FUNCTION 3: MAINTENANCE AND REPAIR AT THE MANAGEMENT LEVEL

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of Required performance
Competence: **3.1 MANAGE SAFE AND EFFECTIVE MAINTENANCE AND REPAIR PROCEDURES**		
3.1.1 MARINE ENGINEERING PRACTICE Theoretical Knowledge **1.** Planned maintenance system as per ISM code	5	
3.1.2 MANAGE SAFE AND EFFECTIVE MAINTENANCE AND REPAIR PROCEDURES Practical Knowledge **1.** Manage safe and effective maintenance and repair procedures relevant to 3..1.1	10	
3.1.3 PLANNING MAINTENANACE, INCLUDING STATUTORY AND CLASS VERIFICATIONS Practical Knowledge **i.** Planning maintenance, including statutory and class verifications relevant to 3.1.1	5	
3.1.4 PLANNING REPAIRS Practical Knowledge **1.** Planning repairs relevant to 3.1.1	5	25
3.2 DETECT AND IDENTIFY THE CAUSE OF MACHINERY MALFUNCTIONS AND CORRECT FAULS		
Practical Knowledge 3.2.1 DETENTION OF MACHINERY MALFUNCTIONS, LOCATION OF FAULTS AND ACTION TO PREVENT DAMAGE **1.** Unplanned maintenance	5	
3.2.2 INSPECTION AND ADJUSTMENT OF EQUIPMENT **1.** Inspection and adjustment of equipment relevant to 3.1.1	5	

3.2.3 NON-DESTRUCTIVE EXAMINATION **1.** Different types of non-destructive examination	10	20
3.3 ENSURE SAFE WORKING PRACTICES		
Practical Knowledge 3.3.1 SAFE WORKING PRACTICES **1.** Risk assessment **2.** Safety officials **3.** Personal protective equipment **4.** Work equipment **5.** Safety induction **6.** Fire precautions **7.** Emergency procedures **8.** Safe move **9.** Safety system of works **10.** Entering enclosed or confined spaces **11.** Permit to work systems **12.** Manual handling **13.** Use of work equipment **14.** Lifting plant **15.** Maintenance of machineries **16.** Hot work **17.** Painting **18.** Hazardous substances **19.** Noise and vibrations	 1 1 1 1 1 1 1 1 1 2 2 1 1 1 1 1 1 1 1	 21
Total for Function 3: Maintenance and Repair at the Management Level		**66 hours**

3.1 MANAGE SAFE AND EFFECTIVE MAINTENANCE AND REPAIR PROCEDURES

3.1.1 MARINE ENGINEERING PRACTICE.
Theoretical knowledge.

3.1.1.1 Planned Maintenance system (PMS) as per ISM Code

The PMS - Planned Maintenance System is a paper/software-based system which allows ship owners or operators to carry out maintenance in intervals according to manufacturers and class/Classification society requirements. The maintenance, primarily supervised by the on board personnel, is then credited towards inspections required by periodic surveys. The planning and scheduling of the maintenance, as well as its documentation, must be made according to a system that is approved by classification societies like American Bureau of Shipping, Germanischer Lloyd, Lloyd's Register, Bureau Veritas or Det Norske Veritas, etc. All these classification societies are members of IACS (International Association Of Classification Societies Ltd). Having a planned maintenance system on ships is now mandatory as per ISM (International Safety Management Code).

Objective of PMS are

- Equipment covered under PMS
- Critical equipment
- Preparation of vessel specific PMS
- Maintenance schedule and job procedures
- Updating of maintenance schedule
- Spare parts inventory
- Recording of defects

Every Vessel must have a Vessel Specific Planned Maintenance System – PMS. The primary objective of the PMS is to improve the effectiveness of maintenance and ensure that machinery and equipment function in a safe, reliable and efficient manner.

The PMS, preferably computerized, should consist of:

- Maintenance Schedules
- Spare Part Inventory
- Records of defects and breakdowns of the machinery and equipment.

The Chief Engineer and Chief Officer in consultation with the Superintendent are responsible for preparing the Vessel Specific PMS.

The PMS must cover the equipment as listed below:

- Critical Equipment
- Hull, Deck Machinery and Equipment
- Cargo Machinery, Equipment and Automation
- Life-saving and Fire-fighting equipment
- Navigational and Radio Equipment
- Main Engine, Auxiliary Engines, Auxiliary and Ancillary Machinery
- Electrical Machinery and Equipment
- Automation Equipment including Alarm and Cut-outs
- Calibration Equipment and Instruments
- Equipment supplied by charterer, owner or others, such as cargo handling equipment

Additionally the PMS can also be utilized to monitor Statutory and Class Surveys.

Planned Maintenance Systems requirements

Today, there is a minimum requirement that one Planned Maintenance system must contain:

- The description and documentation of the Planned Maintenance system are to be in the English language.
- Reports in Planned Maintenance system should be in English, except when not suitable for the crew. In that case a brief English summary is required.
- Planned Maintenance program must include equipment manufacturer requirements.
- Inventory content, i.e. items/systems have to be included in the maintenance program.
- Maintenance time intervals, i.e. time intervals at which the maintenance jobs are to take place.
- Maintenance instructions, i.e. maintenance procedures to be followed.
- Maintenance documentation and history, i.e. documents specifying maintenance jobs carried out and their results.
- Reference documentation, i.e. performance results and measurements taken at certain intervals for trend investigations from delivery stage.
- Document flow chart, i.e. chart showing flow and filling of maintenance documents as planning cards, job cards etc.
- Signing instructions, i.e. who signs documents for verification of maintenance work carried out.

For computerised Planned Maintenance systems there are several additional requirements:

- Each person working on system must have unique loginID and password.

- Computerised system must have adequate backup, either backup copy on board or a regular exchange of data between ship and office.

Documentation on maintenance of the category "Classification Surveys" carried out on items/systems covered by the rules is to be signed by the Chief engineer. With computerised systems, access to update the related maintenance documentation and the maintenance program should only be granted to the Chief engineer.

For ships trading in specific areas, e.g. ferries, planned maintenance systems using other languages than English may be accepted. This arrangement is automatically cancelled in case of change of trade.

MAINTENANCE SCHEDULE – INTERVALSTS

The following factors should be considered:

- Equipment Manufacturers Recommendations and Specifications.
- Company, Industry, Flag Administration standards and guidelines.
- Condition Monitoring and Predictive Maintenance techniques - i.e. Vibration analysis.
- Practical experience and Historical trends in the results of routine inspections, and in the nature and rates of failures.
- The usage of the equipment – Continuous, Intermittent, Stand-by or Emergency.
- Practical or Operational restrictions, e.g. maintenance that can be performed only in dry-dock

MAINTENANCE SCHEDULE – TASK

The Job procedure of each Maintenance Schedule Task must be included in Planned Maintenance System and should be in accordance with the Makers Specific Instructions, Drawings and Service Notes. The Job Procedure should preferably include reference to the Instruction Manual i.e. Page or Drawing number.

ISSUING PMS MAINTENANCE SCHEDULES

Chief Engineer and Chief Officer must ensure that the Maintenance schedules are extracted from the PMS every week. The jobs schedules should be given to the Person in charge of the maintenance. A record is to be maintained on board. Depending on the Trade of the Vessels and nature of the Voyage forward planning must be carried out, Maintenance schedules should be preponed rather than postponed or allowed to become overdue.

If for any reason the Maintenance cannot be carried out, then the job should be postponed and reason for same should be recorded.

RESPONSIBILITIES FOR PERFORMING VARIOUS TASKS

The job responsibilities for all personnel are listed in the Main Shipboard Manual, with detailed inspection responsibilities and Maintenance schedules included in various sections of the MTM. In event of absence of any personnel, the Master or the Chief Engineer may reassign the duties as deemed necessary, after making due consideration for competence and rest hours.

UPDATING COMPUTER BASED PMS MAINTENANCE SCHEDULE

Officer in charge of the maintenance must ensure that the schedule is updated upon completion. The actual work carried out, condition of the equipment in particular critical parts and parts renewed must be entered in the PMS rather than just entering "Done" while updating the schedule. Where relevant, the exact values / readings /measurements observed at the time of overhaul / inspection must be stated in the records. Remarks are to be made if any part would need particular attention or renewal during the next overhaul. Unscheduled Inspections, Routine and Breakdown maintenance must be recorded in the PMS.

SPARE PARTS INVENTORY

An up-to-date Spares Part Inventory is extremely important as it prevents shortfalls and overstocking. Shortfalls lead to last minute orders resulting in expensive airfreight, postponed maintenance, possible non-compliance in third party inspection sand occasionally an incident. Over stocking is blocking money unnecessarily and could lead to loss to the Owners. If the vessel is sold these will be generously donated, for no appreciable value, to the next owner. The Inventory must be maintained within the PMS.

The Chief Engineer and Chief Officer in consultation with the Superintendent must prepare a Vessel specific List of Minimum spares to be maintained for Critical Equipment and Other Machinery/Equipment.

The list of Minimum Spares should be prepared on the basis of

a) Trading area of the Vessel,
b) Duration of Voyages
c) Availability of Spares from Manufacturers and
d) Age of vessels.

The minimum spare parts list should be reviewed if the trading pattern of the vessel changes to areas where supplies are difficult to connect.

DEFECTS

All Defects/Observations as observed on board must be recorded in the appropriate section of the PMS. The complete list of all such defects should be maintained by Chief Engineer and Chief Officer for their respective departments.

The Master and the Chief Engineer, within one month of joining, must send the update on the defect list to the vessels Superintendent, making additions, if any.

The defects requiring shore assistance should be followed up separately on the Repair Order Forms. In case permanent repairs cannot be undertaken whilst the vessel is in service, then a Dry Dock Job Specification/Order should be raised. Computerized PMS that have the Defect Reporting feature may have a provision for raising Dry Dock Specifications.

CRITICAL EQUIPMENT

Critical Equipment is defined as Machinery and Equipment on a Vessel including Alarms and Trips, the sudden failure of which may result in a hazardous situation thereby placing the personnel and/or vessel at risk.

Equipment with redundancy does not fall into the Critical Equipment category, e.g. Fire and GS Pumps.

The company should establish procedures in its safety management system to identify equipment and technical system, the sudden operational failure of which may result in hazardous situation. The SMS should provide for specific measures aimed at promoting the reliability of such equipment or systems. These measures should include the regular testing of standby arrangement or equipment or technical systems that are not in continuous use.

The list of critical equipments or systems can vary according to ship type and operation once identified appropriate tests and other procedures should be developed to ensure reliability.

CRITERIA FOR CHOOSING CRITICAL EQUIPMENTS AND OPERATION:-

As per element 7 of ISM code, the company must establish procedures for preparing plans, instructions, checklists for key shipboard operations related to the safety of the ship, and prevention of pollution and safety of personnel.

Normally criteria for choosing a critical equipment or operation lie as its potential to carry on to a hazardous situation. Thus a critical equipment or operation is that whose direct failure will lead to an accident. Hence with combination with element 10 the following shipboard equipments/ items are subjected to inspections and tests (but are not limited to)

1) Hull and superstructure steel work

2) Safety, firefighting and LSA equipment

3) Navigational equipment

4) Steering gear

5) Anchoring or mooring gear

6) Main engine and auxiliary engine

7) Cargo handling equipment

8) I.G. system

9) Electrical installation

10) Fire detection and alarm system

RESPONSIBILITY

No critical systems, alarms, control or shut down may be by-passed, inhibited or taken out of service without the permission of the Master. The Chief Engineer must approve any changes to critical alarms, control or shut down set points. The Chief Engineer is responsible for communicating any temporary deactivation of a critical alarm or system to the duty personnel. Only those personnel designated by the Chief Engineer are to work on any such critical systems.

INOPERATIVE - CRITICAL EQUIPMENT

Any Critical Equipment found inoperative /defective must be reported immediately by a Non Routine Message to the Office and a Telephone call to the Technical Superintendent. An onboard Risk Assessment will have to be carried out, controls to mitigate any risk posed as

a result of the defect will have to be established and put in place. If the Vessel is in Port, attempts should be made to have the Equipment repaired prior departure.

CRITICAL EQUIPMENT – MAINTENANCE

If routine maintenance is required to be carried out on Critical Equipment, the Staff must carry out a Risk Assessment and forward the assessment to the Office. Only on approval from the Office can the Equipment be taken "Out of Service". If approval is received on phone, a confirmatory e-mail must be sent. Out of service with respect to critical equipment may be defined as equipment that may be immobilized either to carry out routine maintenance or breakdown maintenance. In either case a thorough risk assessment shall be carried out on board by the senior management identifying all hazards and with a backup plan to mitigate any eventuality. The senior management on board after quantifying the level of risk, whether low, medium or high, will inform office accordingly. Permission to carry out high risk maintenance activities on critical machinery shall be given by appropriate levels of management.

3.1.2 MANAGE SAFE AND EFFECTIVE MAINTENANCE AND REPAIR PROCEDURES PRACTICAL KNOWLEDGE

3.1.2.1 Manage safe and effective maintenance and repair procedures

Ships safety management system, as required by SOLAS (R1) Chapter VIII, should be consulted when carrying out maintenance and repair work. Manufacturers Instruction and Operation Manual give guidance on maintenance. Spare parts availability should be checked before starting maintenance procedures. Availability of specific tools and lifting equipment safe should be determined.

A systematic approach to maintenance will include:

a. the establishment of maintenance intervals;
b. the definition of the methods and frequency of inspection;
c. the specification of the type of inspection and measuring equipment to be used, and the accuracy required of it;
d. the establishment of appropriate acceptance criteria (pass/fail);
e. the assignment of responsibility for inspection activities to appropriately qualified personnel;
f. the assignment of responsibility for maintenance activities to appropriately qualified personnel;
g. the clear definition of reporting requirements and mechanisms.

Maintenance intervals should be established based on the following:

a. the manufacturers recommendations and specifications;
b. predictive maintenance determination techniques (i.e. lube oil analysis, vibration analysis);
c. practical experience in the operation and maintenance of the ship and its machinery, including historical trends in the results of routine inspections, and in the nature and rates of failures;
d. the use to which the equipment is put - continuous, intermittent, stand-by, or emergency;
e. practical or operational restrictions, e.g. maintenance that can be performed only in dry-dock;
f. intervals specified as part of class, convention, administration and company requirements;
g. the need for regular testing of standby arrangements.

Inspections

Procedures for planned inspection routines should be written to include the following:

a. acceptance criteria (e.g. pass/fail, tolerances);
b. the use of suitable measuring and testing equipment of the required accuracy;
c. the calibration of the measuring and testing equipment to the appropriate standards;

The following are examples of the types of inspection and test that may be employed:

a. visual
b. vibration
c. pressure
d. temperature
e. electrical
f. load
g. water tightness

Inspection methods

Where appropriate, checklists should be developed to ensure that inspection, test, and maintenance activities are performed in accordance with the procedures, and at the specified intervals. These checklists may be developed from manufacturers' recommendations or specifications.

Permit-to-work systems

Where appropriate, permit-to-work systems should be employed to ensure that inspections and maintenance activities are carried out safely. A well designed permit-to-work procedure will amount to a risk assessment, carried out before any hazardous activity is undertaken. As a result of the assessment, controls will be imposed to eliminate or reduce the risks involved. These may include, among other things, an assessment of the environment in which the work will take place and adjacent areas and compartments (especially for hot work), the isolation of electrical circuits or the draining of pipes and tanks, the provision of appropriate and wellmaintained tools and equipment, the assignment of qualified and experienced personnel, stand -by and emergency arrangements.

