Systems, Equipment and Facilities

7) SAA HB59-1994 Ergonomics – The human factor – A practical approach to work systems design (published by Standards Australia)

8) ASCC National Standard for Manual Tasks 2007

9) ASCC National Code of Practice for the Prevention of Musculoskeletal Disorders from Performing Manual Tasks at Work

3. NOISE

3.1 Background

The accommodation area provides a space within the offshore workplace where personnel can sleep, eat, socialise, pursue recreational activities and recuperate. It can also provide essential respite for those people exposed to high noise levels during their working day. Excessive noise within the accommodation area can have an adverse impact on recreational and recuperative activities and thereby affect the health and welfare of offshore workers. This can lead to lower performance and productivity as well as potential safety issues, particularly when noise affects sleep or communication. Therefore, controlling noise levels within accommodation areas is essential in providing a safe and healthy environment for offshore workers.

3.2 Relevant Standards

There are no Australian regulations that provide acceptable noise levels within offshore accommodation areas. AS 2254:1988 Acoustics – Recommended Noise levels for Various Areas of Occupancy in Vessels and Offshore Mobile Platforms does provide guidance on noise levels but is considered by many to be out-dated and not representative of current best practice (or even common practice). Consequently many companies define corporate standards for noise levels within accommodation areas of fixed facilities. These are often based on more recent research and information, as well as building acoustics standards.

For mobile facilities, noise levels recommended by classification bodies such as ABS, DNV and specialized agencies such as the IMO are often referenced. The guidance on noise levels provided by these authorities has been considered in compiling this technical report, however the information in this section may differ from that presented by those bodies for the following reasons:

- Some of the guidelines from classification bodies relate only to noise on board ships. Whilst some of the facilities mentioned in Section 1.2.1 are ships (but with a primary function other than transportation), the scope of this document does not include facilities in transit or to vessels whose primary function is transportation.
- Some of the classification bodies make a distinction between crew and passengers, with different noise standards for the two groups. This report does not make that distinction because good practice within accommodation areas on offshore petroleum facilities applies to all persons on board.
- The "maximum allowable" noise levels specified in some guidelines are higher than what is considered current good practice. These "minimum standards" for classification purposes do not necessarily achieve the quality goals stated below.
- Some of the standards have not been updated for some time (eg AS 2254:1988, IMO:1981) and therefore do not necessarily reflect current good practice, and classification bodies (ABS, DNV) rely on some of these to set their own standards.

Information from NORSOK S-002, NORSOK C-001 and ISO 15138 has been considered and incorporated into this technical report.

3.3 Goals

The following factors need to be considered in order to achieve a satisfactory acoustic environment for personnel living within the accommodation areas:

- Overall noise levels - these must be as low as reasonably practicable to provide a safe and healthy workplace;
- Noise characteristics - characteristics such as tonality, impulsiveness, excessive low frequency content can be significantly more intrusive than broadband, continuous noise;
- Acoustic privacy between rooms; and
- Speech intelligibility in rooms used for recreation.

The following sections present goals for each of the above considerations.

3.3.1 Accommodation Noise Levels

Table 3-1 presents recommendations on the overall A-weighted noise level, averaged over a representative period T, ($L_{Aeq,T}$) within accommodation areas for fixed and mobile facilities. The time of the day that the noise level should be measured should be at the typical time that the room is being used for its intended purpose.

Table 3-1 : Information for noise levels in occupied spaces

Occupied Space	Objectives	Recommended noise levels ($L_{Aeq,T}$) in dB(A)		
		Overall Noise Levels	HVAC Noise (& NR)	Machinery Generated Noise
All Facilities				
Bathrooms/ Washrooms/ Showers	Noise levels should not prevent respite from high noise and should not reduce the amenity of surrounding occupied spaces	60	55 NR 50	55
Cabins	Noise levels measured at head position on beds should not prevent or interrupt sleep	40	35 NR 30	35
Smoking/ Crib Room (only when the facility operator has made adequate provision for one)	Noise levels should not prevent respite from high noise, or interfere with speech intelligibility	55	50 NR 45	50
Rest And Restitution Areas (separate from office areas)	Noise levels should not prevent rest and recuperation, or interfere with recreational and leisure activities, or speech intelligibility between personnel	45	40 NR 35	40

Occupied Space	Objectives	Recommended noise levels ($L_{Aeq,T}$) in dB(A)		
		Overall Noise Levels	HVAC Noise (& NR)	Machinery Generated Noise
Temporary / Emergency Accommodation	Noise levels at head position on beds should not prevent or interrupt sleep	40	35 NR 30	35
Exceptions For Mobile Facilities**				
Cabins	Noise levels at head position on beds should not prevent or interrupt sleep	45	40 NR 35	40
Rest And Restitution Areas (separate from office areas)	Noise levels should not prevent rest and recuperation, or interfere with recreational and leisure activities, or speech intelligibility between personnel	55	50 NR 45	50

*For explanation of NR, see Section 3.3.2, "Low frequency noise".

**Noise levels are in line with IMO and applies to mobile facilities under way or in dynamic positioning (DP) mode.

The noise levels given in Table 3-1 should be used as a guide and are consistent with ISO 15138. Achieving the noise levels in the table is a goal to aim for; however, fully achieving the objectives the noise levels relate to is the ultimate goal.

The overall noise levels given in Table 3-1 are the noise levels within the various occupied spaces of the accommodation area when the facility is in operation. The overall noise level can include contributions from noise sources within the accommodation area (eg HVAC system noise, recreation areas, laundries, etc) as well as external noise sources such as process plant, helicopter operations, emergency equipment, etc. To successfully meet the overall noise level, the noise contribution from individual sources should be less than the overall noise level. It is good practice for noise levels from the HVAC system to be 5 dB less than the overall noise level. Machinery generated noise should also be 5 dB less than the overall noise level.

3.3.2 Characteristics Of The Noise

Tonal or impulsive noise

Examples of tonal noises are the whining of a turbine, or the whirring of a hydraulic power pump or of thrusters in use. Examples of impulsive noise include the clunking of an anchor chain being raised and the banging of drill pipe being lowered on a deck. Noise containing audible tonality or impulsiveness is generally perceived as being more intrusive and annoying than otherwise indicated by the measured noise level, and hence has the potential to upset rest and cause sleep disturbance to some people.

Therefore, to take into account these characteristics of noise, if the noise emission received within the occupied space of the accommodation area is tonal or impulsive in characteristic then the noise levels given in Table 3-1 should be reduced by 5 dB.

Low frequency noise

Some personnel perceive very high levels of low frequency noise as being annoying. This can cause sleep disturbance. Low frequency noise lies within the 20 Hz to 200 Hz frequency range. When low frequency noise is high then the Noise Rating (NR) should be used in addition to the A-weighted noise level. The octave band sound pressure levels for each NR are defined in BS 8233:1999. The NR level should be 5 dB less than the overall A-weighted noise level and is given in Table 3-1.

3.3.3 Acoustic i\Isolation Between Occupied Spaces

Adequate acoustic isolation between adjacent spaces within the accommodation area is normally required to achieve satisfactory internal noise levels, acoustic privacy and speech intelligibility.

Requirements for partition walls and ceilings

Table 3-2 presents recommended sound insulation index rating (Rw) values for the internal partitions of adjacent spaces to ensure adequate acoustic isolation. The sound transmission class (STC) is essentially the same as the Rw rating.

Table 3-2 Acoustic isolation requirements for partitions

Item	Description of Space	Recommended Rw/STC
1	Separating walls between cabins	43
2	Separating walls between cabins and the corridor	43
3	Separating walls between the conference room and adjacent office and the corridor	43
4	Separating walls between the quiet lounge and TV room, and between the quiet lounge and games room	32
5	Separating walls between adjacent phone booths, and between phone booths and TV room	43
6	Separating walls between the cinema and media room	43
7	Separating walls between the medical centre and corridor, and between adjacent cabins	43
8	Separating walls between ablutions and cabins	50
9	Ceilings	43 (Note 1)
Note 1: The rating here is the sound transmitted between the cabins via the ceiling, ie the R_w quoted is for cabin to cabin noise transmission via the ceiling space.		

ISO 140 defines the method for field measurements of airborne sound insulation between rooms. ISO 717 defines the method for determining partition Rw based on the field measurement results.

If the recommended Rw/STC values given in Table 3-2 cannot be met then administrative ways of controlling noise intrusion should be sought, such as minimising the use of corridors, not allowing talking in corridors adjacent to occupied cabins, etc.

The recommended partition ratings refer to laboratory test values for partitions and are appropriate for design purposes. It is recognised that field measured noise attenuation values may vary from laboratory ratings.