3.1.3 PLANNING MAINTENANCE, INCLUDING STATUTORY AND CLASS VERIFICATIONS PRACTICAL KNOWLEDGE

3.1.3.1 Planning maintenance, including statutory and class verifications

For Machinery Surveys, Classification Societies offers four arrangements for Class follow-up of the components in the Machinery list. The best suited survey arrangement for the Manager depends on the company`s maintenance strategy and operation.

The components covered by the four survey arrangements are listed in the Classification Society`s machinery list. The components are given specific codes for easy identification.

.1. Survey arrangement Machinery Renewal

Machinery Renewal is Classification Society`s default survey arrangement. This survey arrangement is suitable for vessels which carry out most of the maintenance in dock.

Rules and Requirements:

All machinery is to be opened up and/ or function tested at each Main Class Renewal Survey (5 yearly). The time window for crediting: -/+ 15/0 months, no flexibility.

Preparations for survey:

As all Machinery Components are to be opened up and/ or tested at the end of the Renewal Class period, the crew and the Chief Engineer must be prepared for an extensive machinery inspection during Renewal survey. An important point is that even though a component has not achieved the makers recommended running hours for overhaul, it must be opened up or tested during survey.

.2 Survey Arrangement Machinery Continuous

When operating with survey arrangement Machinery Continuous, the Manager is given more flexibility. Components are credited by Classification Society on a continuous basis, either during the annual surveys or when requested by the Manager.

Class involvement

A Classification Society`s Surveyor shall be called in every time a main overhaul is carried out for crediting of Class machinery. Half of all identical components of which there are more than one (e.g. fuel oil booster pumps for the main engine) in the Machinery list, can be credited by the Chief Engineer on behalf of Classification Society every second time overhaul is carried out. Postponement of components maybe granted given that a sighting survey is carried out, and with a maximum period of 3 months.

Surveys/ Preparations

No specific survey interval is required, but all components have to be surveyed with a maximum interval of 5 years. In the Classification Society`s quarterly listing, the Machinery List will for each component show both the last survey date and the due date for the next survey.

.3 Survey Arrangement Machinery PMS (Planned Maintenance System)

Crediting of Machinery Components when on Machinery PMS is based on annual surveys and audits of the reported maintenance history in the vessels computer based planned maintenance system.

All components in the Machinery List can be surveyed by the chief engineer at the time of overhaul. The component may then be credited by the discretion of the attending surveyor during the next annual survey based on the reported maintenance history for the component.

Conditions/ Requirements for PMS

The approval of the survey arrangement Machinery PMS is directly connected to the technical management of the vessel. The Manager is given more flexibility and responsibility, and Classification Society performs audits of the planned maintenance programme rather than performing the actual component survey. In order to ensure that Class related Machinery components are given adequate follow up, the approval of the system itself and the on board system is connected to the Management of the vessel.

Machinery PMS will be deleted upon change of management or change of system. Please note that upon deletion of Machinery PMS, components with more than 5 years since last overhaul will be given a due date 6 months from the date that Machinery PMS was deleted.

The vessel will then be assigned to survey arrangement Machinery Continuous unless otherwise requested.

If a vessel changes Management, and the new Management wants to re-install Machinery PMS, a new initial survey is required to be carried out. Unless the new Manager has a system approval for the on board planned maintenance system, a system approval must be obtained before an initial survey can be carried out on board.

Prior to initial survey on board, the approval of the Manager to use the planned maintenance system must be in order.

Survey/Preparations: Machinery PMS Initial Survey

An initial survey is required on board each vessel in order to obtain the survey arrangement Machinery PMS. The Chief Engineers attendance is required throughout the entire duration of the survey, normally 5-8 hours. During the initial PMS Survey, the system will be audited with respect to the Classification Society`s requirements. Main focus areas will be:

- Work/ job descriptions are to be in accordance with makers requirements and shall cover the Classification Society`s requirements for class components.
- Classification Society`s Machinery Component in the Machinery list included in the maintenance system on board with correct codes.
- All jobs for components with Class scope "main overhaul" shall be identified as Class jobs, with intervals according to maker`s recommendations. No duplicate Class job in the system.
- Continuous improvement of the system. It is required to have a system for review of the planned maintenance system to further increase the focus on continuously improve the efficiency and the input quality of your system. All corrective jobs are to be identified and reviewed in an annual job. If many corrective jobs are identified on a specific component, the maintenance interval may be considered reduced. If intervals are to be increased beyond makers recommended intervals, this shall be approved by the managements organization ashore in agreement with maker, and may be accepted by the attending surveyor during the next annual survey.
- Circulating components. Components being re-used in several positions (cylinder covers, pistons, etc.) must have a traceable maintenance history. This can either be part of the maintenance system, or kept as a separate system.
- If the vessel has class notation Unmanned Machinery Space (UMS), the UMS Class jobs have to be included and especially identified in the PMS.

If the requirements for Machinery PMS are not fulfilled, the survey arrangement will not be granted, or can be deleted if already in operation.

Survey/Preparations: Machinery PMS Annual Survey

At the annual survey, the use of the system including the Chief Engineers familiarity with it will be audited. In addition, the surveyor will review the machinery maintenance history in the PMS on board and perform a general inspection of the engine room.

The Chief Engineer has to prepare the print outs of the following reports before or during the survey:

- All main overhauls (Class linked jobs) carried out since last annual survey.
- Overdue list.

If the requirements for the Machinery PMS are not fulfilled, a condition of class will be issued, and the survey arrangement may be deleted upon consideration.

Changing to Survey Arrangement Machinery PMS

When planning a change to the survey arrangement Machinery PMS it is required that the software used for planned maintenance is approved by Classification Society. Additionally, the Manager needs to hold a company approval for the maintenance system itself and an approval for each applicable vessel. It is important to bear in mind that an installed Planned Maintenance System onboard, is not the same as having the survey arrangement Machinery PMS. Before changing to the Survey Arrangement Machinery PMS a successful initial survey must be carried out on each vessel. The maintenance system should have been in use for approximately 6 months before an initial survey is requested.

System requirements

Several requirements apply to the maintenance system in use on board:

The planned maintenance system shall be computer based

- The system shall be able to produce a maintenance history report of all main overhauls carried out on class related machinery components during a specific period of time.
- The system shall be able to identify all Class machinery with corresponding Classification Society`s codes
- All corrective actions shall be especially identified in the system.
- The job descriptions and maintenance history shall be in English.

- A system for tracing circulating components should be shall be in place(either included in the system or as a separate system)

Vessel Approval

A vessel approval has to be granted to each vessel which the Manager wants to have on Survey Arrangement Machinery PMS. After completion of an initial survey, the survey report is evaluated by the Classification Society`s Head Office. Upon the successful review, a certificate is issued and the vessel is transferred to survey arrangement Machinery PMS.

.4 Survey Arrangement Machinery CM (Condition Monitoring)

Classification Society`s has developed Machinery CM, intended for Managers with an implemented Condition Based Maintenance (CBM) strategy. Machinery CM allows the manager to adjust maintenance intervals based on the monitored condition of applicable components, which gives the manager optimized maintenance with significant flexibility. Machinery CM requires that Machinery PMS is already granted.

The condition based maintenance (CBM) opportunity:

Shipping has a number of opportunities when implementing the condition monitoring activity on rotating machinery.

The traditional classification of the ship can require that the machine should be opened according to operation hours, even if it is in good condition. The advantage is that the maintenance work can be planned according to actual condition and the reliability increases. Will allow for trending the readings and show the results as bas for the survey. The unnecessary work of opening good machines can be avoided, labor costs and spare part consumption goes down. The lubrication intervals of the bearings can be based on condition. This will reduce bearing failures prolong the lifetime and reduce power consumption.

The breakdowns, the unplanned and the unexpected maintenance will be reduced to increase the safety. The quality of the alignment of the shafts can be measured and the misalignment corrected. This will increase the lifetime and reduce energy consumption.

The benefits are many and this opportunity can increase the profits in shipping substantially if the new modern practices are implemented.

The indirect costs in maintenance

Using condition monitoring to its potential.

The most difficult challenge is to create a structure were condition monitoring is part of the maintenance strategy. Once done the next challenge arises, to use CM to its potential.

Even companies that are considered successful very seldom follow up the economical effect of the program or look for ways to develop the program to cover the entire vessel even if the potential for earning more money is there. To become successful it is important to evaluate the economical contribution of condition monitoring on a regular base. Only then will the foundation for the program be allowed to expand and cover the entire ship.

These are some examples of key performance indicators that can be followed to measure the effect:

a. Maintenance cost/Asset value
b. Condition monitoring hours/ Total hours of work
c. Time based hours/ Total hours of work
d. Hired labor hours/ Total hours of work
e. Total hours unplanned repair/ Total repair time
f. Average shock pulse and vibration level
g. Stock of spare parts/Asset value
h. No. of purchase orders of spare parts
i. No. of withdrawals from stock

Rules and Requirements:

The operator must submit a CM programme for approval. The CBM must be a well-established maintenance philosophy and strategy within the management before the process of Class approval can be initiated.

3.1.4 PLANNING REPAIRS PRACTICAL KNOWLEDGE

3.1.4.1 Planning repairs

Ships safety management system, as required by SOLAS (R1) Chapter VIII, should be consulted when carrying out repair work. Manufacturers Instruction and Operation Manual give guidance on repairs. Spare parts availability should be checked before starting repair procedures. Availability of specific tools and lifting equipment safe should be determined. Individual parts are to be tested as per manufacturer's instruction manual.

3.2 DETECT AND IDENTIFY THE CAUSE OF MACHINERY MALFUNCTIONS AND CORRECT FAULTS PRACTICAL KNOWLEDGE

3.2.1 DETECTION OF MACHINERY MALFUNCTIONS, LOCATION OF FAULTSAND ACTION TO PREVENT DAMAGE3.

3.2.1.1 Unplanned maintenance

Comparison is made with normal operating values and abnormal operating conditions. Observation of physical parameters viz. vibrations, noise, temperature, pressures, levels, flow, etc. indicate abnormal conditions. Initial action taken when fault is first identified, considering vessels safety. Bridge is notified of potential problems in good time. Senior engineers are advised when appropriate and advice sought in all cases of doubt. Priorities and scheduled work are re-assessed in light of identified fault. Errors are acknowledged, reported, recorded and corrective action taken.

3.2.2 INSPECTION AND ADJUSTMENT OF EQUIPMENT

3.2.2.1 Inspection and adjustment of equipment

Inspection and adjustment of equipment to be carried out as per relevant data provided by the manufacturers operating manual.

3.2.3 NON-DESTRUCTIVE EXAMINATION

3.2.3.1 Different types of non-destructive examination

Non-destructive examination methods may be divided into conventional and nonconventional.
To the first group belong commonly used methods like visual or optical inspection, liquid penetrant testing, magnetic particle testing, eddy current testing, radiographic testing and ultrasonic testing. The second group includes those Non-destructive methods used only for specialized applications like neutron radiography, acoustic emission, infrared testing, microwave techniques, leak testing, holography etc. It must also be remembered that none of these methods provide solutions to all possible problems, i.e. they are not optional alternatives but rather complementary to each other.

(i) Visual Inspection
(ii) Dye penetrant test
(iii) Magnetic Particle Testing
(iv) Radiography
(v) Portable Hardness
(vi) Thermography.

a. Visual testing (VT)

Often overlooked in listings of non-destructive methods, visual inspection is one of the most common and powerful means of non-destructive testing. Visual testing requires adequate illumination of the test surface and proper eye-sight of the tester. To be most effective visual testing requires training (knowledge of product and process, anticipated service conditions, acceptance criteria, record keeping, for example). It is also a fact that all defects found by other NDT methods ultimately must be substantiated by visual testing. Visual testing can be classified as direct visual testing, remote visual testing and translucent visual testing. Often the equipment needed is simple (a portable light, a mirror on stem, a 2X or 4X hand lens, one illuminated magnifier with magnification 5X or 10X). For internal inspection, light lens systems such as bore scopes allow remote surfaces to be examined. More sophisticated devices of this nature using fibre optics permit the introduction of the device into very small access holes and channels. Most of these systems provide for the attachment of a camera to permit permanent recording.
The applications of visual testing include:

a. Checking of the surface condition of the component.
b. Checking of alignment of mating surfaces.
c. Checking of shape of the component.
d. Checking for evidence of leaking.
e. Checking for internal side defects.

Some of the advantages of visual testing are as follows:

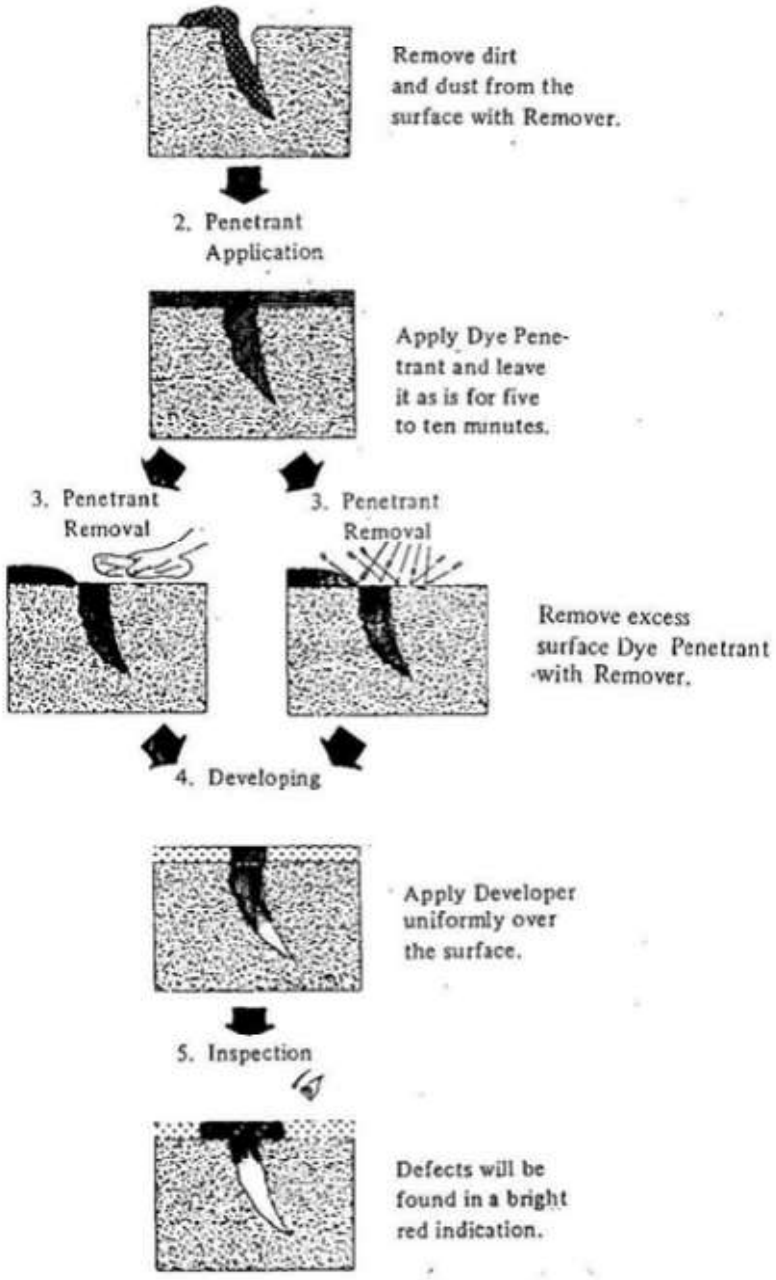
a. Testing is simple
b. Testing speed is high
c. Cost is low
d. Less training
e. On-line testing possibility
f. Permanent record available

Some of the limitations of visual testing are as follows:

a. Can detect only surface defects
b. Difficulty in sizing depth of defects

b. Liquid penetrant testing (PT)

This is a method that can be employed for the detection of surface-breaking defects in any industrial product made from a non-porous material. This method is widely used for testing of non-magnetic materials. In this method, a liquid penetrant is applied to the surface of the product for a certain predetermined time, after which the excess penetrant is removed from the surface. The surface is then dried and a developer is applied to it. The penetrant which remains in the defect is absorbed by the developer to indicate the presence as well as the location, size and nature of the defect. The process is illustrated in the figure below.



Different stages of liquid penetrant testing.

Penetrants used are either visible dye or fluorescent dye. The inspection for the presence of visible dye indications is made under white light while inspection of presence of indications by fluorescent dye penetrant is made under ultraviolet (or black) light under darkened conditions.

Liquid penetrant processes are further sub-divided according to the method of washing of the component. Penetrants can be: (i) water-washable, (ii) post-emulsifiable, i.e. an emulsifier is

added to the excess penetrant on surface of the component to make it water-washable, and (iii) solvent removable, i.e. the excess penetrant needs to be dissolved in a solvent to remove it from the component surface.

In order of decreasing sensitivity and decreasing cost, the liquid penetrant processes can be listed as follows:

a. Post emulsifiable fluorescent dye penetrant.
b. Solvent removable fluorescent dye penetrant.
c. Water washable fluorescent dye penetrant.
d. Post emulsifiable visible dye penetrant.
e. Solvent removable visible dye penetrant.
f. Water washable visible dye penetrant.

The advantages of liquid penetrant testing are:

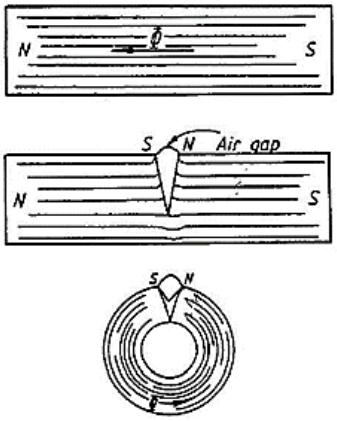
a. Relatively low cost.
b. High portability.
c. Highly sensitive to fine, tight cracks.
d. Fairly simple method.
e. Can be used on a variety of materials.
f. All surface defects are detected in one operation, regardless of orientation.

The limitations of liquid penetrant testing are:

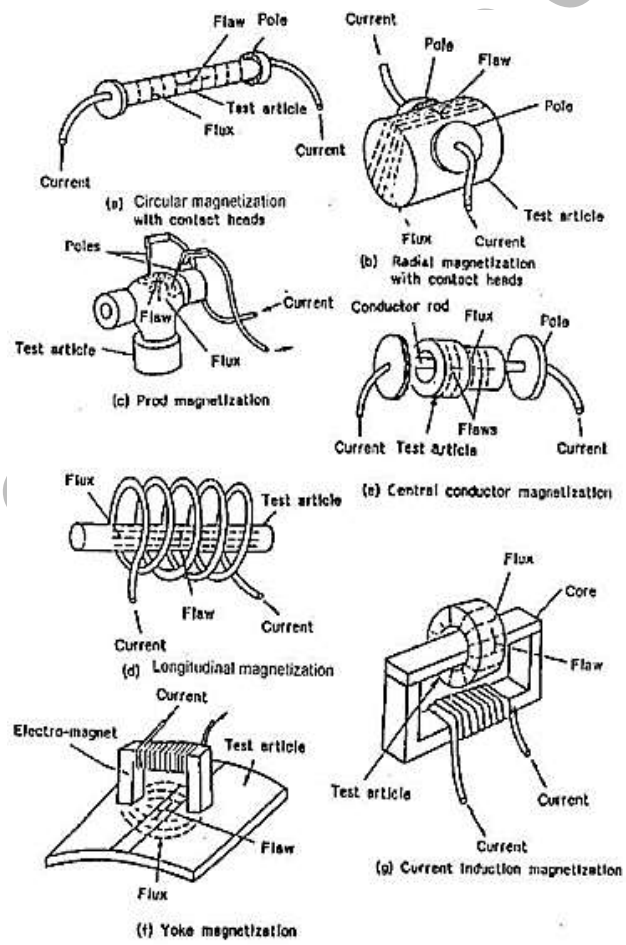
a. Test surface must be free of all contaminants (dirt, oil, grease, paint, rust, etc.).
b. Detects surface defects only.
c. Cannot be used on porous surfaces and is difficult to use on very rough surfaces.
d. No permanent record.

c. Magnetic particle testing (MT)

Magnetic particle testing is used for testing materials that can be easily magnetized. This method is capable of detecting open to surface and just below the surface defects. In this method the test object is first magnetized by using either a permanent or an electromagnet, or by passing electric current through or around the object. The magnetic field thus introduced into the object is composed of magnetic lines of force. Whenever there is a defect which interrupts the flow of magnetic lines of force, some of these lines must exit and re-enter the object. These points of exit and re-entry form opposite magnetic poles. Whenever minute magnetic particles are sprinkled onto the surface of such an object, these particles are attracted by these magnetic poles to create a visual indication approximating the size and shape of the defect. In the figure below illustrates the basic principles of this method.



Basic principle of magnetic particle testing.



Different magnetizations used in magnetic particle testing.

Advantages of magnetic particle testing:

a. It does not need very stringent pre-cleaning operation.
b. Best method for the detection of fine, shallow surface cracks in ferromagnetic material.
c. Will work through thin coating.
d. Inspection of complex geometries.
e. Portable NDT method.

The limitations of magnetic particle testing include the following:

a. Applicable only to ferromagnetic materials.
b. Orientation and strength of magnetic field is critical. There is a need to magnetise twice: longitudinally and circumferentially.
c. Large currents sometimes required and "burning" of test parts is a possibility.
d. After testing the object must be demagnetized, which may be difficult sometimes.

d. Radiographic testing method

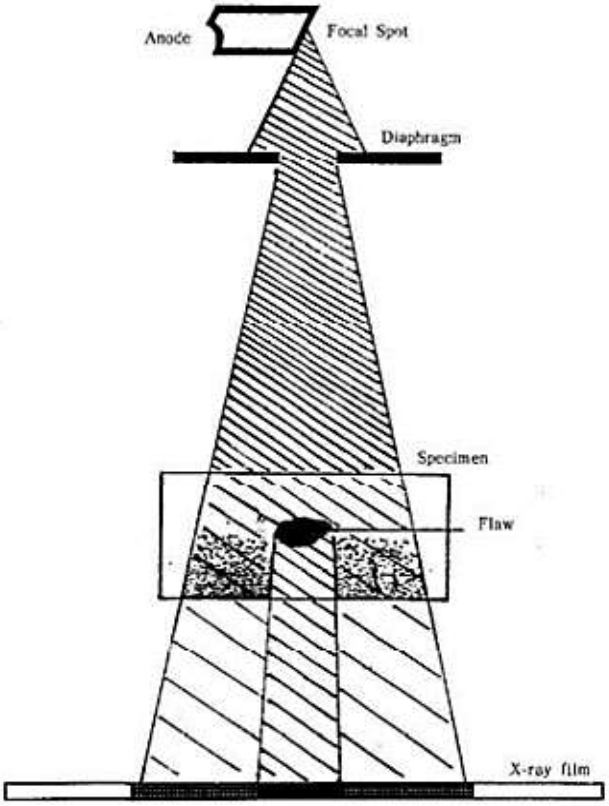
The radiographic testing method is used for the detection of internal flaws in many different materials and configurations. An appropriate radiographic film is placed behind the test object and is exposed by passing X rays or gamma rays (Co-60 & Ir-192 radioisotopes) through it. The intensity of the rays while passing through the object is modified according to its internal structure and thus the exposed film, after processing, reveals a shadow picture known as a radiograph. It is then interpreted to obtain data about the present defects. This method is used on a wide variety of objects such as forgings, castings and weldments.

The advantages of radiographic testing include that:

a. It is useful on wide variety of materials.
b. It can be used for checking internal malstructure, misassembly or misalignment.
c. It provides permanent record.
d. Devices for checking the quality of radiograph are available.

Some of the limitations of this method are that:

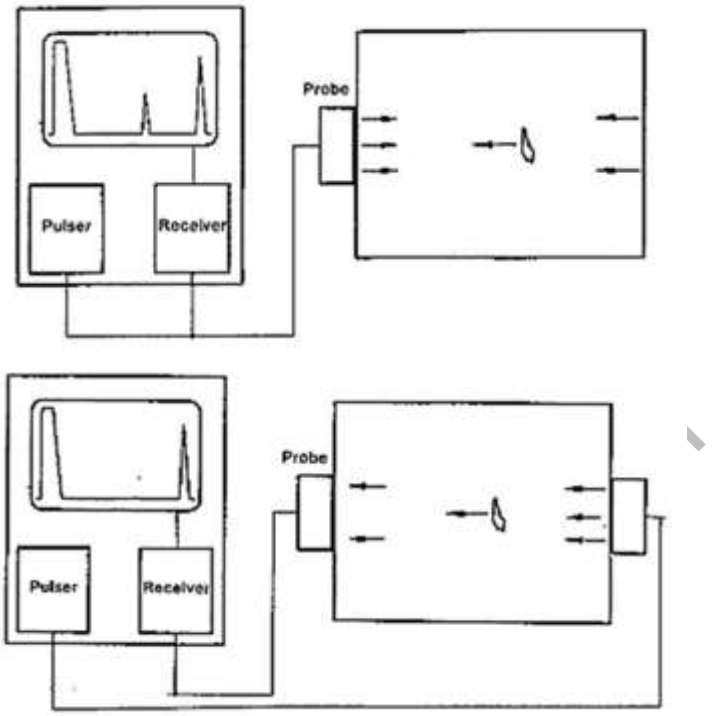
a. Access to both sides of the object is required.
b. It cannot detect planar defects readily.
c. The thickness range that can be inspected is limited.
d. Sensitivity of inspection decreases with thickness of the test object.
e. Considerable skill is required for interpretation of the radiographs.
f. The depth of defect is not indicated readily.
g. X rays and gamma rays are hazardous to human health. The iaea's radiation safety series are referred for personal safety and radiation protection.



Arrangement for radiographic testing method.

e. Ultrasonic testing (UT)

Ultrasonic inspection is a non-destructive method by which high frequency sound waves are introduced into the object being inspected. Most ultrasonic inspection is done at frequencies between 0.5 and 20 MHz. The sound waves travel through the material with some loss of energy (attenuation) due to material characteristics. The intensity of sound waves is either measured, after reflection (pulse echo) at interfaces (or flaw) or is measured at the opposite surface of the specimen (pulse transmission). The reflected beam is detected and analyzed to define the presence and location of flaws. The degree of reflection depends largely on the physical state of matter on the opposite side of the interface. Partial reflection occurs at metal liquid or metal-solid interfaces. Ultrasonic testing has a higher penetrating power than radiography and can detect flaws deep in the test object (up to about 7 metres of steel). It is quite sensitive to small flaws and allows the precise determination of the location and size of the flaws. The basic principle of ultrasonic testing is illustrated in the figure below.



Basic components of an ultrasonic flaw detection system.
(a) Pulse echo method
(b) Through transmission method.

The ultrasonic testing method is:

a. Used for detection of flaws in materials and for thickness measurement.
b. Used for the determination of mechanical properties and grain structure of materials.

Some of the advantages of ultrasonic testing are that:

a. It has high sensitivity which permits detection of minute defects.
b. It has high penetrating power which allows examination of extremely thick sections.
c. It has a high accuracy of measurement of flaw position and size.
d. It has fast response which permits rapid and automatic inspection.
e. It needs access to only one surface of the specimen.
f. Some of the limitations of this method are:
g. Unfavourable geometry of the test object causes problems during inspection.
h. Inspection of materials having coarse grain microstructure is difficult.
i. It requires the use of a couplant.
j. Defect orientation affects defect detectability.
k. Reference standards and calibration are required.
l. Rough surfaces can be a problem and surface preparation is necessary.

f. Leak testing (LT)

The leak testing method of NDT includes several techniques to detect, locate and measure leaks which have occurred in the pressure boundary or envelope of a component, vessel, pipeline or piping component.
Many modern designs are based on the "leak before break" principle, in which critical thicknesses and other dimensions are selected so that a vessel will crack and leak before the crack grows to catastrophic proportions. In these applications, the ability to detect the leak at a very early stage is important. In other applications, checking for a through leak is the only way to fully assure the integrity of a component or weld.
The pressure envelope separates two areas which are or could be at different pressures.
The contained fluid will try to travel from the region of higher pressure to that of lower pressure.
The relative pressures may be natural or imposed (where the envelope is pressurized or the potential exit point is subjected to a vacuum as part of the inspection procedure.)
Techniques for leak testing include visual examination for escaping fluids or bubbles, electronic sensing of the noise emitted by the escaping fluids, or chemical or radiological detection of small quantities of contained fluids or fluids specifically introduced as tracers.

A simple bubble test for leak detection.

TABLE 1.1. COMPARISON OF VARIOUS NDT METHODS

Technique	Access requirements	Equipment cost	Inspection cost	Remarks
Visual	Can be used to view the interior of complex equipment. One point of access may be enough.	B/D	D	Very versatile; little skill required.
Radiography	Must be able to reach both sides.	A	B/C	Despite high cost, large area can be inspected at one time. Considerable skill required in interpretation.
Ultrasonics	One side access is sufficient.	B	B/C	Requires point-by-point search hence extensive work needed on large structures; skilled personnel required.
Magnetic particle	Requires a clean surface.	C	C/D	Only useful on magnetic materials such as steel; little skill required; cannot detect buried defects.
Penetrant	Requires flaw to be open to the penetrant (i.e. clean and at the surface).	D	C/D	For all materials; some skill required; only detects surface-breaking defects.
Eddy current	Requires reasonably smooth and clean surface	B/C	C/D	For electrically conductive materials only; for surface breaking flaws; variations in thickness of coatings, or comparison of materials; considerable skill is usually required.