Footfall noise

Footfall noise can have a significant impact when low noise areas within an accommodation area are located below or immediately adjacent to high traffic areas such as messes, laundries, offices, control rooms, smoking rooms, accommodation area exits and entrances, etc.

Good practice is to control footfall noise by avoiding layouts which have high traffic areas above or adjacent to quiet areas (eg cabins). However, this may not always be reasonably practicable because of other layout considerations, so mechanical isolation methods may be necessary to reduce the impact of footfall noise. Such methods include the use of floating floors, damped deck plates, treatments to ceilings and undersides of decks, and resilient floor coverings such as carpets. These methods are discussed further in section 3.4.2.

Control of cross talk between rooms via the HVAC ducting

Noise can easily propagate along HVAC ducting with very little attenuation. This can result in conversations (or other noise) in one room being clearly audible in another. Table 3-3 lists the recommended noise attenuation for ducting systems that link the various spaces within the accommodation area. Duct attenuation should be calculated using specialist HVAC noise modelling software or manually calculated using the method described in the Duct Work for Air Conditioning Application Manual (see references).

Table 3-3 Cross talk recommendations between rooms

Rooms	Recommended Attenuation
Recreation / Cabins	50 dB
Cabins / Cabins	43 dB
Cabins / Corridors	43 dB

3.3.4 Speech Intelligibility

Table 3-4 gives those rooms that may require acoustic ceilings or absorptive wall linings to provide good speech intelligibility. Table 3-4 also gives information on the minimum noise reduction coefficient (NRC) for the ceilings of rooms that has been found to provide good speech intelligibility. Some rooms may require treatment to both ceilings and walls if the room is very large, or if very high quality speech intelligibility is required.

Table 3-4 Recommended acoustic treatments for speech intelligibility within rooms

Item	Description	Treatment
1	Cabins	Ceiling only - acoustic tiles to ceiling with an NRC of 0.5
2	Cinema	Acoustic tiles to ceiling with an NRC of 0.6 (may also require treatments to walls)
3	General recreation room	Ceiling only - acoustic tiles to ceiling with an NRC of 0.5
4	Offices rooms	Ceiling only - acoustic tiles to ceiling with an NRC of 0.5
5	Meeting rooms	Ceiling only - acoustic tiles to ceiling with an NRC of 0.5

3.4 Information for Achieving Goals

The following provides general information for achieving the goals given in Section 3.3.

Achieving noise goals within the accommodation area is highly dependent on the noise control measures incorporated within the facility. The success of noise control is dependent on how it is incorporated in the design of facilities, how well it is implemented during construction, and how it is maintained during the life of the facility. New builds are most likely to successfully achieve noise level goals. Retrofit noise controls for existing facilities are feasible but are likely to be more costly, more difficult to implement, and may not be as effective as those considered during facility design.

Where possible some specific examples of relevant noise and vibration control treatments are provided. However, the information provided here is general in nature and may not address all of the issues which need to be considered. If more specific information is required or the effectiveness and suitability of noise controls need to be assessed, then it is recommended that suitably qualified personnel should be utilised for the assessment.

3.4.1 Project Management Steps

New facility designs

The earlier noise control is considered in the design of a new project the more likely the project is to achieve satisfactory noise levels in accommodation areas. Key to success is the definition of robust target noise levels which are clearly stated and widely understood. Therefore, the first step in the design process which follows is the definition of noise goals.

Definition of noise goals

Appropriate noise goals for accommodation areas should be defined at the outset of the design process. When setting noise goals, due consideration should be given to requirements specified in legislation, national and international standards, corporate standards, relevant codes of practice and guidance documents, where these do not exist Table 3-1 presents information on the overall A-weighted noise levels within accommodation areas for fixed and mobile facilities.

Table 3-1 gives information on noise levels within the accommodation.

Noise within the accommodation typically originates from the following sources:

- HVAC system;

- Airborne noise from plant and equipment within accommodation;
- Structure-borne noise from plant and equipment within accommodation;
- Airborne noise from plant and equipment outside the accommodation; and,
- Structure-borne noise from plant and equipment outside the accommodation.

Therefore, to meet noise level goals within the accommodation the cumulative noise impact of the above sources needs to be considered. This is can be achieved by setting individual noise limits for these noise sources so that the cumulative noise levels from all sources do not exceed the noise level goals.

For example if a cabin noise level not exceeding 40 dB(A) is required, then this may be achieved by specifying a maximum allowable HVAC noise level of 35 dB(A) and a maximum allowable noise level of 35 dB(A) each for airborne and structure-borne sound intrusion.

Noise goals should be clearly stated in the Basis of Design documentation and should be communicated to design teams early in the design so they are correctly incorporated into the design process.

Preliminary design review – identification of major noise and vibration issues

Good practice is for new designs to be reviewed as early as possible to identify the potential for noise and vibration problems. The review should include:

- Examination of preliminary layouts to minimise the possibility of incompatible uses of adjacent rooms / spaces (refer section 3.4.3) and to ensure adequate space requirements for acoustic isolation of services;
- Identification of the potential sources of noise intrusion into accommodation spaces from externally located plant and equipment;
- Identification of the potential sources of noise intrusion from mechanical equipment located within the accommodation area (eg fans, transformers, HVAC equipment, etc); and
- Identification of sound and vibration transmission paths.

Preliminary calculations or modelling of noise intrusion into accommodation spaces is recommended to evaluate noise levels and to determine the extent of any noise control measures that may be required. The findings of the preliminary design review need to be communicated to design teams to ensure that they are fully aware of the potential noise control challenges likely to be encountered during the design process.

Consideration and selection of noise control measures

Design teams need to consider the noise control options available to achieve the required acoustic environment within accommodation spaces. Consideration needs to be given to the hierarchy of control:

- Eliminate the noise source
- Substitute the noise source for a quieter source

- Introduce engineering noise control and design optimisation to reduce the impact of noise sources, eg:
  - Optimisation of room layouts
  - Application of acoustic absorption to control reverberation
  - Vibration isolation of noise sources
  - Enclosing noise sources
  - Optimisation of equipment layouts to minimise noise impacts

- Isolation of the receiving space from the noise source, eg
  - Selection of building elements with appropriate acoustic insulation properties
  - Acoustic screening of noise sources
  - Employing floating floor constructions
  - Vibration isolation of receiving spaces

Noise controls should be selected and incorporated into the design based on the outcome of an ALARP (as low as reasonably practicable) assessment.

Set project noise and vibration control specifications

Noise control specifications should be set for the project including:

- Plant and equipment noise limits;
- Sound insulation requirements for building elements;
- Vibration isolation requirements;
- Room absorption requirements; and
- Testing requirements.

Noise and vibration limits and controls should be written into equipment and material specifications issued to vendors. Due consideration should be given to contractual requirements including guarantees, assurance inspections, FAT noise and vibration requirements, and processes for managing non-compliance (penalties, how rectification work will be undertaken, etc).

Where noise and vibration controls are not the vendor's responsibility (room layouts, routes for hydraulic services, etc) the responsibility for compliance with the specification should be passed to the design team.

Evaluation of vendor data

Information received from vendors and material suppliers should be reviewed for compliance with the project noise and vibration control specification. For non-compliant bids, alternatives should be considered which either achieve compliance or which achieve as low as reasonably practicable (ALARP) outcomes.

Finalisation of noise control options during design and re-evaluation of noise and vibration impacts

Noise and vibration impacts should be re-evaluated by calculation or modelling using information returned from vendors. Noise and vibration controls should be selected using an ALARP assessment process based on the outcomes of the re-evaluation.

Installation and commissioning

Where appropriate (as defined in the project noise and vibration specification), factory acceptance testing should be undertaken before delivery of equipment and materials.

Appropriately experienced supervision of the construction and installation of equipment and materials is essential to prevent compromising or short-circuiting of noise and vibration control measures. Specialist acoustic inspections should be undertaken to ensure the fabrication/installation does not compromise the noise control treatment. This is particularly important for floating floor/walls/ceiling constructions, acoustic enclosures, etc.

Noise and vibration testing should be undertaken during commissioning and any remedial actions identified should be addressed.

Existing facility

If an existing facility does not meet the goals then the following steps provide a guide to determine practicable noise control options:

- Establish current noise levels (for the noisiest mode of operation)
- Undertake an engineering noise control assessment which:
  - identifies various noise contributors
  - ranks noise contributors
  - develops noise control options
  - provides cost estimates for noise control treatments
- Select noise control options using an ALARP process.