* (A: Highest cost, D: Lowest cost)

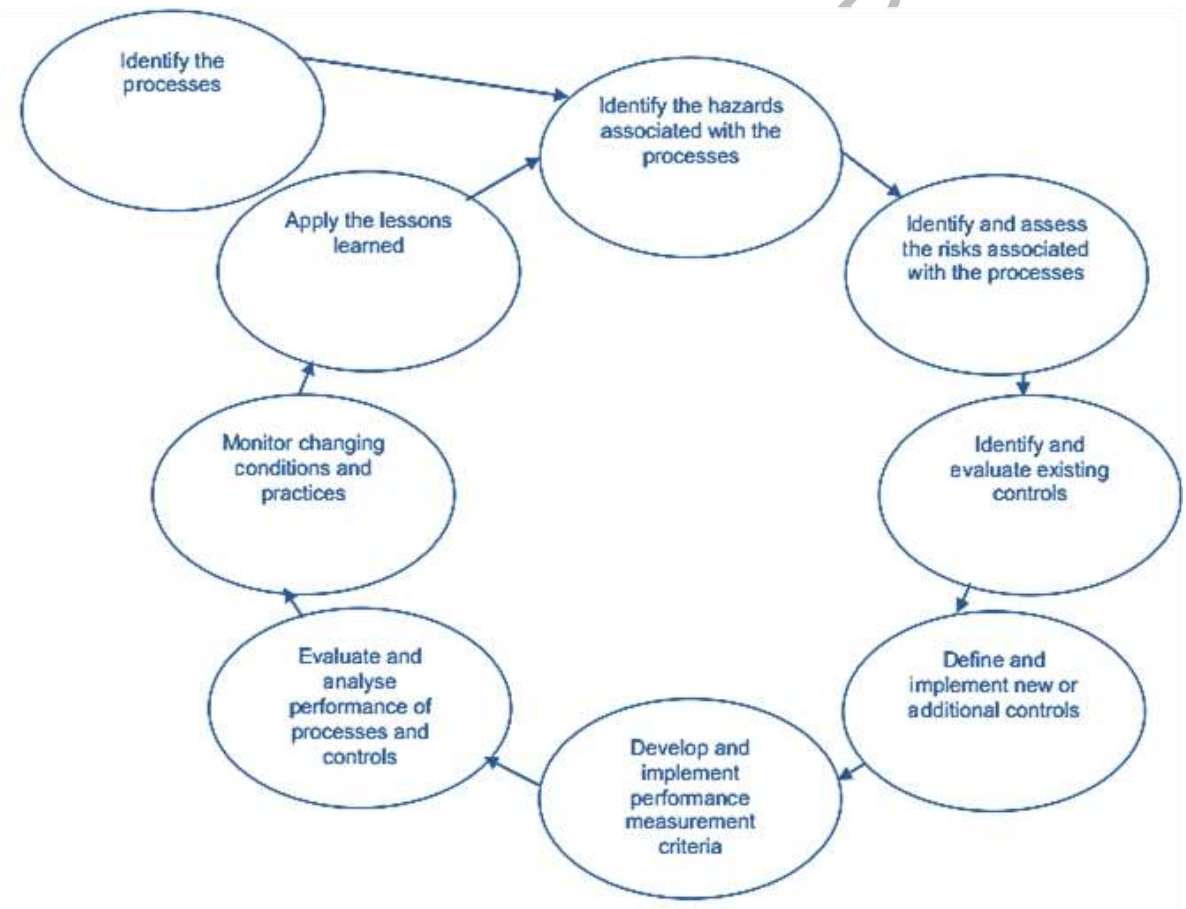
3.3 ENSURE SAFE WORKING PRACTICES PRACTICAL KNOWLEDGE

3.3.1 SAFE WORKING PRACTICES

3.3.1.1 Risk assessment

Risk management may be defined as:

"The process whereby decisions are made to accept a known or assessed risk and/or the implementation of actions to reduce the consequences or probability of occurrence."
The risk management process may be summarized by the flowchart below



Although there are many different RA methodologies, in general a usual approach is as follows:

Step 1: Identification of shipboard operations / systems / tasks

Step 2: Identification of Hazards

Step 3: Identification of existing control measures

Step 4: Risk Evaluation
- Calculation of risk
- Probability (or frequency) Determination
- Consequence (or Severity) Assessment

Step 5: Risk Reduction
- Action and Timescale
- Identification and implementation of new Risk Control measures

Step 6: Review of risk assessment
- Evaluation of control measures
- Need for new risk assessment
- Periodical review of risk assessment
- Accidents / near misses

STEP 1: When to perform a risk assessment

RAs are conducted in order to identify and address potential hazards to personnel, property and the environment, for:

a. existing shipboard operations/tasks
b. in case of new operations/tasks
c. in case of non-routine tasks
d. in case of changes to procedures or equipment.
e. in case of incidents, accidents, serious near misses, etc.
f. prior to the introduction of new critical equipment or procedures.
g. for preparation of complex or high risk jobs and projects.

When deciding which operations/tasks to assess first, normally selected these which have the more potential of loss/harm to personnel, property and the environment, or to those related to the existing accident records. In practice the risks in the workplace should be assessed before work begins on any task which no valid risk assessment exists.

STEP 2: Identification of hazards

The identification of hazards is the first and most important step since all that follows depends on it. It must be complete and accurate, and should be based, as far as possible, on observation of the activity. But hazard identification is not as easy as it may first appear.

Completeness and accuracy can be achieved only if the process is systematic. Those charged with the task must have sufficient training and guidance to ensure that it is conducted in a thorough and consistent manner. The terms used should be clearly defined and the process must be fully described; for example, hazards must not be confused with incidents, and incidents must not be confused with consequences.

The risks associated with each hazard are evaluated in terms of the likelihood of harm and the potential consequences. This, in turn, enables the organization to establish priorities and to decide where its scarce resources may be used to greatest effect.

The combination of likelihood and consequence is normally illustrated as follows:

RISK ESTIMATOR

Likelihood \ Consequence	Slightly Harmful	Harmful	Extremely Harmful
Highly Unlikely	Trivial Risk	Tolerable Risk	Moderate Risk
Unlikely	Tolerable Risk	Moderate Risk	Substantial Risk
Likely	Moderate Risk	Substantial Risk	Intolerable Risk

The table below indicates the recommended response in each case.

Trivial	No action is required.
Tolerable	No additional controls are required. Monitoring is required to ensure control is maintained.
Moderate	Efforts are required to reduce risk. Controls are to be implemented within a specified time.
Substantial	New work not to start until risk reduced. If work in progress, urgent action to be taken. Considerable resources may be required.
Intolerable	Work shall not be started or continued until the risk has been reduced. If reduction is not possible, the activity shall be prohibited.

STEP 3: Identification of existing controls/measures

Before the harmful effects of a hazard can be determined, existing controls/measures that may mitigate the effects of that hazards has to be taken into account.

During any operation, controls can be: procedural, human recourses, training, control systems, appropriate design and construction, maintenance, communication, use of proper equipment etc.

STEP 4: Risk Evaluation

There are two main methods for determination of risk level, qualitative and quantitative. In qualitative risk assessment, someone is using personal judgment whereas in quantitative can actually be measured based on company and/or industry data.
Risk is normally evaluated as a function of the severity of the possible Consequences (C) for a hazard and the Frequency/Probability (P) of occurrence of that particular hazard.

Usually is used a simple relation between C and P, to calculate the risk (R):

Risk (R) = Consequence (C) × Frequency (P) (R=C×P)

Given this knowledge, estimated risk of hazards can be used to make reliable decisions in terms of improving safety by reducing the risk and risks can be reduced by reducing the severity of the consequences, reducing the frequency/probability of occurrence or a combination of the two.

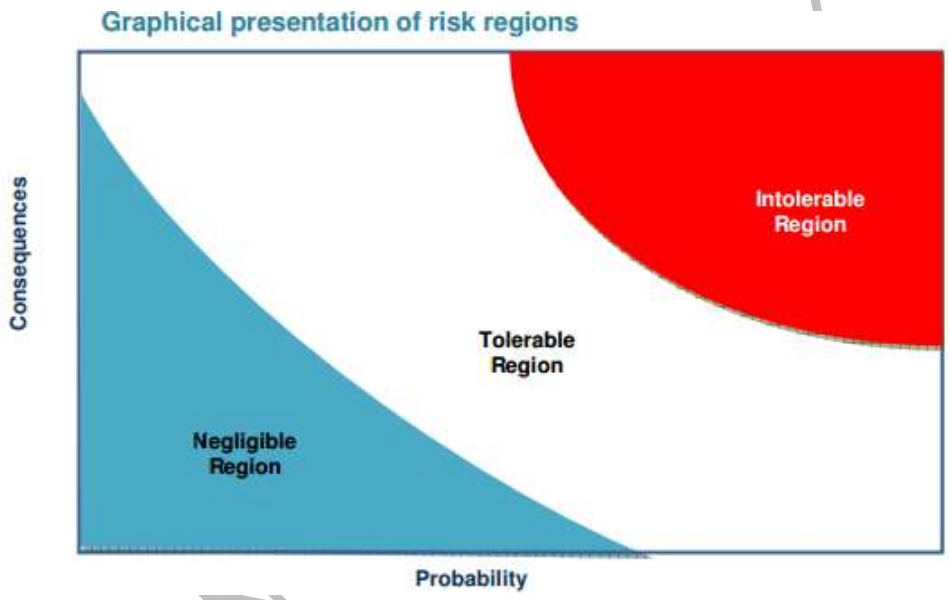
Assessment of the level of the risk using risk criteria

Level of risk is evaluate based on the severity and probability as estimated by the RA process and categorize their possible combinations to be High, Medium or Low risk within the Risk Matrix. Once the risk level has been determined, the response can be defined. Higher risk levels require a greater level of response.

High/Intolerable Risk: Goal is to take steps to reduce risk to at least a medium level.

Medium/ Tolerable Risk: Perform RA and identify risk control measures.

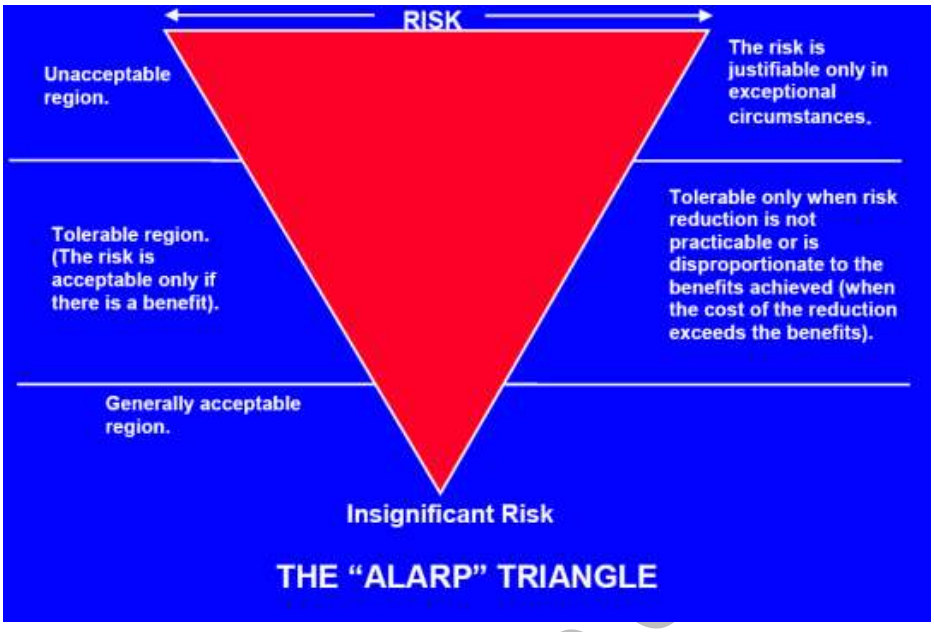
Low/Negligible Risk: Address as part of normal, on-going improvement processes.



STEP 5: Risk Reduction

ALARP (**A**s **L**ow **A**s **R**easonable **P**racticable) Principle

The methods of reducing the risk level of a hazard can be put in one scale and balanced against efforts needed in another. This effort may be represented by money or time or a combination of the two. If it can be shown that there is a gross imbalance between the two, e.g. the reduction of risk level is insignificant compared to the cost of implementing the solution, it will not be reasonably practicable to go ahead.



The purpose of this step is:

- Eliminate Hazards with intolerable risk at whatever cost. If this is not practicable abandoning the operation should be considered.
- Reducing the risk of those in ALARP region if it is cost effective. Higher costs could be considered acceptable if the risk is close to the intolerable region.
- Reducing the risk levels of those in the negligible region with minimal effort.

STEP 6: Review of assessment

Evaluation of control measures

In this step, implementation of the new control measures is followed up and recorded and evaluation of the controls should be made to ensure they remain in place and have the desired effect.

Need for new risk assessment

Risk assessment should not normally be carried out every time an operation/task takes place. The original risk assessment can be reviewed instead of performing a new one, provided that nothing has changed and the applicability of the existing procedures is ensured. However the risk assessment should be carried out if there changes in materials, equipment, operations/procedures, software etc.

Periodical review of risk assessment

Performed risk assessments should reviewed periodically to ensure the applicability of existing procedures/conditions and periodicity may vary depending on the hazard level of the operation/task/system.

Accidents / near misses

In cases of accidents or near misses, the risk assessment should be reviewed to determine if a control/measure failed, a control is missing or new hazards are present.

The risk assessment process never stops because the system will make use of previous experience, new measures will be based on improved measures and so on.

The risk assessments records should be filed and organized under the SMS filing system in order to be easily retrievable otherwise there will be the need of repetitive assessments of the same operation and on the other hand there will not be the necessary objective evidence as may be requested by auditors/PSC etc.

3.3.1.2 Safety officials

The Safety Officer is responsible for passenger and crew safety drills, abandon ship procedures, crew safety training, supervision of ships tenders, instructions on safety of all shipboard personnel, with particular reference to emergency procedures, fire-fighting and lifesaving equipment aboard the ship. Lifeboats, life rafts and launching devices, life jackets, life rings, fire alarms and detection systems, sprinkler system, fire extinguishers, watertight and fire doors, fire and bilge pumps.

Advises the Staff Captain of any defects or malfunctions of safety related equipment.

Previous experience of which minimum 1 to 2 years in subordinate positions onboard ships along with a diploma certification is required for this position. Fluency in English language is a must.

3.3.1.3 Personal protective equipment

Personal protective equipment (PPE) refers to protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury. The hazards addressed by protective equipment include physical, electrical, heat, chemicals, biohazards, and airborne particulate matter. Protective equipment may be worn for job-related occupational safety and health purposes, as well as for sports and other recreational activities. "Protective clothing" is applied to traditional categories of clothing, and "protective gear" applies to items such as pads, guards, shields, or masks, and others.

The purpose of personal protective equipment is to reduce employee exposure to hazards when engineering and administrative controls are not feasible or effective to reduce these risks to acceptable levels. PPE is needed when there are hazards present. PPE has the serious

limitation that it does not eliminate the hazard at source and may result in employees being exposed to the hazard if the equipment fails.

Any item of PPE imposes a barrier between the wearer/user and the working environment. This can create additional strains on the wearer; impair their ability to carry out their work and create significant levels of discomfort. Any of these can discourage wearers from using PPE correctly, therefore placing them at risk of injury, ill-health or, under extreme circumstances, death. Good ergonomic design can help to minimise these barriers and can therefore help to ensure safe and healthy working conditions through the correct use of PPE.

Practices of occupational safety and health can use hazard controls and interventions to mitigate workplace hazards, which pose a threat to the safety and quality of life of workers. The hierarchy of hazard control hierarchy of control provides a policy framework which ranks the types of hazard controls in terms of absolute risk reduction. At the top of the hierarchy are elimination and substitution, which remove the hazard entirely or replace the hazard with a safer alternative. If elimination or substitution measures cannot apply, engineering controls and administrative controls, which seek to design safer mechanisms and coach safer human behavior, are implemented. Personal protective equipment ranks last on the hierarchy of controls, as the workers are regularly exposed to the hazard, with a barrier of protection. The hierarchy of controls is important in acknowledging that, while personal protective equipment has tremendous utility, it is not the desired mechanism of control in terms of worker safety.

» Gloves

» Visor and Helmet

» Half Face Mask

» Ear Plugs

» Ear Phone

» Electrical Gloves

» Vest

» Safety Shoes

» Safety Shoes

» Boots

» Google

» Mask

» Helmet

» Working Gloves

» Head Protection

PPE by type

Respirators

Air-purifying respirator

Respirators serve to protect the user from breathing in contaminants in the air, thus preserving the health of one's respiratory tract. There are two main types of respirators. One type of respirator functions by filtering out chemicals and gases or airborne particles from the air breathed by the user. Gas masks and particulate respirators are examples of this type of respirator. A second type of respirator protects users by providing clean, respirable air from another source. This type includes airline respirators and self-contained breathing apparatus (SCBA). In work environments, respirators are relied upon when adequate ventilation is not available or other engineering control systems are not feasible or inadequate.

In the United Kingdom, an organization that has extensive expertise in respiratory protective equipment is the Institute of Occupational Medicine. This expertise has been built on a long-standing and varied research programme that has included the setting of workplace protection factors to the assessment of efficacy of masks available through high street retail outlets.

The Health and Safety Executive (HSE), NHS Health Scotland and Healthy Working Lives (HWL) have jointly developed the RPE (Respiratory Protective Equipment) Selector Tool, which is web-based. This interactive tool provides descriptions of different types of respirators and breathing apparatuses, as well as "do's and dont's" for each type.