The following provides some examples of some simple fixes that could be used:

- Replace high noise equipment with low noise equipment (low noise fans, air diffusers, etc)
- Vibration isolate the equipment or receiver (ie accommodation building, or individual rooms within)
- Acoustically isolate the receiver (eg floating floor/walls/ceiling for affected spaces)
- Limit the use of the machinery to times which do not cause a major impact to the accommodation (eg weekly checks of firewater pumps, only operate during shift changes)
- Fit silencers to air intakes or exhausts of fans

ALARP

An ALARP assessment procedure provides a systematic approach for assessing noise control treatments. The ALARP process should be documented and should engage key stakeholders such as designers, operators, maintainers, HSE personnel, etc.

Noise management philosophy

A buy quiet policy will help to ensure that noise goals are achieved for accommodation areas. The policy should be applied during the design of new facilities as well as when buying new / replacement equipment for existing facilities.

3.4.2 Accommodation Construction Considerations

The way in which the accommodation is fixed on to or built into the facility significantly impacts the noise control considerations.

For mobile facilities the accommodation is an integrated part of the structure, ie it is built into the hull, or is rigidly attached to the deck of the super-structure, and hence vibration generated by the propulsion systems, power generation, winches, pumps, etc, on the facility can be transmitted to the accommodation area. The noise generated by the vibration transmitted to the accommodation area is termed "structure-borne noise". Essentially, large thin (lightly damped) surfaces such as walls, floors and ceilings can efficiently convert vibration into noise. Therefore any vibration passed into these elements can manifest itself as noise in rooms. Hence, structure-borne noise can be a significant contributor to accommodation noise levels if care is not taken in the vessel and accommodation fit-out design.

The major things that influence the level of structure-borne noise are:

- Vibration levels from plant and equipment;
- Inherent damping within the super structure of the facility which can attenuate vibration levels before they reach accommodation areas;
- Separation distance between vibration sources and accommodation areas; and
- The degree of vibration isolation of the accommodation from the supporting superstructure.

For fixed facilities in Australia, two types of accommodation construction are commonly encountered:

1) accommodation integrated into the superstructure for the facility; and

2) accommodation independently supported off the main structure.

For accommodation which is integrated into the facility's superstructure the considerations are the same as those for mobile facilities. For independently supported accommodation structures, there is opportunity to vibration isolate the complete accommodation structure from the main facility by seating it on vibration isolation mounts.

Vibration imparted to the facility structure by operating equipment

Many items of equipment located on a facility can generate vibration, and the level of vibration that they impart to the facility's structure will determine how much structure-borne noise is transmitted to receiving rooms within an accommodation area. Mechanical equipment (generators, pumps, winches, transformers, etc), piping, process equipment, and propulsion systems can be significant contributors. To reduce the vibration levels within the facility's structure, there are primarily two options: use equipment that generates low vibration levels, or vibration isolate equipment from the structure. The hierarchy of controls is firstly use low vibration generating equipment, and where this is not possible, or does not achieve low enough vibration levels, then vibration isolate the equipment.

In some cases there is the opportunity to use equipment which generates low vibration levels in preference to equipment that inherently generates high vibration levels, eg centrifugal versus reciprocating pumps, turbine generators versus diesel driven generators, etc.

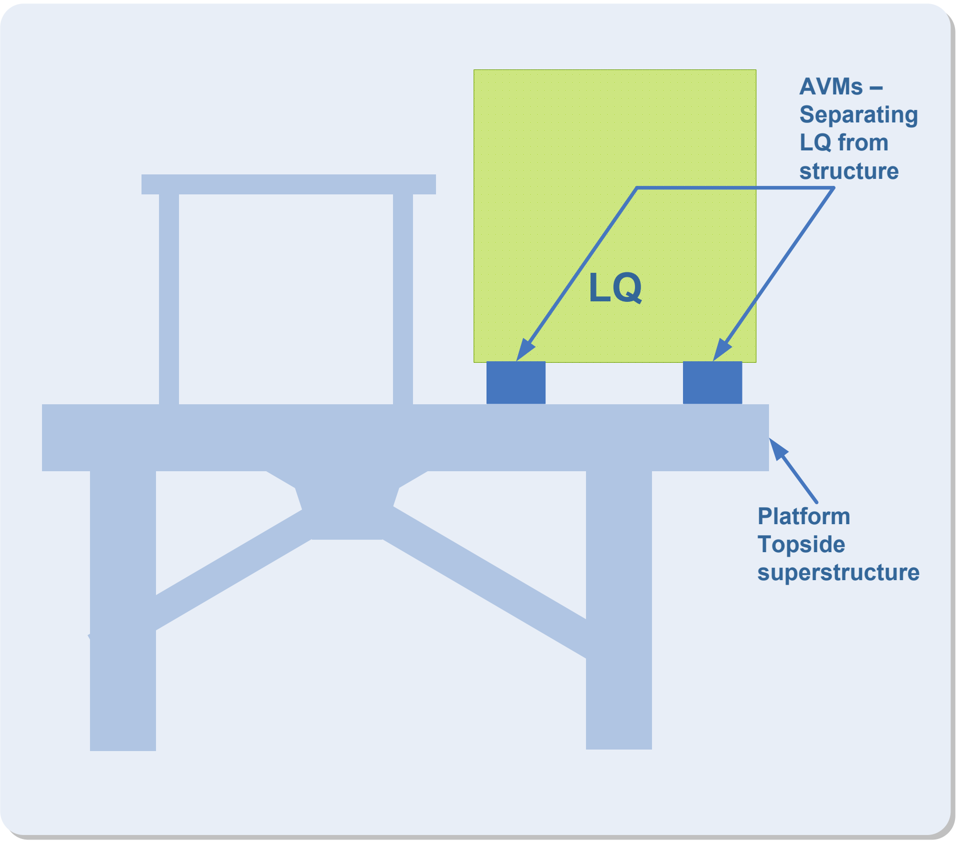
The vibration isolating of equipment from its supporting structure can also be very effective in reducing vibration imparted into accommodation areas. However, in some cases, because the equipment is physically supported by the superstructure of the facility, it is not always practicable to vibration isolate the equipment. In such cases there may be opportunities to reduce the vibration levels imparted to the structure by applying damping around the equipment, or the receiving areas. The effectiveness of this form of treatment is dependent on many factors such as the type of damping that can be practically employed, the distance and transmission path between the source of vibration and the receiver, the frequency characteristics of the vibration source, etc.

Transmission path from the vibrating equipment to receiver

Typically the closer the accommodation is to high vibrating equipment the more likely it is to be affected by structure-borne noise. Therefore, vibrating equipment should not be located directly above, below or adjacent to noise sensitive areas within the accommodation module unless it is vibration isolated.

If the accommodation is independently supported off the structure, it is good practice to have the connection points vibration isolated from the superstructure. This ensures that structure-borne noise from the superstructure is not passed through the connection points into the accommodation (see Figure 3-1). Vibration isolation should be provided at all connection points including interconnecting walkways, hand rails, cable trays, piping, etc.

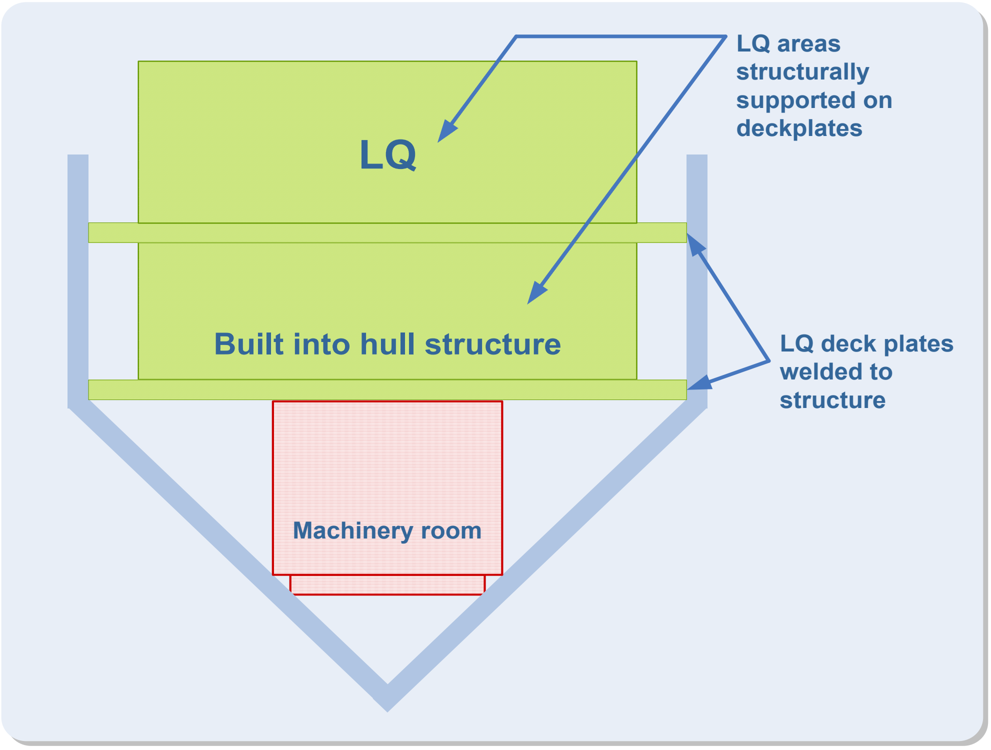
Figure 3-1 Vibration isolation living quarters (LQ) using anti-vibration mounts (AVM)



Accommodation fit-out

When accommodation is integrated into the facility's structure (see Figure 3-2), as may be the case with ship accommodation, then good practice is to ensure that the accommodation utilises a floating floor/walls/ceiling fit-out. Figure 3-3 in section 3.4.7 shows a typical floating floor/wall/ ceiling fit-out system. The selection of the fit-out system and attention to the installation details of the system are key to the system successfully attenuating structure-borne noise.