In the United States, The National Institute for Occupational Safety and Health (NIOSH) provides recommendations on respirator use, in accordance to NIOSH federal respiratory regulations 42 CFR Part 84. The National Personal Protective Technology Laboratory (NPPTL) of NIOSH is tasked towards actively conducting studies on respirators and providing recommendations.

Skin protection

Locker containing personal protective equipment

Occupational skin diseases such as contact dermatitis, skin cancers, and other skin injuries and infections are the second most common type of occupational disease and can be very costly. Skin hazards, which lead to occupational skin disease, can be classified into four groups. Chemical agents can come into contact with the skin through direct contact with contaminated surfaces, deposition of aerosols, immersion or splashes. Physical agents such as extreme temperatures and ultraviolet or solar radiation can be damaging to the skin over prolonged exposure. Mechanical trauma occurs in the form of friction, pressure, abrasions, lacerations and contusions. Biological agents such as parasites, microorganisms, plants and animals can have varied effects when exposed to the skin.

Any form of PPE that acts as a barrier between the skin and the agent of exposure can be considered skin protection. Because a lot of work is done with the hands, gloves are an essential item in providing skin protection. Some examples of gloves commonly used as PPE

include rubber gloves, cut-resistant gloves, chainsaw gloves and heat-resistant gloves. For sports and other recreational activities, many different gloves are used for protection, generally against mechanical trauma.

Other than gloves, any other article of clothing or protection worn for a purpose serve to protect the skin. Lab coats for example, are worn to protect against potential splashes of chemicals. Face shields serve to protect one's face from potential impact hazards, chemical splashes or possible infectious fluid.

Eye protection

A paintball player wearing appropriate eye protection against impact.

Each day, about 2000 US workers have a job-related eye injury that requires medical attention. Eye injuries can happen through a variety of means. Most eye injuries occur when solid particles such as metal slivers, wood chips, sand or cement chips get into the eye. Smaller particles in smokes and larger particles, such as broken glass also account for particulate matter causing eye injuries. Blunt force trauma can occur to the eye when excessive force comes into contact with the eye. Chemical burns, biological agents, and thermal agents, from sources such as welding torches and UV light also contribute to occupational eye injury.

While the recommended usage of eye protection varies by occupation, the provision of safety furnished by said piece of equipment can be generalized. Safety glasses provide minimum protection from external debris, and are recommended to provide side protection via a wrap-around design or via side shields. Goggles provide better protection than safety glasses, and are effective in preventing eye injury from chemical splashes, impact, dusty environments and welding. It is recommended that goggles with high air flow be used, in order to prevent fogging. Face shields are a useful form of additional protection to be worn over the standard eyewear, and provide protection from impact, chemical, and blood-borne hazards. Full-facepiece respirators are considered the best form of eye protection when respiratory protection is needed as well, but may be less effective against potential impact hazards to the eye. Eye protection used for welding operations is shaded to different degrees, depending on the specific operation.

Hearing protection

Industrial noise is often overlooked as an occupational hazard, as it is not visible to the eye. Overall, about 22 millions workers in the United States are exposed to potentially damaging noise levels each year. Occupational hearing loss accounted for 14% of all occupational illnesses in 2007, with about 23,000 cases significant enough to cause permanent hearing impairment. About 82% of occupational hearing loss cases occurred to workers in the manufacturing sector. The Occupational Safety and Health Administration establishes occupational noise exposure standards.[9] NIOSH recommends that worker exposures to noise be reduced to a level equivalent to 85 dBA for eight hours to reduce occupational noise-induced hearing loss.

PPE for hearing protection consists of earplugs and earmuffs. Workers who are regularly exposed to noise levels above the NIOSH recommendation should be furnished hearing protection by the employers, as they are a low-cost intervention.

Protective clothing and ensembles

A complete PPE ensemble worn during high pressure cleaning work.

This form of PPE is all-encompassing and refers to the various suits and uniforms worn to protect the user from harm. Lab coats worn by scientists and ballistic vests worn by law enforcement officials, which are worn on a regular basis, would fall into this category. Entire sets of PPE, worn together in a combined suit, would also fall into this category.

Ensembles

Below are some examples of ensembles of personal protective equipment, worn together for a specific occupation or task, to provide maximum protection for the user.

Chainsaw protection (especially a helmet with face guard, hearing protection, kevlar chaps, anti-vibration gloves, and chainsaw safety boots). Specific information about chainsaw protection appears in the chainsaw safety clothing article.

Bee-keepers wear various levels of protection depending on the temperament of their bees and the reaction of the bees to nectar availability. At minimum most bee keepers wear a brimmed hat and a veil made of hardware cloth similar to window-screen material. The next level of protection involves leather gloves with long gauntlets and some way of keeping bees from crawling up one's trouser legs. In extreme cases, specially fabricated shirts and trousers can serve as barriers to the bees' stingers.

Diving equipment, for underwater diving, constitute of equipment such as a diving mask, an underwater breathing apparatus, a diving suit or wetsuit, and flippers.

Firefighters wear PPE designed to provide protection against fires and various fumes and gases. PPE worn by firefighters include bunker gear, self-contained breathing apparatus, a helmet, safety boots, and a PASS device.

3.3.1.4 Work equipment

The term “work equipment” applies to any machine, apparatus, tool or installation used at work, ranging from hand tools to the main engines. The exception to this is the safety equipment and apparatus provided in compliance with SOLAS requirements, which is subject to other merchant shipping regulations.

In practice, work equipment supplied by the ship is generally the responsibility of the Company.

Any equipment made available to workers should comply with any relevant standards laid down in regulations and maintained in accordance with manufacturer's instructions. Equipment not covered by specific regulations or type approvals should comply with the appropriate British Standard or its nearest international equivalent.

The employer is responsible for ensuring that workers are properly trained to use any equipment they need to do their job.

Instruction does not necessarily have to be a formal training course. All instruction or information must be in a language that those concerned understand, and communicated effectively.

Hatches

Any hatch covering must be of sound construction and material, fi t for purpose, free from patent defect and properly maintained.

The master must ensure that:

- a hatch covering is only used if it can be removed and replaced without endangering personnel
- a hatch is not used unless the covering has been completely removed or properly secured
- only an competent person operates a power-operated hatch covering, except in the event of an emergency.

Lifting plant

Maritime Rule Part 49 deals with the use, handling and testing of lifting plant aboard ship.

"Lifting appliance" means (for the purposes of Maritime Rules 49.4 to 49.11 inclusive) any stationary cargo-handling appliance on board a ship used for suspending, raising or lowering loads or moving loads from one position to another while they are suspended or supported.

For the purposes of Rule 49.12 it means any appliance or gear fitted in or carried by the ship and used in the ship's machinery spaces to lift any item associated with the operation, maintenance and servicing of such spaces.

The Rules require, amongst other things, that the owner and master of a ship must ensure that:

- a certificate of test is obtained for every lifting appliance and every item of loose gear carried on the ship and that the validity of the certifi cate of test is maintained
- every lifting appliance and every item of loose cargo gear carried on the ship I maintained in good repair and working order
- a person using a lifting appliance on a ship or any item of loose cargo gear carried by the ship must:
  - do so in a safe and proper manner; and

  - not load the lifting appliance or gear beyond its safe working load or loads, except for testing purposes required by Rule 49.5, in which case it must be loaded and used under the direction of a competent person
- no person may use a ship's lifting appliance or item of loose cargo gear unless there is in force for that lifting appliance or item of loose cargo gear a valid certificate of test.

Lifting plant should be kept in good, efficient working order and in good repair. Systematic preventative maintenance should be carried out, following any manufacturer's instructions. This should include regular inspection by a competent person to assess whether the lifting plant is safe for continued use.

The master is required to ensure that any one-trip sling, pre-slung cargo sling, or any pallet or similar piece of equipment for supporting loads or lifting attachment that forms an integral part of the load is not used unless it is of good construction, adequate strength for the purpose for which it is used and free from patent defect.

Only those trained and competent to do so, may operate any ship's lifting plant. The same applies to the operation of ship's ramp or a retractable car deck, except in the event of an emergency endangering health and safety.

Training should consist of theoretical instruction enabling the trainee to appreciate the factors affecting the safe operation of the lifting plant, and supervised practical work with the appropriate plant etc. Employers may issue certificates to personnel who have successfully completed training, specifying the type of appliance on which the test was carried out.

Employers should keep records of training and testing undertaken, and should ensure the routine monitoring of the competence of those operating lifting appliances.

<u>Testing and examination of lifting equipment</u>

The employer and the master are responsible for ensuring that:

- no lifting plant on board ship is used:
  - after manufacture or installation, or
  - after any repair or modification that is likely to alter the safe working load, or affect the lifting plant's strength or stability, without first being tested by a competent person
- no lifting appliance on board ship is used unless it has been suitably tested by a competent person within the preceding five years
- no lifting plant is used unless it has been thoroughly examined by a competent person at least once in every 12-month period.

<u>Competent person</u>

"Competent person" means a person, who in relation to ship's lifting appliances and loose cargo gear, is authorised to carry out any testing, thorough examination and issue of certificates of test required by this Part. They may be authorised by one of the following:

- the manufacturer of that equipment, or
- a classifi cation society in pursuance of a scheme of classifi cation or certification of such equipment, or
- a testing establishment recognised by:
  - (for a New Zealand ship or a foreign ship) the Director
  - (for a foreign ship) the Flag State Administration
- an international or national inspection agency approved by:
  - (for a New Zealand ship or a foreign ship) the Director
  - (for a foreign ship) the Flag State Administration
- •a Flag State Administration.

Thorough examination

"Thorough examination" means a detailed visual examination by a competent person, supplemented if necessary by other means or measures of examination, to arrive at a reliable conclusion as to the safety of the lifting appliance or item of loose cargo gear examined.

The owner or master of a ship must ensure that every lifting appliance on the ship and every item of loose cargo gear carried by the ship is thoroughly examined by a competent person at least once in every 12 months.

The competent person must ensure that the completion of a satisfactory thorough examination is recorded in the register of equipment required by Rule 49.9.

If on completion of a thorough examination the competent person considers the lifting appliance or item of loose cargo gear is unsatisfactory, that lifting appliance or item of loose cargo gear must not be used until any defect is remedied to the satisfaction of a competent person.

Marking lifting equipment

The master of a ship must ensure that no lifting appliance on a ship and no item of loose cargogear carried by the ship is used in loading or unloading a ship unless:

- the lifting appliance is clearly and permanently marked with its safe working load for each operating condition
- the item of loose cargo gear is clearly and permanently marked with its safe working load
- the safe working load or loads of a ship's lifting appliance and safe working load of loose cargo gear carried on a ship must be marked on each lifting appliance and item of loose cargo gear by a competent person, having regard to the design, strength, material of construction and proposed use of the lifting appliance or gear.

Register of equipment

The master of a ship must ensure that a register of equipment listing all the ship's lifting appliances and items of loose cargo gear, stating their safe working loads, is kept and maintained on board in accordance with the requirements of Rule Part 49.

The register must record particulars of all tests undertaken or certificates of test issued as required by Rule 49.5, examinations undertaken as required by Rule 49.6, inspections undertaken as required by Rule 49.7(1) that prove unsatisfactory, and any heat treatment, maintenance, repair or replacement of lifting appliances or loose cargo gear.

A register of equipment may be kept in any convenient form, provided each entry is clearly legible and is authenticated by the responsible person.

Rigging plan

The owner and the master of a ship fi tted with derricks or cranes for working cargo must ensure that the ship has on board a fully detailed rigging plan and any other relevant information necessary to permit the safe rigging of the ship's derricks or cranes, and associated gear.

Access to ships' holds, cargo decks and cranes

When a ship is being loaded or unloaded alongside a quay or another ship, adequate and safe means of access to the ship is required, properly installed, secured and adjusted to suit tidal conditions.

From a wharf (quay), access to the ship must be by means of a gangway with nets slung from the ship's side to the opposite side of the gangway, or an enclosed solid structure, or by other means that will prevent a person falling from the gangway and landing on the wharf or in the water.

Access to a ship's hold, cargo deck or crane may be by means of:

- a fixed stairway or where this is not practicable, a fixed ladder or cleats or cups of suitable dimensions, of adequate strength and proper construction. In no case shall any straight ladder exceed 6 m in length without a landing or rest point
- alternative means of access such as certified man cages, which may be supported by a spreader.

So far as is reasonably practicable, the means of access will be separate from the hatchway opening.

Only a competent person is to be permitted to open or close power-operated hatch covers.

The hatch covers are not to be opened or closed while any person is liable to be injured by the operation of the covers.

Before loading or unloading takes place, any hatch cover or beam that is not adequately secured against displacement is to be removed.

Hatch covers and beams are not to be removed or replaced while work is in progress in the hold under the hatchway.

The provisions of this section will apply, with appropriate modification and application, to power operated ship's equipment such as a door in the hull of a ship, a ramp, a retractable deck or similar equipment.

A safe means of escape must always be available.

Machinery

All dangerous parts of machinery are to be effectively guarded, unless they are in such a position or of such construction as to be as safe as they would be if effectively guarded.

Only an authorised person is to be permitted to:

- remove any guard where this is necessary for the purpose of the work being carried out
- remove a safety device or make it inoperative for the purpose of cleaning, adjustment or repair.

If any guard is removed, adequate precautions must be taken, and the guard shall be replaced as soon as practicable.

If any safety device is removed or made inoperative, the device will be replaced or its operation restored as soon as practicable and measures taken to ensure that the relevant equipment cannot be used or inadvertently started until the safety device has been replaced or its operation restored.

3.3.1.5 Safety induction

All new personnel joining a vessel (other than passengers) must undergo a safety induction by a responsible officer which must, as a minimum, cover the requirements of the relevant parts of the

STCW Code attached to the International Convention on Standards of Training, Certification and Watchkeeping 1978 as amended in 1995 (STCW 95).

This training should cover:

personal survival techniques

- fire prevention and fi re fighting
- elementary first aid
- personal safety and social responsibilities.

The statutory content of such training is set out in section A-VI/I Tables 1-4 of the STCW Code.

It is recommended that each company should design and implement a standard induction programme for each vessel, covering the STCW requirements, and incorporating any expanded detail specific to that vessel's particular needs.

This chapter gives guidance on the subjects to be covered.

On completion of the standard safety induction, it is also recommended that new personnel receive departmental induction covering safe working practices, areas of responsibility, departmental Standing Orders, and training/certification requirements to operate specific machinery or undertake specific tasks.

3.3.1.6 Fire precautions

The prevention of fi re on board ship is of utmost importance. Significant organizational measures can be taken to reduce the risk of fi re.

Smoking

Conspicuous warning notices should be displayed in any part of the ship where smoking is forbidden (permanently or temporarily) and observance of them should be strictly enforced.

Ashtrays or other suitable containers should be provided and used at places where smoking is authorised.

Electrical and other fittings

All electrical appliances should be firmly secured and served by permanent connections whenever possible.

Flexible leads should be as short as practicable and so arranged as to prevent their being chafed or cut in service.

Makeshift plugs, sockets and fuses should not be used.

Circuits should not be overloaded since this causes the wires to overheat, destroying insulation and thus resulting in a possible short-circuit that could start a fi re. Notices should be displayed warning that approval should be obtained from a responsible officer to connect any personal electrical appliances to the ship's supply.

All portable electrical appliances, eg lights should have insulation readings taken before use, and should be isolated from the mains after use.

Electrical equipment that is to be used in any cargo area should be of an approved design.

All fixed electric heaters should be fitted with suitable guards securely attached to the heater and the guards maintained in position at all times. Drying clothing on or above the heaters should not be permitted – suitably designed equipment should be supplied or areas designated.