Figure 3-2 LQ integrated with the facility structure



3.4.3 Accommodation Layout Considerations For Noise

Appropriate layout of rooms within the accommodation can significantly impact on the "acoustic quality" of occupied spaces in the following way:

- Maintaining acoustic privacy;
- Prevention of noise intrusion from adjacent rooms; and
- Improving speech intelligibility.

The following presents some information on good acoustic practices that should be considered in new builds when locating rooms within the accommodation.

Table 3-5 Layout considerations with respect to internal functional layout considerations

Occupied space	Other occupied spaces that could cause impact	Considerations
Cabins	Cabins	• Ideally locate all cabins on the same level within the accommodation area. • If cabins are located above each other try to ensure adequate acoustic transmission loss through the floor and address footfall noise impacts.
Cabins	Ensuites	• Avoid having WC or Showers on the same walls as bed heads. • Where possible have a vestibule between the ensuite and cabin, particularly if multiple cabins are serviced by one ensuite. • Do not rigidly support hydraulic service runs off cabin wall's fit-out or supporting structure.
Cabins	Ablution rooms	• Do not locate ablution rooms directly above cabins. Preferably locate on separate level. • Avoid having common walls with cabins, unless using a high performing acoustic wall between cabins and ablutions room. • Do not rigidly support hydraulic service piping (pressurised water, grey water, etc) off cabin wall's fit-out or supporting structure.
Cabins	Service ducting rooms	• Do not locate adjacent to cabins, particularly if un-treated hydraulic services are located inside of ducting. • Do not rigidly support hydraulic service runs off cabin wall's fit-out or supporting structure.
Cabins	Corridors	• Avoid running major access corridors through cabin area. Ideally corridors should only service the cabins. • Avoid having corridors directly above cabins, preferably locate corridors above corridors.
Cabins	Exit and Entrance	• If the exit /entrance opens up on to a high noise area, then use a sound lock. • Use acoustically rated doors with appropriate door seals.
Cabins	Galley	• Ideally locate on separate floor. • Avoid having the galley directly above or below cabins. • Avoid having common walls with cabins, unless high performing acoustic walls between cabins and galley.

Occupied space	Other occupied spaces that could cause impact	Considerations
Cabins	Laundry/ Plant rooms	• Ideally locate on separate floors. • Avoid having laundry/plant rooms above or below cabins. • Do not locate laundry or plant room machinery against walls in common with cabins (ie washing machines, dryers, transformers, etc)
Cabins	Media rooms/ Recreation rooms/ offices/ Smoking Rooms/ wheel house/ control and operations rooms	• Ideally locate on separate floor. • Avoid having media room above or below cabins. • Avoid having those spaces above cabins. High footfall noise will impact cabins below. • Avoid having the doors of these rooms opening into cabin areas. • Avoid having common walls with cabins, unless high performing acoustic wall between cabins and rooms.
Cabins	Gymnasiums/ workshops	• Ideally locate on separate floor. • Avoid having gym/workshop above cabins. For gyms high footfall noise and impact noise may affect cabins below. For workshops, dropped objects, and working on objects seated on the floor can be significant noise sources. • Avoid having common walls with cabins, unless high performing acoustic wall between cabins and the room.
Media rooms	Plant rooms	• Locate media room away from plant room • Avoid having common walls with plant rooms, unless high performing acoustic wall between plant rooms and media room
Media rooms	Gymnasiums/ workshops	• Ideally locate on separate floor. • Avoid having above room otherwise; high footfall noise will impact room. • Avoid having common walls with room, unless high performing acoustic wall between media rooms and the gymnasiums/workshops.
Media rooms	Galley/ Recreation rooms/ Offices/ Smoking Rooms	• Ideally locate on separate floor. • Avoid having galley above media room, as high footfall noise will impact room. • Avoid having common walls with rooms, unless high performing acoustic wall between rooms and media room.

Bed arrangement within cabins

Good practice for minimising noise impacts in rooms would be to have beds within rooms arranged so that the bed is not adjacent to WCs in adjacent ensuites. Where reasonably practicable bed heads should not be located adjacent to high noise areas (eg walls in common with plant rooms, ensuites, toilets, hydraulic service ducts, etc) unless adequate acoustic isolation is provided.

Where vibration from the surrounding structure is high and a floating floor system is not employed or not working effectively, then seating the bed on vibration pads may assist in reducing vibration impacts.

Layout considerations with respect to external noise and vibration sources

Noise and vibration sources located outside of the accommodation area can significantly impact noise levels within it. In general terms the further that the accommodation is located away from high noise and vibrating equipment the lower will be the impacts from these sources. However, offshore facilities are very compact by the nature of their design so it is not always reasonably practicable to achieve sufficient distance between the accommodation and high noise and vibration equipment.

There are some simple rules which will help reduce the noise and vibration impacts:

- Locate high noise and vibration equipment as far away from the accommodation as possible;
- Use low noise and vibration generating equipment (seek to substitute high with low noise and vibration generating equipment);
- Use sound locks to keep high external noise levels out of the accommodation area;
- Reduce physical connections between the accommodation external walls and the facility super structure, so that structure borne noise is not readily transmitted to the accommodation structure; and
- Ideally do not locate the accommodation adjacent or directly below the helideck. If this is the case (as in many offshore facilities) minimise sleep disturbance to personnel in affected cabins by only using these cabins for day shift.

Considerations for minimising noise impacts within accommodation areas of mobile facilities (which typically have the accommodation unit as an integrated part of the structure) are:

- Avoid locating rooms with low noise limits above, below or against common walls (or bulkheads) with machinery spaces;
- Avoid locating low noise rooms (cabins) close to (immediately above or adjacent to) bow thrusters and propulsion systems;
- Avoid locating winches and windlasses above or adjacent to low noise rooms; and
- Avoid locating wheel houses and control rooms over cabins.

3.4.4 HVAC Considerations

If external noise sources have been appropriately controlled, the dominant noise sources in many rooms may be noise from the Heating, Ventilation and Air Conditioning (HVAC) systems. HVAC systems include noise sources inherent to their functionality, such as:

- Noise generated by the air handling unit’s fan which is transmitted within the ducting (both supply air and return air);
- Noise generated from the air flow through and over components within the ducting (bends within the ducting system, constant volume boxes, etc); and
- Noise generated from the air flow through the diffuser at the air outlet terminal.

Noise generated from the air flow can be significantly influenced by the overall layout of the system and the selection of components.

Noise generators in any HVAC system include:

- Fans either as sole components or part of the Air Handling Unit (AHU), which pushes or pulls the air through the system;
- The chillers which supplies cooling fluid to the AHU, and uses a vapour-compression refrigeration cycle (noise sources include the compressor and cooling fans of the chillers);
- Air flow through the duct – the noise generation is velocity related (the higher the velocity the more noise that is generated);
- Flow discontinuities or turbulence at changes of direction, duct take-offs or over objects such as dampers or sensors inserted in the flow;
- The response of the duct wall to flow disturbances; and
- Air flow through the grilles / terminals / diffusers in the room.

The generated noise can be delivered to the room through several mechanisms:

- Through the duct at the terminal in the room;
- Noise within the duct passes through the duct wall and then radiates into the rooms below; and,
- As regenerated noise due to vibration passed into other elements in the room from the ducting, such as the ceiling, light fittings etc.

Methods to reduce and control noise generated in HVAC systems include:

- Selection of low-noise fans;
- In-line silencers at the AHU;
- Duct silencers or duct internal lining;
- Reduced / controlled duct air velocity;
- Separation of branches/ bends etc to minimise flow disturbance;
- Use of flow guides in bends / tees;
- Selection of low noise sensors / CVs / Diffusers / terminal boxes etc;

- Control of duct breakout using duct wall thickness or external insulation; and,
- Vibration isolation of the ducting.