When using drying cabinets or similar appliances, the ventilation apertures should not be obscured by overfilling of the drying space. Any screens or fi ne mesh covers around the ventilation apertures should be regularly inspected and cleaned, so that they do not become blocked by accumulated fluff from clothing.

The use of portable heaters should be avoided wherever possible. If they are required while the ship is in port (as temporary heating during repairs and as additional heating during inclement weather) a protective sheet of a non-combustible material should be provided to stand them on to protect wooden floors or bulkheads, carpets or linoleum. Portable heaters should be provided with suitable guards and should not be positioned close to furniture or other fittings. These heaters should never be used for drying clothes.

Personal portable space-heating appliances of any sort should not be used at sea and notices to this effect should be displayed.

The construction and installation of electric heaters should always be carried out in accordance with the relevant regulations and instructions or guidance supplied by the manufacturer.

Spontaneous combustion

Dirty waste, rags, sawdust and other rubbish – especially if contaminated with oil – may generate heat spontaneously that may be sufficient to ignite flammable mixtures or may set the rubbish itself on fire. Such waste and rubbish should therefore be properly stored until it can be safely disposed of.

Materials in ship's stores, including linen, blankets and similar absorbent materials are also liable to ignite by spontaneous combustion if damp or contaminated by oil.

Strict vigilance, careful stowage and suitable ventilation are necessary to guard against such a possibility. If such materials become damp, they should be dried before being stowed away. If oil has soaked into them, they should be cleaned and dried, or destroyed. They should not be stowed in close proximity to oil or paints, or on or near to steam pipes.

Machinery spaces

All personnel should be made fully aware of the precautions necessary to prevent fi re in machinery spaces in particular, the maintenance of clean conditions, the prevention of oil leakage and the removal of all combustible materials from vulnerable positions.

Suitable metal containers should be provided for the storage of cotton waste, cleaning rags or similar materials after use. Such containers should be emptied at frequent intervals and the content safely disposed of.

Wood, paints, spirits and tins of oil should not be kept in boiler rooms or machinery spaces including steering gear compartments.

All electric wiring should be well maintained and kept clean and dry. The rated capacity of the wires and fuses should never be exceeded.

Galleys

Galleys and pantries present particular fire risks. Care should be taken in particular to avoid overheating or spilling fat or oil and to ensure that burners or heating plates are shut off when cooking is finished. Extractor flues and ranges etc. should always be kept clean.

Means to smother fat or cooking oil fi res, such as a fi re blanket, should be readily available close to stoves. Remote cut-offs and stops should be conspicuously marked and known to galley staff.

3.3.1.7 Emergency procedures

Action in the event of fire

The risk of fire breaking out on board a ship cannot be eliminated but its effects will be much reduced if the advice given in this chapter is conscientiously followed.

Training in fire-fighting procedures and maintenance of equipment should be assured by regular drills. Access to fire-fighting equipment should be kept clear at all times and emergency escapes and passageways should never be obstructed.

A fi re can usually be put out most easily in its first few minutes. Prompt and correct action is essential.

The alarm should be raised and the bridge informed immediately. If the ship is in port, the local fire authority should be called. If possible, an attempt should be made to extinguish or limit the fire by any appropriate means readily available, either using suitable portable extinguishers or by smothering the fire, eg for a fat or oil fi re in the galley.

The different types of portable fi re extinguishers on board are appropriate to different types of fire. Water extinguishers should not be used on oil or electric fi res.

Openings to the space should be shut to reduce the supply of air to the fi re and to prevent it spreading. Any fuel lines feeding the fi re or threatened by it should be isolated. If practicable combustible materials adjacent to the fi re should be removed.

If a space is filling with smoke and fumes, any personnel not properly equipped with breathing apparatus should get out of the space without delay. If necessary, escape should be effected by crawling on hands and knees because air close to deck level is likely to be relatively clear.

After a fi re has been extinguished, precautions should be taken against its spontaneous reignition.

Personnel should not re-enter a space in which a fi re has occurred without wearing breathing apparatus until it has been fully ventilated.

Musters and drills

Musters and drills are required to be carried out regularly in accordance with Maritime Rules.

Musters and drills are designed to prepare a trained and organized response to dangerous situations, which may unexpectedly threaten loss of life at sea. It is important that they should be carried out realistically, approaching as closely as possible to emergency conditions.

Changes in the ship's function and changes in the ship's personnel from time to time should be reflected in corresponding changes in the muster arrangements.

The muster list must be conspicuously posted before the ship sails and, on international voyages and where appropriate should be supplemented by emergency instructions for each crew member (eg in the form of a card issued to each crew member or affixed to individual crew berths and bunks). These instructions should describe the allocated assembly and action, if any, to be taken on hearing such signals.

Drills and training

An abandon ship drill and a fi re drill must be held within 24 hours of leaving port if more than

25% of the crew have not taken part in drills on board the ship in the previous month.

As soon as possible but not later than two weeks after joining the ship, onboard training in the use of the ship's life-saving appliances, including survival craft equipment, must be given to crew members.

As soon as possible after joining the ship, crew members should also familiarize themselves with their emergency duties, the significance of the various alarm systems and the locations of their lifeboat station and of all lifesaving and fi re fighting equipment.

All the ship's personnel concerned should muster/assemble at a drill wearing lifejackets properly secured. The lifejackets should continue to be worn during lifeboat drills and launchings but in other cases may be subsequently removed at the master's discretion if they would impede or make unduly onerous the ensuing practice, provided they are kept ready to hand.

The timing of emergency drills should vary so that personnel who have not participated in a particular drill may take part in the next.

Any defects or deficiencies revealed during drills and the inspections which accompany them should be made good without delay.

Fire drills

Efficient fi re-fighting demands the full co-operation of personnel in all departments of the ship. A fire drill should be held simultaneously with the first stage of the abandon ship drill. Fire-fighting parties should assemble at their designated stations.

Engine room personnel should start the fi re pumps in machinery spaces and see that full pressure is put on fire mains. Any emergency pump situated outside machinery spaces should also be started; all members of the crew should know how to start and operate the emergency pump.

The fi re parties should be sent from their designated stations to the selected site of the supposed fi re, taking with them emergency equipment such as axes and lamps and breathing apparatus. The locations should be changed in successive drills to give practice in differing conditions and in dealing with different types of fore so that accommodation, machinery spaces store rooms, galleys and cargo holds or areas of high fi re hazard are all covered from time to time.

An adequate number of hoses to deal with the assumed fi re should be realistically deployed.

At some stage in the drill, they should be tested by bringing them into use, firstly with water provided by the machinery space pump and secondly with water provided by the emergency pump alone.

The drill should extend, where practicable, to the testing and demonstration of the remote controls for ventilating fans, fuel pumps and fuel tank valves, the closing of openings and the appropriate isolation of electrical equipment.

- Fire extinguishers

Fixed fire extinguishing installations should be tested to the extent practicable.

Portable fire extinguishers should be available for demonstration of the manner of their use.

They should include the different types applicable to different kinds of fire.

At each drill, one extinguisher or more should be operated by a member of the fi re party, a different member on each occasion. Extinguishers so used should be recharged before being returned to their normal location or sufficient spares should otherwise be carried for demonstration purposes.

- Breathing apparatus

Breathing apparatus should be worn by members of the fi re-fighting parties so each member in turn has experience of its use. Search and rescue exercises should be undertaken in various parts of the ship. The apparatus should be cleaned and verified to be in good order before it is stowed; cylinders of self-contained breathing apparatus should be recharged or sufficient spare cylinders otherwise carried for this purpose.

In addition to the statutory inspection, fire appliances, fire and watertight doors, other closing appliances, and fi re detection and alarm systems which have not been used in the drill should be inspected, either at the time of the drill or immediately afterwards.

<u>Survival craft drills</u>

IMO MSC/Circ1136 sets out the current procedure for drills. Arrangements for liferaft or lifeboat drills should take account of prevailing weather conditions.

Crew members should muster wearing warm outer clothing and lifejackets properly secured.

Where appropriate, the lowering gear and chocks should be inspected and a check made to ensure that all working parts are well lubricated.

When turning out davits or when bringing boats or rafts inboard under power, seafarers should always keep clear of any moving parts.

The engines on motor lifeboats should be started and run ahead and astern. Care should be taken to avoid overheating the engine and the propeller shaft stern gland. All personnel should be familiar with the engine starting procedure.

Hand-operated mechanical propelling gear, if any, should be examined and similarly tested.

Radio life-saving appliances should be examined and tested, and the crew instructed in their use.

Water spray systems, where fitted, should be tested in accordance with the lifeboat manufacturer's instructions.

When a drill is held in port, as many as possible of the lifeboats should be cleared and swung out. Each lifeboat should be launched and manoeuvred in the water at least once every 3 months.

Where launching of free-fall lifeboats is impracticable, they may be lowered into the water provided that they are free-fall launched at least once every six months. However, this may be extended to 12 months provided that arrangements are made for simulated launching which will take place at intervals not exceeding 6 months.

When fast rescue boats/rescue boats are carried which are not also lifeboats they should be launched and manoeuvred in the water every month so far as is reasonable and practicable. The interval between such drills, must not, exceed 3 months.

Where simultaneous off-load/on-load release arrangements are provided great care should be exercised to ensure that the hooks are fully engaged before a boat is recovered, after it has been stowed and prior to launching.

Where davit-launched liferafts are carried then on-board training, including inflation, must be carried out at intervals not exceeding four months. Great care should be taken that the hook is properly engaged before taking the weight of the raft. The release mechanism should not be cocked until just prior to the raft landing in the water. If the raft used for the inflation is part of the ship's statutory equipment and not a special training raft, then it must be repacked at an approved service station.

Where the handle of the lifeboat winch would rotate during the operation of the winch, it should be removed before the boat is lowered on the brake or raised with an electric motor. If a handle cannot be removed, personnel should keep well clear of it.

Personnel in a fast rescue boat /rescue boat or survival craft being lowered should remain seated, keeping their hands inside the gunwale to avoid them being crushed against the ship's side. Lifejackets should be worn. In totally enclosed lifeboats seat belts should be secured. Only the launching crew should remain in a lifeboat being raised.

During drills, lifebuoys and lines should be readily available at the point of embarkation.

While craft are in the water, crews should practice manoeuvring the vessel by oar or the appropriate motive power and should operate the water spray system when fitted on enclosed lifeboats.

Seafarers should keep their fingers clear of the long-link when unhooking or securing clocks onto lifting hooks while the boat is in the water, and particularly if there is a swell.

Before craft in gravity davits are recovered by power; the operation of the limit switches or similar devices should be checked.

A portable hoist unit to recover a craft should be provided with a clutch or have an attachment to resist the torque. These should be checked if neither device is available, the craft should be raised by hand.

Where liferafts are carried, instruction should be given to the ship's personnel in their launching, handling and operation. Methods of boarding them and the disposition of equipment and stores on them should be explained.

The statutory scale of life-saving appliances must be maintained at all times. If the use of a liferaft for practice would bring equipment below the specified scale, a replacement must first be made available.

<u>Drills and rescue from dangerous spaces</u>

There is a statutory requirement for drills simulating the rescue of an incapacitated person from a dangerous space to be carried out every two months. Each drill should be recorded in the official log book. A drill should normally be held soon after significant changes in crew members.

Any attempt to rescue a person who has collapsed within a space should be based on a prearranged plan, which should take account of the design of the individual ship. Allocation of personnel to relieve or back-up those first into the space should be borne in mind.

Regular drills should prove the feasibility of the ship's rescue plan under different and difficult circumstances. The space should be made safe or, for operational convenience, a non dangerous space may be used, provided that it provides realistic conditions for an actual rescue.

If there are indications that the person in the space is being affected by the atmosphere, the person outside the space should immediately raise the alarm.

Assisting a casualty

Anyone on board ship may find a casualty, and everyone should know the basic priorities for action, ie the positioning of an unconscious casualty and how to give artificial respiration. These actions may save life until more qualified help arrives.

Personnel encountering a casualty should first ensure that they are not themselves at risk. If necessary the casualty should be removed from danger, or danger removed from the casualty but see below on casualties in an enclosed space.

If there is only one unconscious casualty (irrespective of the total number of casualties) immediate basic treatment should be given to the unconscious casualty, then help should be summoned

If there is more than one unconscious casualty, help should be summoned first, then appropriate treatment given, priority being any casualty with stopped breathing/heart.

If the unconscious casualty is in an enclosed space:

- personnel must not enter the enclosed space unless they are a trained member of a rescue team acting upon instruction
- help should be summoned and the master informed
- it must be assumed that the atmosphere in the space is unsafe - the rescue team must not enter unless wearing breathing apparatus
- separate breathing apparatus or resuscitation equipment should also be fitted on the casualty as soon as possible
- the casualty should be removed quickly to the nearest safe adjacent area outside the enclosed space unless their injuries and the likely time of evacuation makes some treatment essential before they are removed.

Should it be necessary to remove injured persons from a hold, the best available method should be adopted but where practicable all access openings should be opened and the following equipment used where available:

- a manually-operated davit, suitably secured over the access opening
- a cage or stretcher fitted with controlling lines at the lower end.

Casualties who have been exposed to a hazardous chemical should rest quietly and be observed for at least 24 hours in case any complications arise.

Dangerous goods

Emergency responses to spillage of dangerous goods are contained in the IMO Medical First Aid Guide and the IMO Emergency Procedures for Ships Carrying Dangerous Goods (EmS). Both of these are available either as free-standing documents or incorporated into the International Maritime Dangerous Goods (IMDG) Code.

Recommendations on emergency action differ depending on where the goods are stowed and whether a substance is gaseous, liquid or solid. When dealing with incidents involving flammable gases or flammable liquids, all sources of ignition, eg naked lights, unprotected light bulbs, electric hand tools, should be avoided.

Normally dangerous goods in packaged form can be handled without the use of special protective clothing or equipment. If the packaging has been damaged, the contents may have spilt or leaked.

Under these circumstances the emergency team may have to deal with toxic corrosive or flammable solids, liquids or vapours. Vapours may arise from a spilt substance itself or as a result of the reaction between spilt substances themselves and other materials. Eye protection should always be worn, and if hazardous dust may be encountered, respiratory protection should be used (where the substance offers a significant toxic hazard this should be self-contained breathing apparatus).

- Spillages

In general the recommendation is to wash spillages on deck overboard with copious quantities of water, and, where there is likely to be a dangerous reaction with water, from as far away as practicable.

Disposal of dangerous goods overboard is a matter for judgment by the master, bearing in mind that the safety of the crew has priority over pollution of the sea.

If it is safe to do so, spillages and leakages of substances, articles and materials identified in the IMDG Code as “marine pollutant” should be collected for safe disposal. Absorbent material should be used for liquids.

Spillages collected with absorbent material and kept in plastic bags or other receptacles may need to be stowed safely for ultimate disposal ashore. Collection of spillages with absorbent material under deck may not be fully effective, and precautions for entry into enclosed spaces should be observed.

A careful inspection for structural damage should be carried out after dealing with spillages of highly corrosive substances.

- Fire

Water is generally recommended as the fi re fighting medium for most dangerous goods at sea.

However, reference should be made to the relevant schedules.

Where possible, a package should be removed from the vicinity of the fi re. Where there is a possibility that the heat will cause chemical or physical change in the substance, or affect the integrity of a package, leading to rupture and dispersal of the contents, keeping the

packages cool may limit the hazard. Care should be exercised with those substances liable to polymerise, as this reaction can continue long after the removal of external heat.

For incidents under deck, the best course of fi re fighting will usually be to batten down the hatch, exclude all ventilation and operate the fixed fi re-fighting installation. Self-contained breathing apparatus should be worn when battening down the hatches or if there is any need to enter the space, for example after the fi re is out.

For certain substances which are highly reactive with water, only the use of dry chemical fire extinguishers is recommended. This would not preclude the use of suitable powdered inert material if available in sufficient quantity. The only alternative is the use of copious quantities of water, which will have a cooling effect on the fi re, although reacting with the substance.

Where a recommendation advises against the use of foam, this does not preclude the use of special foams.

The general fi re-fighting recommendations for a number of dangerous goods suggest that they should be jettisoned if there is a likelihood of their involvement in a fi re. Where full or nearly full container loads or other units are concerned, this may be impractical, in which case everything possible should be done to prevent the spread of fi re to those containers.

If, despite preventative measures, fi re seems likely to affect these containers, it should be borne in mind the contents may burn with explosive violence and personnel should be withdrawn accordingly.

3.3.1.8 Safe movement

Personnel are reminded to take care as they move about the ship. The following points are all too often overlooked:

- watch out for tripping hazards, and protrusions such as pipes and framing
- always bear in mind the possibility of a sudden or heavy roll of the ship
- wear suitable footwear that will protect toes against accidental stubbing and falling loads, and provide a good hold on deck and give firm support while using ladders – extra care should be taken when using ladders while wearing sea boots it is dangerous to swing on or vault over stair rails, guardrails or pipes; and to jump off hatches
- manholes and other deck accesses should be kept closed when not being used; guardrails should be erected and warning signs posted when they are open
- spillage of oil, grease or soapy water should be cleared up as soon as practicable
- areas made slippery by snow, ice or water should be treated with sand or some other suitable substance
- the presence of temporary obstacles should be indicated by appropriate warning signs
- litter and loose objects, eg tools, should be cleared up

- wires and ropes should be coiled and stowed
- lifelines should be rigged securely across open decks in rough weather
- ladders should be secured and ladder steps in good condition; care should be taken when using ladders and gangways providing access to or about the vessel, particularly when wearing gloves
- never obstruct the means of access to fi re fighting equipment, emergency escape routes and watertight doors.

Drainage

Decks that need to be washed down frequently or are liable to become wet and slippery, should be provided with effective means of draining water away. Apart from any open deck these places include the galley, the ship's laundry and the washing and toilet accommodation.

Drains and scuppers should be regularly inspected and properly maintained.

Where drainage is by way of channels in the deck, these should be suitably covered.

Duck boards, where used, should be soundly constructed and designed and maintained so as to prevent accidental tripping.

Transit areas

Where necessary for safety, walkways on decks should be clearly marked, eg by painted lines or other means. Where a normal transit area becomes unsafe to use for any reason, the area should be closed until it can be made safe again.

Transit areas should where practicable have slip-resistant surfaces. Where an area is made slippery by snow, ice or water, sand or some other suitable substance should be spread over the area. Spillages such as oil or grease should be cleaned up as soon as possible.

When rough weather is expected, life-lines should be rigged securely across open decks.

Gratings in the deck should be properly maintained and kept closed when access to the space below is not required.

Permanent fittings that may cause hazards to movement, eg pipes, single steps, framing, door arches, top and bottom rungs of ladders, should be made conspicuous by use of contrasting colouring, marking, lighting or signing. Temporary obstacles can also be hazardous and, if they are to be there for some time, they should be marked by appropriate warning signs.

When at sea, any gear or equipment stowed to the side of a passageway or walkway should be securely fi xed or lashed against the movement of the ship.

Litter and loose objects, eg tools, should not be left lying around. Wires and ropes should be stowed and coiled so as to cause least obstruction.

Particular attention should be given to areas to which shore-based workers and passengers have access, especially on deck, as they will be less familiar with possible hazards.

When deck cargo is being lashed and secured, special measures may be needed to ensure safe access to the top of, and across, the cargo.

Lighting

The level of lighting should be such as to enable obvious damage to, or leakage from, packages to be seen. When there is a need to read labels or container plates or to distinguish colours the level of lighting should be adequate to allow this, or other means of illumination should be provided.

Lighting should be reasonably constant and arranged to minimise glare and dazzle, the formation of deep shadows and sharp contrasts in the level of illumination between one area and another.

Where visibility is poor, eg due to fog, clouds of dust, or steam, which could lead to an increase in the risks of accidents occurring, the level of lighting should be increased above the recommended minimum.

Lighting facilities should be properly maintained. Broken or defective lights should be reported to the responsible person and repaired as soon as practicable.

Before leaving an illuminated area or space a check should be made that there are no other persons remaining within that space before switching off or removing lights.

Unattended openings in the deck should either be kept illuminated or be properly or safely closed before lights are switched off.

- Portable or temporary lights

When portable or temporary lights are in use, the light supports and leads should be arranged, secured or covered so as to prevent a person tripping, or being hit by moving fi ttings, or walking into cables or supports. Any slack in the leads should be coiled.

The leads should be kept clear of possible causes of damage, eg running gear, moving parts of machinery, equipment and loads. If they pass through doorways, the doors should be secured open. Leads should not pass through doors in watertight bulkheads or fi re door openings when the ship is at sea. Portable lights should never be lowered or suspended by their leads.

Where portable or temporary lighting has to be used fittings and leads should be suitable and safe for the intended usage. To avoid risks of electric shock from mains voltage, the portable lamps used in damp or humid conditions should be of low voltage, preferably 12 volts, or other suitable precautions taken.

Guarding of openings

People may fall or trip on hatchways. Hatchways open for handling cargo or stores should be closed as soon as work stops, except during short interruptions where they cannot be closed without prejudice to safety or mechanical efficiency because of the heel or trim of the ship.

The guard-rails or fencing should have not sharp edges and should be properly maintained.

Where necessary, locking devices and suitable stops or toe-boards should be provided. Each course of rails should be kept substantially horizontal and taut throughout their length.

Guard-rails or fencing should consist of an upper rail at a height of 1 m and intermediate guard rails at distances not exceeding 380 mm and the lowest rail is not to be more than 230 mm above the deck. The rails may consist of taut wire or taut chain.

Where the opening is a permanent access way, or where work is in progress which could not be carried out with the guards in place, guards do not have to be fitted during short interruptions in the work, eg for meals, although warning signs should be displayed where the opening is a risk to other persons.

Watertight doors

All members of the crew who would have occasion to use any watertight doors should be instructed in their safe operation.

Particular care should be taken when using power operated watertight doors that have been closed from the bridge. If opened locally under these circumstances the door will re-close automatically with a force sufficient to crush anyone in its path as soon as the local control has been released.

The local controls are positioned on each side of the door so that a person passing through may open the door and then reach to the other control to keep the door in the open position until transit is complete. As both hands are required to operate the controls, no person should attempt to carry any load through the door unassisted.

Notices clearly stating the method of operation of the local controls should be prominently displayed on both sides of each watertight door.

No one should attempt to pass through a watertight door when it is closing and/or the warning bell is sounding.

Shipboard vehicles

Persons selected to drive ships' powered vehicles and powered mobile lifting appliances should be fi t to do so, and have been trained for the particular category of vehicle or mobile lifting appliance to be driven, and tested for competence.

Authorizations of crew members should either be individually issued in writing or comprise a list of persons authorised to drive. These authorisations may need to be made available for inspection.

Maintenance of ships' powered vehicles and powered mobile lifting appliances should be undertaken in accordance with manufacturers' instructions.

Drivers of ships' powered vehicles and powered mobile lifting appliances should exercise extreme care, particularly when reversing.

3.3.1.9 Entering enclosed or confined spaces

Based on the findings of the hazard identification process, appropriate control measures should be put into place to protect those who may be affected. This chapter highlights suggested control measures for entry into enclosed or confined spaces.

The atmosphere of any enclosed or confined space is potentially dangerous. The space may be deficient in oxygen and/or contain flammable or toxic fumes, gases or vapours. Where possible, alternative means of working that avoid entering the space should be found.

Should there be any unexpected reduction of ventilation of those spaces that are usually continuously or adequately ventilated then such spaces should be treated as dangerous spaces.

If a deficiency of oxygen is suspected in any space, or that toxic gases, vapours or fumes could be present, the space should be treated as dangerous.

Precautions on entering dangerous enclosed or confined spaces

The following precautions should be taken before a potentially dangerous space is entered so as to make the space safe for entry without breathing apparatus and to ensure it remains safe whilst persons are within the space.

1. A competent person should make an assessment of the space and a responsible officer to take charge of the operation should be appointed
2. The potential hazards should be identified
3. The space should be prepared and secured for entry
4. The atmosphere of the space should be tested
5. A “permit-to-work” system should be used
6. Procedures before and during the entry should be instituted

Where the procedures listed above have been followed and it has been established that the atmosphere in the space is or could be unsafe, then the additional requirements including the use of breathing apparatus.

No one should enter any dangerous space to attempt a rescue without taking suitable precautions for their own safety otherwise they put their own lives at risk and may prevent the person they intended to rescue being brought out alive.

Duties and responsibilities of a competent person and of a responsible officer

A competent person is a person capable of making an informed assessment of the likelihood of a dangerous atmosphere being present or arising subsequently in the space. This person should have sufficient theoretical knowledge and practical experience of the hazards that might be met to be able to assess whether precautions are necessary.

This assessment should include consideration of any potential hazards associated with the particular space to be entered. It should also take into consideration dangers from neighbouring or connected spaces as well as the work that has to be done within the space.

A responsible officer is a person appointed to take charge of every operation where entry into a dangerous space is necessary. This officer may be the same as the competent person or another officer. Both the competent person and/or the responsible officer may be a shore-side person.

It is for the responsible officer to decide on the basis of the hazard identification process the procedures to be followed for entry into a potentially dangerous space. These will depend on whether the assessment shows:

- there is a minimal risk to the life or health of a person entering the space then or at any future time
- there is no immediate risk to health and life but a risk could arise during the course of work in the space, or
- the risk to life or health is immediate.

For inland water vessels such as harbour craft either or both the competent person and the responsible officer may only be available from shore-based personnel. No entry into a potentially dangerous space should be made in these circumstances until such suitably qualified persons are available.

Identifying potential hazards

- Oxygen deficiency

If an empty tank or other confined space has been closed for a time the oxygen content may have been reduced owing to a number of reasons:

  - ✓ rusting may have occurred due to oxygen combining with steel
  - ✓ oxygen absorbing chemicals may have been present
  - ✓ oxygen absorbing cargoes may have been carried or gases from volatile cargoes may have displaced the oxygen in tanks
  - ✓ hydrogen may have been produced in a cathodically-protected cargo tanks used for ballast
  - ✓ oxygen may have been displaced by the use of carbon dioxide or other fi re-extinguishing or fi re-preventing media, or inert gas in the tanks or inter-barrier spaces of tankers or gas carriers.
- Toxicity of oil cargoes

Hydrocarbon gases are flammable as well as toxic and may be present in fuel or cargo tanks that have contained crude oil or its products.

Hydrocarbon gases or vapours may also be present in pump rooms and cofferdams, duct keels or other spaces adjacent to cargo tanks due to the leakage of cargo.

The components in the vapour of some oil cargoes, such as benzene and hydrogen sulphide are very toxic.

- Toxicity of other substances

Cargoes carried in chemical tankers or gas carriers may be toxic.

There is the possibility of leakage from drums of chemicals or other packages of dangerous goods where there has been mishandling or incorrect stowage or damage due to heavy weather.

The trace components in inert gas such as carbon monoxide, sulphur dioxide, nitric oxide and nitrogen dioxide are very toxic.

The interaction of vegetable or animal oils or sewage with sea water may lead to the release of hydrogen sulphide which is very toxic.

Hydrogen sulphide or other toxic gases may be generated where the residue of grain or similar cargoes permeates into or chokes bilge pumping systems.

The chemical cleaning, painting or the repair of tank coatings may involve the release of solvent vapours.

- Flammability

Flammable vapours may still be present in cargo or other tanks that have contained oil products or chemical or gas cargoes.

Cofferdams and other spaces that are adjacent to cargo and other tanks may contain flammable vapours if there has been leakage into the space.

- Other hazards

Although the inhalation of contaminated air is the most likely route through which harmful substances enter the body, some chemicals can be absorbed through the skin.

Some of the cargoes carried in chemical tankers and gas carriers are irritant or corrosive if permitted to come into contact with the skin.

The disturbance of rust, scale or sludge residues of cargoes of animal, vegetable or mineral origin, or of water that could be covering such substances may lead to the release of toxic or flammable gases.

Preparing and securing the space for entry

When opening the entrance to a potentially dangerous space, precautions should be taken in case gases (unpressurised or pressurised) are released from the space.

The space should be isolated and secured against the ingress of dangerous substances by blanking off pipelines or other openings and by closing valves. Valves should then be tied or some other means used to indicate that they are not to be opened and notices placed on the relevant controls. The officer on watch should be informed.

Where necessary, any sludge or other deposit liable to give off fumes should be cleaned out.

This may in itself lead to the release of gases, and precautions should be taken.

The space should be thoroughly ventilated either by natural or mechanical means and then tested to ensure that all harmful gases are removed and no pockets of oxygen deficient atmosphere remain.

Compressed oxygen should not be used to ventilate any space.

Where necessary pumping operations or cargo movements should be suspended when entry is being made into a dangerous space.

Testing the atmosphere of the space

Testing of a space should be carried out only by persons trained in the use of equipment.

Testing should be carried out before entry and at regular intervals thereafter.

If possible, the testing of the atmosphere before entry should be made by remote means. If this is not possible, the person selected to enter the space to test the atmosphere should only do so in accordance with the additional precautions, which include the wearing of breathing apparatus.

Where appropriate, the testing of the space should be carried out at different levels.

Some monitoring equipment is designed for personal use purely to provide a warning against oxygen deficiency and hydrocarbon concentrations when there is a change in conditions. This should not be used as a means to determine whether a dangerous space is safe to enter.

- Testing for oxygen deficiency

A steady reading of at least 20% oxygen by volume on an oxygen content meter should be obtained before entry is permitted.

A combustible gas indicator cannot be used to detect oxygen deficiency.

Testing for flammable gases and vapours

The combustible gas indicator (sometimes called an explosimeter) detects the amount of flammable gas or vapour in the air. An instrument capable of providing an accurate reading at low concentrations should be used to judge whether the atmosphere is safe for entry.

Combustible gas detectors are calibrated on a standard gas. When testing for other gases and vapours reference should be made to the calibration curves supplied with the instrument.

Particular care is required should accumulations of hydrogen be suspected.

In deciding whether the atmosphere is safe to work in, a "nil" reading on a suitably sensitive combustible gas indicator is desirable but, where the readings have been steady for some time, up to 1% of lower fl ammable limit may be accepted, eg for hydrocarbons in conjunction with an oxygen reading of at least 20% by volume.

Direct measurement of trace components of inert gas (see "Toxicity of other substances") is not required when the gas freeing of the atmosphere of a tank reduces the hydrocarbon concentration from about 2% by volume to 1% of lower fl ammable limit or less in conjunction with a steady oxygen reading of at least 20% by volume, because this is suffi cient to dilute the components to a safe concentration.

If, before the commencement of gas freeing, the hydrocarbon concentration of a tank containing inert gas is below 2% by volume due to excessive purging by inert gas, then additional gas freeing is necessary to remove toxic products at the safe level without specialised equipment and trained personnel. If this equipment is not available for use, the period of gas freeing should be considerably extended.

- Testing for toxic gases

The presence of certain gases and vapours on chemical tankers and gas carriers is detected by fixed or portable gas or vapour detection equipment.

The readings obtained by this equipment should be compared with the occupational exposure limits for the contaminant given in international industry safety guides.