It is important to recognise that the above considerations should be included for not only the supply air system, but also the return air system and any extract systems such as toilet / laundry / galley / medical centre extracts which may be isolated from the main system.

HVAC systems can negatively impact acoustical privacy in two ways:

- Cross-talk, where noise is transmitted through the ducting from one room to another; and
- Through door grilles designed to allow the flow of air from the room to the corridor or ablutions.

Generally accommodation areas in both mobile and fixed offshore accommodation areas are very compact in layout and design, with space in ceiling voids and service shafts where HVAC ducting is housed being very limited or congested. Therefore, careful design is extremely important because any modifications or rectification work to reduce noise from the HVAC can be difficult to implement.

For new designs

For onshore projects the opportunity to alter the layout of the HVAC system may still exist late in the design or even during the construction phase, however, often in offshore applications this opportunity does not exist. It is therefore important that the HVAC ducting system and layout is reviewed from an acoustical perspective by an appropriately qualified acoustics engineer early enough in the design that issues can be identified and all potential remedies investigated.

For existing facilities

For an existing facility with high HVAC noise, an engineering noise control study can assist in identifying mitigation work that may be possible to undertake. The assessment should be done by an appropriately qualified acoustics engineer who should identify:

- The sources of the high noise observed from the system;
- Noise control options for reducing noise; and
- The practicality of undertaking the mitigation work.

3.4.5 Mechanical Equipment Considerations Within Accommodation

With so much focus on the large external noise sources that are common in the offshore industry, it is often easy to miss incorporating or reviewing noise control requirements and consideration of equipment located within the accommodation. However, because of their very location, such equipment can lead to higher noise levels in accommodation areas than would otherwise be desired if care is not taken. Control of noise and vibration from mechanical equipment located within the accommodation is important in achieving noise levels that are ALARP.

Perhaps fortunately, many construction contractors have some understanding of these issues and their control mechanisms, and try to mitigate the problems during commissioning. However, as for all noise issues, retrospective rectification of any such issues can be expensive, and therefore due attention to noise control during the design stage is recommended.

Typical mechanical equipment located in the accommodation area that may give rise to noise impacts within the accommodation includes:

- Main HVAC Chillers;
- HVAC Booster Fans;
- Dedicated extract fans for medical facilities/ sick bay, galley, laundry, ablutions, workshops, laboratory, electrical rooms;
- Extract fans and chillers for dry stores, cool room and freezer;
- Laundry equipment including washers and dryers;
- Galley equipment including dish-washers;
- Workshop equipment eg grinders, breathing air compressor etc;
- Lift/elevator driver;
- Seawater / booster pumps for potable water, grey water etc;
- Transformers; and
- Speakers in theatre / media rooms.

Noise impact from mechanical equipment located in the living quarters arise from two potential paths: airborne noise, and structure-borne noise. For consideration of the control of airborne noise the following actions should be considered:

- Separation of the equipment and sensitive areas (this is also addressed in section 3.4.3 above);
- Selection of low noise equipment during design;
- Acoustic treatments to the walls and ceilings of plant rooms, to increase the acoustic absorption within the plant room and hence reduce the "build-up" of reverberant noise; and
- Improve the acoustic partitions around rooms containing noise producing equipment, ie increased acoustic performance of walls, ceiling and floor.

Structure-borne noise from the mechanical equipment within the accommodation area can also significantly contribute to noise levels (see Section 3.4.2). Structure-borne noise is best and most efficiently controlled by vibration isolation at the source. All of the equipment identified above should be considered for vibration isolation – and isolation only discarded if detailed analysis demonstrates it is not necessary. See Section 3.4.6 for details on the AVM systems.

Piping

In any accommodation building, piping carries pressurised water to the accommodation and grey and black water away from these areas (hydraulic services piping). Sometimes it is not appropriate to use flexible piping in these systems. Additionally, noise can be generated in these systems by pulsation (often called "water hammer" as a result of a fast acting valve opening or closing) or by flow conditions such as high flow rates or turbulence.

Piping is normally mounted on the service shaft riser walls and on the underside of the floor above, or on adjacent bulkhead. These locations may be the wall or ceiling or floor of an accommodation space, and therefore the issue of structure borne noise from the piping arises. It is considered good practice to include vibration isolation of all pressurised water systems from the surrounding structure to prevent structure-borne noise transmission.

For unpressurised systems such as grey and black water the noise generation is limited to flow related issues. These can still pose a problem however as these systems are commonly GRF (fibreglass) piping, which is a much poorer insulator of sound that steel piping. Good practice is to avoid running this piping in the ceiling space above accommodation areas; however, a combination of acoustic insulation and vibration isolating the piping is an alternative noise control option which can be very effective when implemented correctly.

3.4.6 Vibration Isolation Of Equipment

Good practice is for all mechanical equipment, including hydraulic systems located within or close to the accommodation to be vibration isolated from its supporting structure. The vibration isolation should include vibration isolating all connecting piping (eg suction and discharge piping from pumps, chilled water for refrigeration chillers, etc).

Piping and ducting which passes through or are supported by the accommodation should also be vibration isolated, eg exhaust ducting, process lines, hydraulic hoses, plumbing, fresh and seawater piping, etc.

The following is a list of typical equipment found within the accommodation area that would be expected to be vibration isolated:

- Pumps;
- Chillers;
- AHU;
- Macerators;
- Washing machines;
- Dryers; and
- Extraction fans.

Typical vibration isolation mounts use on mechanical equipment

The vibration isolation is achieved by seating equipment on anti-vibration mounts (AVMs), with the mount stiffness selected so as to adequately attenuate the principal vibration generated by the equipment. AVMs come in many different types and forms but are typically either based on rubber, springs, or a combination of rubber and springs.

There are a large number of anti-vibration mounts on the market, but they come in essentially two forms – springs and dampers or absorptive mounts (usually a rubber compound). Each has its advantages and disadvantages. The correct selection of AVM's is not simple – for example if the resonant frequency of the mounting, or the mounted equipment matches an operation frequency of the equipment being isolated, the vibration problem will become considerably worse. However, typically the equipment vendor should be able to provide appropriate vibration isolators for the equipment under consideration. If not, specialist advice should be sought.

When implementing vibration isolation of equipment it is important to recognise secondary vibration paths from the equipment to the structure. Piping, instrument and electrical connections can all "short-circuit" the vibration isolation if not considered during the design. Use of flexible piping and electrical connections to washers, pumps, transformers etc is a good way to avoid these issues.

For mounts to be effective they must not be over compressed. The performance of vibration isolation mounts can be significantly reduced, sometimes to the point of not isolating at all, if the mounts are over compressed. Over compression can arise when the mounts are not selected properly, or additional loading is placed on the mounts to that which it was originally designed to meet, or the mount has failed (eg rubber material can become harden with time, or the rubber can deteriorate due to oil, etc). Hence AVMs should be checked over on a regular basis to ensure they function as required.

Vibration isolation of connected piping

There are primarily two options for vibration isolating piping, the first is to place a flexible spool piece between the machine and pipe, and the second is to vibration isolate the pipe from the structure.

Short circuiting of the vibration isolation system

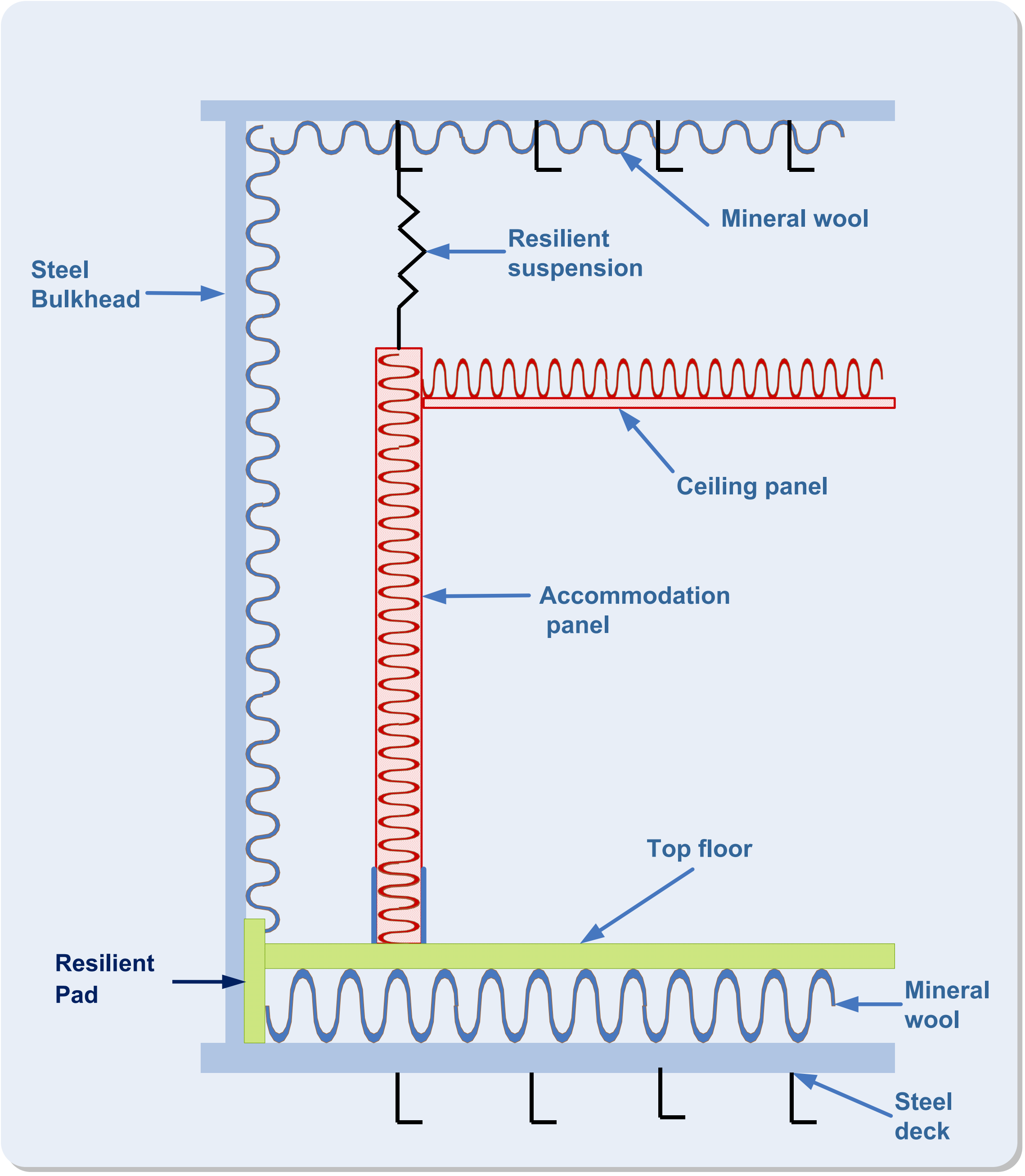
The vibration isolation system used to isolate the equipment can easily be compromised if there are hard connections between the vibrating item and its supports (eg pump casing touching adjacent wall/supports/etc).

3.4.7 Floating Fit-out Considerations

As highlighted in section 3.4.2 floating fit-outs are commonly used in offshore facilities to reduce the structure-borne noise impacts from external and internal noise and vibration sources. Figure 3-3 shows a typical floating floor/wall/ ceiling fit-out system. The fit-out isolates the occupant of the room from the surrounding structure by effectively building a room within a room.

However, the ability of the fit-out system to isolate the occupant from noise and vibration (particularly structure-borne noise) can be severely compromised if care is not taken in the design of the system, and during the construction and maintenance of the system. An acoustic specialist should be used to assess the design, inspect the installation during construction, and review any modifications that may be made during operation if there is any doubt on the performance of the proposed system.

Figure 3-3 Typical LQ floating floor/wall/ceiling fit-out



3.4.8 Location Of Temporary Or Portable Equipment On Deck

The location of temporary or portable equipment close to an accommodation area has the potential to significantly impact noise levels within the area. When undertaking the logistics for the portable or temporary equipment design/procurement/installation expected noise emission and likely level of vibration generated by the equipment should be considered and mitigated as required. Typically rotating equipment like generators, compressors, pumps, etc may require the skid (along with any associated piping) of the package to be vibration isolated from the supporting deck. If the equipment noise levels are high then the use of an acoustic enclosure over the package may be required. For equipment powered by diesel engines vibration isolation and suitable acoustic enclosures should be considered for the package.

3.5 Relevant References

1) AMSA, Marine Orders 14 – Accommodation

2) AS 2254:1988 Acoustics – Recommended Noise Levels for Various Areas of Occupancy in Vessels and Offshore Mobile Platforms

3) AS 1948:1987 Acoustics—Measurement of Airborne Noise on Board Vessels and Offshore Platforms

4) NORSOK S-002 Working Environment (Edition 4, Aug 2004)

5) NORSOK C-001 Living Quarters Area (Edition 3, May 2006)

6) UK H&SE – Operations Notice 82 (April 2010) – Guidance for the provision of accommodation offshore

7) World Health Organisation

8) AS 2107 – Recommended design sound levels and reverberation times for building interiors

9) ABS Crew habitability on offshore installations May 2002

10) ABS Crew habitability on Ships 2001

11) DNV Comfort Class Rules for classification.

12) IMO Resolution A.468(XII) Code on Noise Levels on Board Ships 1981

13) Building Code of Australia

14) Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) - Duct Work for Air Conditioning Application Manual, 1987

15) BS 8233:1999 - Sound insulation and noise reduction for buildings - Code of practice

16) ISO 15138:2007 - Petroleum and natural gas industries - Offshore production installations - Heating, ventilation and air-conditioning

4. WHOLE BODY VIBRATION

4.1 Background

Nearly all offshore oil and gas facilities have equipment and processes on board which generate vibration, and depending on how well it is isolated from the supporting structure, vibration will be transmitted to the surrounding structure, and in turn to the accommodation area of the facility. The level of deck vibration within the accommodation has the following impacts on personnel:

- Not perceivable;
- Perceivable but does not cause annoyance;
- High enough in level to cause annoyance or discomfort and hence reduce the amenity of the accommodation; and
- Sufficiently high enough in level so that it can directly degrade performance and health.

Generally the vibration generated within offshore facilities is steady in characteristics (ie the steady vibration generated by motors, pumps, generators); however, there are some activities which can result in single-impulse shock loads (tripping of drilling strings, crane usage, etc).

Mobile facilities and some fixed facilities can also be impacted by the sea state, which results in the facility being oscillated at very low frequency. It is recognised that this form of oscillation may result in motion sickness, body instability, fatigue and increased health risk aggravated by shock loads. However, vibratory motion produced by sea states, which is generally below 1 Hz in frequency content, is not considered in this report.

Vibration originating within facilities due to the operation of machinery or processing equipment which can impact the amenity, comfort ("comfort" means the ability of the crew to use a space for its intended purpose with minimal interference or annoyance from vibration), and possibly resulting in degraded performance and health of personnel within the accommodation facility is between the 1 Hz and 80 Hz in frequency content.

4.2 Relevant Standards

There is currently no prescriptive legislation within Australia relating to whole body vibration. Comcare (the agency responsible for workplace safety, rehabilitation and compensation in the Australian Commonwealth Government) have prepared the OHS Code of Practice 2008 which provides practical guidance with regard to human vibration in the workplace. However, this code of practice does not address whole body vibration in relation to comfort and amenity.

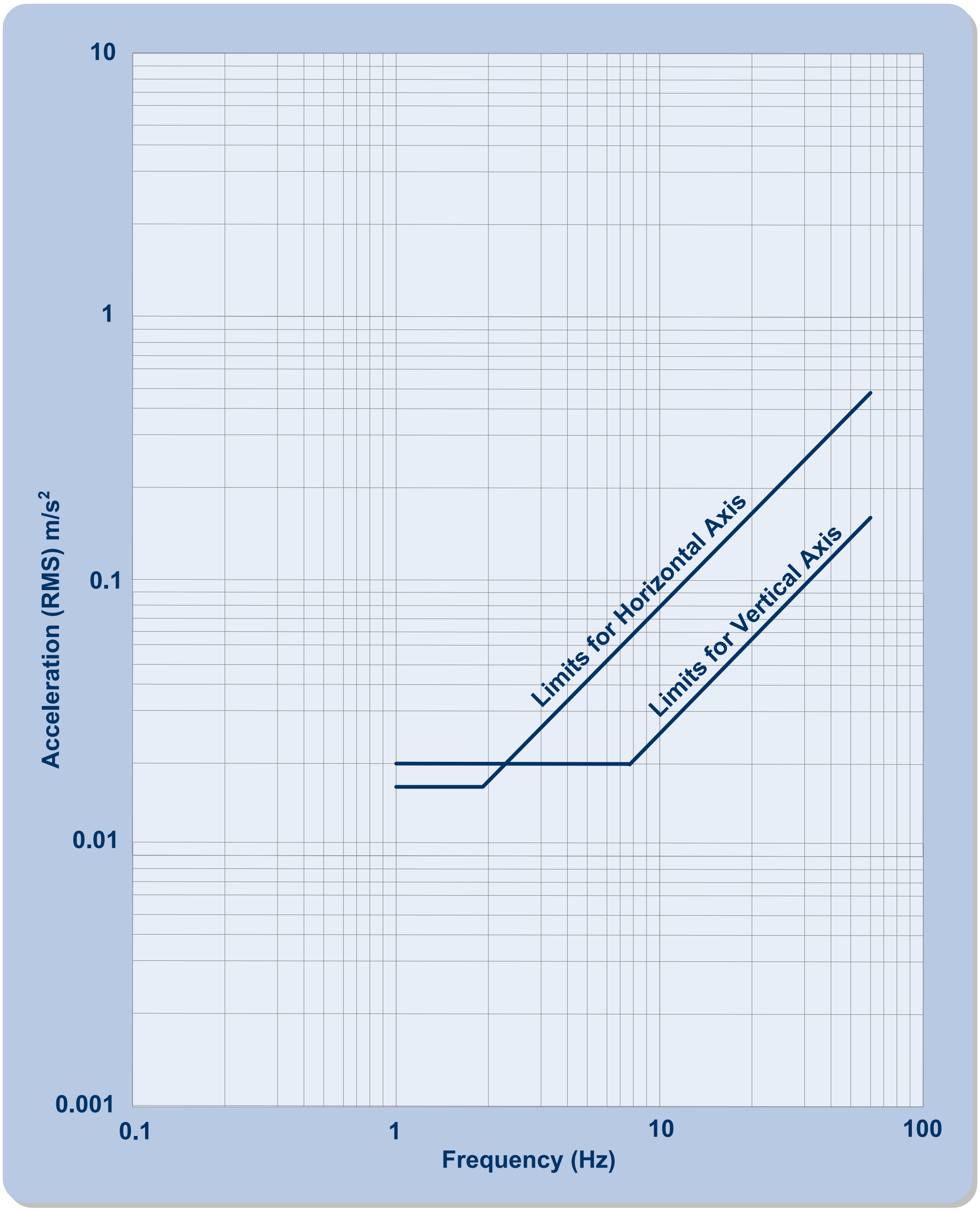
There are several national and international standards relating to whole body vibration (Ref 1 to 6). Although some of these standards provide tentative guidance on the magnitude of vibration at which adverse comment may begin to arise, acceptable magnitudes of vibration are not stated.

In 2001 the UK Health and Safety Executive (UK H&SE) published an offshore technology report entitled "Noise and Vibration". This document suggested vibration limits for sleeping, recreation and similar areas derived from BS 6841, where the vibration levels recommended are just detectable (ie Category V).

4.3 Goals

Figure 4-1 presents the recommended vibration levels that should be considered for the whole body vibration within accommodation areas for both fixed and mobile facilities in the horizontal and vertical direction. The vibration levels are given as RMS acceleration levels in m/s^2. The information is consistent with the category V recommended levels (for sleeping, recreation and similar areas in living accommodation) from the UK H&SE Noise and Vibration Technology Report 2001/068; the vibration limits presented are just perceivable.

Figure 4-1 : Recommended vibration limits for offshore facilities: 'horizontal' and 'vertical' axes



No vibration levels are given for frequencies below 1Hz, or for those above 80Hz. The whole body response to vibration below 1Hz in frequency is generally perceived as motion sickness, and for frequencies above 80 Hz there is no evidence of significant impact upon the body. Quantitative assessment of sea-sickness would depend upon anticipated sea-states and minimum crewing requirements, and are outside the scope of this document. Qualitative (layout) measures to minimise the incidence of sea-sickness are encompassed the recommendations in Chapter 2 of this technical report.

4.4 Information For Achieving Goals

To ensure that vibration levels are acceptable within accommodation on offshore facilities the following general practices should be followed:

1) Use low vibration generating equipment;

2) Vibration isolate vibrating equipment from the accommodation, and/or from the superstructure of the offshore facility;

3) Avoid structural resonances of decks with vibration excitation sources within the facility;

4) Ensure all equipment is in proper working order, aligned and balanced; and

5) Utilise floating floor constructions for manned areas within the accommodation where there is the potential for high vibration on the facilities.

A review of items 1 to 4 indicate that the potential sources of exposure to whole body vibration are essentially the same as the sources of exposure to noise with a few additional requirements. Consequently, many of the mitigation measures for minimising whole body vibration are the same as those described for controlling structure-borne noise in section 3.4.

4.5 Relevant References

1) AS2670.1-2001 "Evaluation of human exposure to whole body vibration – general requirements

2) AS2670.2- 1990 "Evaluation of human exposure to whole-body vibration - Continuous and shock-induced vibration in buildings (1 to 80 Hz)–

3) ISO 2631-1:1997 "Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration - Part 1: General requirements

4) ISO 2631-2:2003 "Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration - Part 2: Vibration in buildings (1 Hz to 80 Hz)

5) BS6841 "Guide to measurement and evaluation of human exposure to whole-body mechanical vibration and repeated shock

5. LIGHTING

5.1 Background

Adequate lighting is essential for safe and efficient access and egress, and for task performance. Task performance is strongly related to illumination levels. If lighting is inadequate, tasks may take longer to complete and the likelihood of errors is increased.

Lighting also plays an integral part in creating an appropriate visual environment and can be used to enhance the overall environment in offshore accommodation. The contribution that factors such as aesthetics, colour, and the psychological effects of lighting can make to the overall visual environment and to personnel comfort, satisfaction, and wellbeing should not be discounted - particularly in the living areas of offshore accommodation.

In addition to illuminance levels, many external factors influence the visibility of an object within the visual field. The study and application of lighting design is a hugely complex area.

5.2 Goals

The goals of lighting provision within the facility's accommodation spaces are to:

- Facilitate visual task performance;
- Allow for safe movement of personnel; and,
- Aid in the creation of an appropriate visual environment.

5.3 Scope

The scope of this section is limited to the design of artificial lighting for the rest, restitution, and recreation areas of a facilities accommodation spaces.

The information contained in this section is offered to assist facility operators with identifying areas where practical improvements to the overall visual environment may be achievable.

5.4 Lighting Design Requirements

Lighting within a facility's accommodation should ensure adequate visibility of corridors and access ways; stairways; floor level and/or surface changes; fixtures and furnishings; signage; equipment and the required tasks, night and day, during normal and abnormal operating conditions.

In addition to providing required illumination levels, lighting design should be aimed at achieving:

- Control of shadowing;
- Elimination of both direct and reflective glare;
- Good task specific visibility within the overall visual environment;
- Legibility of essential information including signage and notice boards;
- Safe and easy maintainability of light fittings;

- Maintainability of other equipment within the accommodation without disconnection and removal of light fittings or cabling;
- Flexibility to adapt the lighting for specified activities in multipurpose areas; and
- An appropriate visual environment that contributes to the safety, health, comfort and wellbeing of the personnel on board.

Emergency and back up lighting should be provided for all locations essential for safe evacuation of the area and accommodation.

Safety equipment, including safety signage, should be adequately illuminated and identified so as to be easily locatable in all conditions.

5.5 Recommended Illuminance Levels

It is emphasised that any information on recommended illuminance levels only presents a vastly oversimplified summary of lighting design requirements. Reference to the standards listed in Section 5.6 is essential. AS/NZS 1680 Series provides the most comprehensive information on lighting and reference to this Standard is recommended to supplement the older and less comprehensive information given in ABS and AS1150 [Refs. 1, 2 & 4].

The choice of an appropriate apparent colour of light source for a room is an important aspect of lighting design and is largely determined by the function of the room. This may involve such psychological aspects of colour as the impression given of warmth, relation, clarity, etc., and other considerations such as the need to have a colour appearance compatible with daylight and yet to provide a white colour at night. For rooms lit to a maintained illuminance of 240 lx or less, a warm or intermediate colour is preferred (<3300 degrees K for warm, or no greater than 5300 degrees K for intermediate); cool apparent colour lamps tend to give rooms a gloomy appearance at such illuminances. Lamps of different correlated colour temperature should not be used in the same room unless a specific effect is desired [Ref. 3].

5.6 REFERENCES

1) ABS Guide for Crew Habitability on Offshore Installations 2002

2) ABS Guide for Crew Habitability on Ships 2001

3) AS 1680 Series Interior Lighting

Part 0 – 2009 Safe Movement

Part 1 – 2006 General Principles and Recommendations

Part 2.0 – 1990 Recommendations for Specific Tasks and Interiors (superseded)

Part 2.1 – 2008 Circulation spaces and other general areas

Part 2.2 – 2008 Office and screen based tasks

Part 2.4 – 1997 Industrial Tasks & Processes

4) AS 1150 1983 Artificial Illumination in Ships

5) NORSOK Standard S-002 2004 Working Environment

6. AIR QUALITY

6.1 Background

Personnel may spend in excess of 12 hours per day in offshore accommodation and poor indoor air quality has the potential to result in significant adverse impacts on health as well as comfort.

6.2 Relevant Legislation and Standards

Schedule 3 of the OPGGSA imposes the duty for the operator to take all reasonably practicable steps to ensure the facility and its activities are safe and without risk to health.

Currently, there are no Australian standards or guidelines for indoor air quality. The National Health and Medical Research Council did publish "Ambient Air Quality Goals and Interim National Indoor Air Quality Goals" but this publication was rescinded on 19 March 2002. However, the National Environment Protection Council (NEPC) has published national ambient air quality standards for six key air pollutants: carbon monoxide, ozone, sulphur dioxide, nitrogen dioxide, lead and particles. The standards, which are set out below, apply to ambient air, not indoor air but nonetheless may be regarded as appropriate standards for indoor air quality. Supplement 1 to AS 1668.2 - The Use of Ventilation and Air-Conditioning in Buildings Part 2: Ventilation Design for Indoor Air Contaminant Control (excluding requirements for the health aspects of tobacco smoke exposure) uses these levels as the values for maximum acceptable concentrations of contaminants in outdoor air.

Table 6-1: National ambient air quality standards

Contaminant	Exposure time	Exposure limit	Condition
Carbon monoxide (CO)	8 hours	9.0 ppm	1 day a year
Nitrogen dioxide (NO2)	1 hour	0.12 ppm	1 day a year
	1 year	0.03 ppm	None
Photochemical oxidants (as ozone)	1 hour	0.10 ppm	1 day a year
	4 hours	0.08 ppm	1 day a year
Sulphur dioxide (SO2)	1 hour	0.20 ppm	1 day a year
	1 day	0.08 ppm	1 day a year
	1 year	0.02 ppm	None
Lead (Pb)	1 year	0.50 $\mu g/m^3$	None
Particles as PM10	1 day	50.0 $\mu g/m^3$	5 days a year
LEGEND: ppm = parts per million by volume $\mu g/m^3$ = micrograms per cubic metre			

The Building Code of Australia requires that all occupied rooms have 'adequate flow-through or cross-ventilation and air quality'. This must be provided by natural ventilation from permanent, openable windows, doors or other devices with an aggregate openable size of not less than 5% of the floor area of the room to be ventilated, or a mechanical ventilation system conforming to AS 1668.2 2002 - The Use of Ventilation and Air-Conditioning in Buildings Part 2: Ventilation Design for Indoor Air Contaminant Control (excluding requirements for the health aspects of tobacco smoke exposure) and AS/NZS 3666 2002 Air-Handling and Water Systems of Buildings – Microbial Control

AS 1668.2:2002 sets minimum requirements for preventing an excess accumulation of airborne contaminants, or objectionable odours. These minima are based on needs to control body odour, food odour, air contaminants, or carbon dioxide concentrations. The ventilation rate is designed to maintain levels of indoor carbon dioxide exhaled by occupants below 1000 ppm. This carbon dioxide level is used as a surrogate for body odours unacceptable to 20% of visitors entering an occupied space. It is recognised that odours from other sources (eg environmental tobacco smoke) require greater ventilation rates.

The Safe Work Australia (formerly ASCC, formerly NOHSC) Guidance Note on the Elimination of Environmental Tobacco Smoke in the Workplace [NOHSC:3019(2003)] states that given the health risks of environmental tobacco smoke, all Australian workplaces should be made completely smoke-free as soon as possible, ie, environmental tobacco smoke should be excluded.

AS1668.2-2002 does not prescribe other requirements associated with comfort, such as temperature or relative humidity but there are a number of sources of recommendations for these parameters as shown below.

Table 6-2: Sources of recommendations for temperature and relative humidity

Source	Temperature	Relative Humidity
American Bureau of Shipping Guide for Crew Habitability on Offshore Installations 2002 Guide for Crew Habitability on Ships 2001	Non-adjustable air temperature of 22°C +/-1°C Adjustable range of air temperatures between 18°C and 26.5°C	30% - 70%
ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy	19.5°C - 26°C	15% - <60%
ISO 15138: 2000 Petroleum and natural gas industries – Offshore production installations – Heating, Ventilation and Air-Conditioning.	19°C - 24°C	30% - 70%

6.3 Goals

The goal for indoor air quality in offshore accommodation is to provide air which is free from harmful contaminants and which contributes to a comfortable living environment in terms of temperature, humidity and air movement.

Since exposure to environmental tobacco smoke (ETS) is a recognised health hazard, the goal is no smoking within offshore accommodation. However, where smoking within offshore accommodation is permitted by the facility operator and adequate provision is made for it, then the goal is that smoking is confined to designated smoking areas, which are separated from other areas by partitions and doors. Air from air conditioned spaces, which are the source of cigarette smoke, should be exhausted to atmosphere and it should not be possible for smoke to enter common areas, sleeping accommodation or areas where food and drink are served or consumed.

6.4 Information for Achieving Goals

Dilution ventilation is widely used to address indoor air quality by maintaining occupant comfort and controlling odours associated with human bio-effluents. Conventional heating, ventilation and air-conditioning systems are designed as dilution or mixing ventilation systems. Conditioned air is supplied to indoor spaces and mixes with room air. This provides a uniform temperature throughout the room and addresses other comfort requirements. Exhaust air is then returned to the air-conditioning plant for re-cooling and mixing with approximately 10–30% fresh outdoor air to dilute polluted air from the space. In this way, pollutants may be circulated through the space many times and for that reason it is essential that contaminants generated inside the offshore accommodation are captured and exhausted and that air intakes are located to avoid cross-contamination from:

- Exhausts from fuel-burning equipment;
- Lubricating oil vents, drain vents and process reliefs;
- Dust discharge from drilling dry powders;
- Helicopter engine exhaust;
- Flares;
- Other ventilation systems;
- Temporary equipment; and
- Supply and support vessels.

As noted above, preference should be given to the prohibition of smoking within offshore accommodation to eliminate potential for exposure to environmental tobacco smoke (ETS). However, if this is not practicable, then designated smoking enclosures are an effective ventilation approach to reducing ETS levels generally. Whilst exposure within designated smoking enclosures may be higher, properly designed designated smoking enclosures will assist in eliminating the exposure of personnel outside the smoking enclosure to ETS contaminants. Designated smoking enclosures need to be well sealed and the use of automatic door closers should be considered.

Designated smoking enclosures should be independently ventilated. Air should be exhausted with no recirculation to other areas. Ideally, designated smoking enclosures should be placed under a negative pressure with respect to other areas, or airlocks should be provided to prevent cross-contamination of air. Make-up air for designated smoking enclosures may be drawn from the non-smoking areas or can be independently supplied. Ventilation rates should be appropriate to the level of use (and contaminant generation) of the enclosure.

The ventilation system should provide a positive airflow from non-smoking areas towards smoking enclosures. The required outdoor airflow for the non-smoking areas and the smoking enclosure should be supplied to the enclosure through outlets located in the non-smoking areas. This provides dilution ventilation for smoking enclosures by means of transfer air from non-smoking areas. The exception to this is if it would result in a velocity of airflow through the non-smoking area in excess of 0.35 m/s, In that case, part of the required outdoor airflow may be supplied though outlets in the smoking enclosure but the location and type of supply air outlets should be such that they do not cause air to circulate from smoking enclosures to non-smoking areas. Air from the smoking enclosures should not be recycled to air outlets supplying air to non-smoking areas.

Operators should periodically undertake an engineering program to assess the effectiveness of HVAC systems, to ensure that air conditioning and ventilation capabilities of the HVAC plant still meet the stated goals, particularly in existing facilities. Many older facilities have significantly increased the "heat load" on their HVAC system. The addition of electronic equipment and additional pressurised areas without upgrading HVAC capability, over time, may reduce the effectiveness of HVAC plants in achieving the stated goals.

6.5 References

1) ABS Guide for Crew Habitability on Offshore Installations 2002

2) ABS Guide for Crew Habitability on Ships 2001

3) ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy

4) Australian Maritime Safety Authority, Marine Orders 14 – Accommodation.

5) Australian / New Zealand Standard 3666:2002 Air-Handling and Water Systems of Buildings

6) Australian Standard 1668:2002 The Use of Ventilation and Air-conditioning in Buildings

7) Australian Standard 1921:1976 Air Conditioning and Ventilation in Ships, Cabins and Living Spaces of Merchant Ships

8) ISO 7730, 1994, Moderate Thermal Environments – Determination of the PMV and PPD Indices and Specification of the Conditions of Thermal Comfort.

9) ISO 15138: 2000 Petroleum and natural gas industries – Offshore production installations – Heating, Ventilation and Air-Conditioning.