These occupational exposure limits provide guidance for the level of exposure to toxic substances that should not be exceeded if the health of the persons is to be protected.

However, it is necessary to know for which chemical a test is being made in order to use the equipment correctly and it is important to note that not all chemicals may be tested by these means.

When a toxic chemical is encountered for which there is no means of testing then the additional requirements should also be followed.

A combustible gas indicator will probably not be suitable for measuring levels of gas at or around its occupational exposure limit, where there is solely a toxic, rather than a flammable, risk. This level will be much lower than the flammable limit, and the indicator will probably not be sufficiently sensitive to give accurate readings.

Use of control systems

Entry into a dangerous space should be planned in advance and use should preferably be made of a "permit-to-work" system. See Chapter 16 for arrangements to be followed in a "permit-to work" system and a sample "permit-to-work" at the chapter's Annex.

For situations where a well established safe system of work exists, a checklist may be accepted as an alternative to a full "permit-to-work" provided that the principles of the "permit-to-work" system are covered and the risks arising in the dangerous space are low.

Procedures and arrangements before entry

Access to and within the space should be adequate and well illuminated.

No source of ignition should be taken or put into the space unless the master or responsible officer is satisfied that it is safe to do so.

In all cases rescue equipment should be positioned ready for use at the entrance to the space.

Rescue equipment means breathing apparatus, together with fully charged spare cylinders of air, lifelines and rescue harnesses, and torches or lamps approved for use in a flammable atmosphere, if appropriate. A means of hoisting an incapacitated person from the confined space may be required.

The number of personnel entering the space should be limited to those who actually need to work in the space. When necessary a rescue harness should be worn to facilitate recovery in the event of an accident.

At least one attendant should be detailed to remain at the entrance to the space while it is occupied.

An agreed and tested system of communication should be established between any person entering the space and the attendant at the entrance, and between the attendant at the entrance to the space and the officer on watch.

Before entry is permitted it should be established that entry with breathing apparatus is possible.

Any difficulty of movement within any part of the space, or any problems if any incapacitated person had to be removed from the space, as a result of breathing apparatus or lifelines or rescue harnesses being used, should be considered and any risks minimised.

Lifelines should be long enough for the purpose and capable of being firmly attached to the harness, but the wearer should be able to detach them easily should they become tangled.

Procedures and arrangements during entry

Ventilation should continue during the period that the space is occupied and during temporary breaks. In the event of a failure of the ventilation system any personnel in the space should leave immediately.

The atmosphere should be tested periodically while the space is occupied and personnel should be instructed to leave the space should there be any deterioration of the conditions.

If unforeseen difficulties develop, the work in the space should be stopped and the space evacuated so that the situation can be re-assessed. Permits should be withdrawn and only reissued, with any appropriate revisions, after the situation has been re-assessed.

If any personnel in a space feel in any way adversely affected they should give the pre-arranged signal to the attendant standing by the entrance and immediately leave the space.

Should an emergency occur the general (or crew) alarm should be sounded so that back-up is immediately available to the rescue team. Under no circumstances should the attendant

enter the space before help has arrived and the situation has been evaluated to ensure the safety of those entering the space to undertake the rescue.

If air is being supplied through an airline to the person who is unwell, a check should be made immediately that the air supply is being maintained at the correct pressure.

Once the casualty has been reached, the checking of the air supply must be the fi rst priority.

Unless the casualty has been gravely injured, eg a broken back, the person should be removed from the dangerous space as quickly as possible.

Procedures on completion

On expiry of the "permit-to-work", everyone should leave the space and the entrance to the space should be closed or otherwise secured against entry or alternatively, where the space is no longer a dangerous space, declared safe for normal entry.

Additional requirements for entry into a space where the atmosphere is suspect or known to be unsafe

If the atmosphere is considered to be suspect or unsafe to enter, the space should only be entered if it is essential for testing purposes, for the safety of life or of the ship, or for the working of the ship. Breathing apparatus should always be worn.

The number of persons entering the space should be the minimum compatible with the work to be performed.

Except in the case of an emergency, or where impracticable because movement in the space would be seriously impeded, two air supplies should be available. The wearer should use the continuous supply provided from outside the space while working. If it becomes necessary to change over to the self-contained supply, the user should immediately leave the space.

Precautions should be taken against any disruption to the air supply while the individual is inside the enclosed space. Special attention should be given to supplies originating from the engine room.

Where remote testing of the space is not reasonably practicable, or where a brief inspection only is required, a single air supply may be acceptable provided that the wearer of breathing apparatus can be hauled out immediately in the case of an emergency.

In addition to rescue harnesses, wherever practicable lifelines should be used. A person stationed at the entrance who has been trained in how to pull an unconscious person from a dangerous space should attend lifelines. If hoisting equipment would be required for any rescue, arrangements should be made to ensure that personnel would be available to operate it as soon as necessary.

When appropriate, portable lights and other electrical equipment should be of a type approved for use in a flammable atmosphere.

Protective clothing should be worn if there is any likelihood that chemicals, whether in liquid, gaseous or vapour form, may come into contact with the skin and/or eyes.

Breathing apparatus and resuscitation equipment

No one should enter a space where the atmosphere is unsafe or suspect without wearing breathing apparatus that they are trained to use, even to rescue another person.

Breathing apparatus for those working in a dangerous space will usually comprise a continuous supply from outside the space and a self-contained supply to enable the wearer to escape to a safe atmosphere in the event of diffi culty with, or failure of, the continuous supply. It should not be necessary to remove any part of the equipment or any protective clothing to change over to the self-contained supply.

Equipment for use with two air supplies may consist of:

- a conventional self-contained breathing apparatus of the open circuit compressed air type that has been tested for use with air line connections; or
- a compressed air line breathing apparatus incorporating an emergency self-contained supply. The compressed air line breathing apparatus should be of the demand valve type. The emergency self-contained supply should comply with the relevant parts of the appropriate Standard.

The capacity of the self-contained supply should be sufficient for the wearer to escape to a safe atmosphere. When determining this capacity it should be recognised that, under stress or in difficult conditions, the wearer's breathing rate may be in excess of the nominal breathing rate of 40 litres per minute.

The responsible officer should make sure that the supply of air from outside the space is continuous and is available only to those working in the space. Pipeline or hoses supplying air should be placed so that they are not likely to be so distorted that supply might be interrupted or damaged.

If the purpose for which such air lines are used is not immediately apparent to personnel engaged in the entry, then notices should be posted at appropriate positions.

Where a mechanical pump is being used it should frequently be checked carefully to ensure that it continues to operate properly. Any air pumped directly into a pipeline or put into reserve bottles must be fi ltered and should be as fresh as possible.

Pipelines or hoses used to supply air should be thoroughly blown through to remove moisture and it is essential that where the air supply is from a compressor sited in a machinery space, the engineer of the watch is informed so that the compressor is not shut down until the work has been completed.

Everyone likely to use breathing apparatus must be instructed by a competent person in its proper use.

The master, or responsible officer, and the person about to enter the space should undertake the full pre-wearing check and donning procedures recommended in the manufacturer's instructions.

In particular they should check that:

1. there will be sufficient clean air at the correct pressure
2. low pressure alarms are working properly
3. the facemask fits correctly against the user's face so that, combined with pressure of the air coming into the mask, there will not be an ingress of oxygen deficient air or toxic vapours when the user inhales. It should be noted that facial hair or spectacles may prevent the formation of an air-tight seal between a person's face and the facemask
4. the wearer of the breathing apparatus understands whether or not their air supply may be shared with another person and if so is also aware that such procedures should only be used in an extreme emergency
5. when work is being undertaken in the space, the wearer should keep the self-contained supply for use when there is a failure of the continuous supply from outside the space.

When in a dangerous space:

- no one should remove their own breathing apparatus
- the breathing apparatus should not be removed unless it is necessary to save their life.

It is recommended that resuscitators of an appropriate kind should be provided where any person may be required to enter a dangerous space. Where entry is expected to occur at sea, the ship should be provided with appropriate equipment. Otherwise entry should be deferred until the ship has docked and use can be made of shore side equipment.

- Maintenance of equipment for entry into dangerous spaces

All breathing apparatus, rescue harnesses, lifelines, resuscitation equipment and any other equipment provided for use in, or in connection with, entry into dangerous spaces, or for use in emergencies, should be properly maintained, inspected periodically and checked for correct operation by a competent person and a record of the inspections and checks kept.

All items of breathing apparatus should be inspected for correct operation before and after use.

Equipment for testing the atmosphere of dangerous space, including oxygen meters, should be kept in good working order and, where applicable, regularly serviced and calibrated. Due regard should be paid to manufacturers' recommendations, which should always be kept with the equipment.

3.3.1.10 Permit to work systems

There are many types of operation on board ship where the routine actions of one person may inadvertently endanger another or when a series of action steps need to be taken to ensure the safety of those engaged in a specific operation. It is necessary, before the work is done, to identify the hazards and then to ensure that they are eliminated or effectively controlled.

Ultimate responsibility rests with the employer to see that this is done.

The permit-to-work system consists of an organised and pre-defined safety procedure. A permit-to-work does not in itself make the job safe, but contributes to safety.

The particular circumstances of individual ships will determine when permit-to-work systems should be used.

In using a permit-to-work, the following principles apply:

- the permit should be relevant and accurate. It should state the location and details of the work to be done, the nature and results of any preliminary tests undertaken, the measures undertaken to make the job safe and the safeguards that need to be taken during the operation
- the permit should specify the period of its validity (which should not exceed 24 hours) and any time limits applicable to the work which it authorises
- only the work specified on the permit should be undertaken
- before signing the permit, the authorising officer should ensure that all measures specified as necessary have in fact been taken
- the authorising officer retains responsibility for the work until he has either cancelled the permit or formally transferred it to another authorised person who should be made fully conversant with the situation. Anyone who takes over, either as a matter of routine or in an emergency, from the authorising officer, should sign the permit to indicate transfer of full responsibility
- the person responsible for carrying out the work should countersign the permit to indicate his understanding of the safety precautions to be observed
- the person completing the work should notify the responsible officer that the work has been done and get the permit cancelled.

3.3.1.11 Manual handling

Based on the findings of the hazard identification process, appropriate control measures should be put into place to protect those who may be affected.

The assessment should take full account not only of the characteristics of the load and the physical effort required, but also of the working environment (eg ship movement, confined space, high or low temperature, physical obstacles such as steps or gangways) and any other relevant factors (eg the age and health of the person, the frequency and duration of the work).

General

The term "manual handling" is used to describe any operation which includes any transporting or supporting of a load, lifting, putting down, pushing, pulling, carrying or moving by hand or by bodily force. This guidance is generally concerned with preventing musculo-skeletal injury.

Musculo-skeletal injuries can occur as a result of accident, poor organisation or an unsatisfactory working method.

Role of employers

So far as reasonably practicable, the employer must take appropriate measures or provide the means to avoid the need for any manual handling operations which may cause injury to workers, for example by re-organisation of the work, or automating or mechanising the operation.

Before instructing personnel to lift or carry by hand where there is a risk of injury, employers should consider whether alternative means of doing the same job would reduce the risk of injury.

Where there is no practical alternative to manual handling, it is recommended that the employer:

- carry out an assessment of the manual handling operations, taking into account the factors
- take appropriate steps to reduce the risk of injury
- provide workers with a general indication, and where it is available, precise information on:
    - the weight of each load
    - where the centre of gravity of any load is not positioned centrally, the heaviest side of the load
- provide workers with proper training and information on how to handle loads correctly and the risks to their health and safety from incorrect handling.

Means of reducing the risk of injury may include:

- re-organisation of work stations (to enable workers to maintain good posture while lifting and carrying)
- taking account of an individual's capabilities when allocating tasks.

There are often severe limitations in a ship on the improvements that can be made, but the employer should ensure that, as far as reasonably practicable, risks have been minimised.

Instruction for personnel may involve experienced and properly trained personnel demonstrating best practice especially to new recruits.

3.3.1.12 Use of work equipment

Based on the findings of the hazard identification process, appropriate control measures should be put into place to protect those who may be affected.

Use of tools and equipment

Tools should be used only for the purpose for which they were designed. Personnel should ensure that they use the correct tools or equipment for a task. Use of unsuitable tools or equipment may lead to accidents.

Loose clothing or jewellery should never be worn while using machinery, as there is a risk that it may become caught in moving parts and long hair should be tied back and covered with a hair net or safety cap.

Only those competent to use equipment should do so. New recruits should always be shown how to use any equipment that may injure them or another person if it is carelessly or incorrectly handled or used.

Incorrect use of tools and equipment can cause accidents, as well as damage to the equipment in question. Instructions for use should always be consulted and followed, where they are available.

When not in use equipment should be stowed in a tidy and correct manner. Any cutting edges should be protected.

Hand tools

Damaged or worn tools should not be used and cutting edges should be kept sharp and clean.

A competent person should carry out repairs and dressing of tools.

Wherever practicable, a tool in use should be directed away from the body, so that if it slips it does not cause injury. However, when using a spanner more control is gained by pulling towards the body. When using a tool with a cutting edge, both hands should be kept behind the blade.

A chisel is best held between thumb and base of index finger with thumb and fingers straight, palm of hand facing towards the hammer blow. A saw should not be forced; it should be pushed with a light, even movement.

Portable power operated tools and equipment

Power operated equipment may be dangerous unless properly maintained, handled and used and should only be used by competent persons. The flexible cables of electric tools should comply with the relevant Standard.

Before work begins, personnel should ensure that power supply leads and hoses are in good condition, laid safely clear of all potentially damaging obstructions and do not obstruct safe passage. Where they pass through doorways, the doors should be secured open.

The risk of electric shock is increased either by perspiration or in locations which are damp, humid or have large conductive surfaces. In such conditions power tools should be operated from low voltage supplies (no more than 50 volts AC with a maximum of 30 volts to earth or 50 volts DC).

Where it is not practicable to use low voltages, other precautions such as a local isolating transformer supplying one appliance only or a high sensitivity earth leakage circuit breaker (also known as a residual current device) should be used.

The risk associated with portable electric tools also applies to portable electric lamps.

The supply to these should not exceed 24 volts.

Double insulated tools are not recommended for use on ships because water can provide a contact between live parts and the casing, increasing the risk of fatal shock.

Chain linkages or similar devices should be fitted between sections of pneumatic hose to prevent whip-lash in the event of breakage. Alternatively, safety valves can be used which close off the lines.

Accessories and tool pieces (drill bit, chisel etc) should be absolutely secure in the tool.

In particular, retaining, springs, clamps, locking levers and other built-in safety devices on pneumatic tools should be replaced after the tool piece is changed. Accessories and tool pieces should not be changed while the tool is connected to a source of power.

Correct safety guards for appliances should be securely fixed before starting any operation.

They should only be removed when the machinery is not operating. However, if removal is essential for maintenance or examination of the equipment, the following precautions should be taken:

- removal should be authorised by a responsible person, and only a competent person should carry out the work or examination
- there should be adequate clear space and lighting for the work to be done
- anyone working close to the machinery should be told what the risks are and instructed in a safe system of work and precautions to take
- a warning notice should be conspicuously posted.

During temporary interruptions to work, eg meal breaks and also at completion of a task, equipment should be isolated from power sources and left safely or stowed away correctly.

Where the work operation causes high noise levels, hearing protection should be worn. Where flying particles may be produced, the face and eyes should be protected.

The vibration caused by reciprocating tools (eg pneumatic drills, hammers, chisels) or high speed rotating tools can give rise to a permanent disablement of the hands known as “dead” or “white” fingers. Initially this appears as a numbness of the fingers and an increasing

sensitivity to cold, but in more advanced stages, the hands become blue and the finger tips swollen. Those prone to the disability should not use such equipment. Others should be advised not to use them for more than 30 minutes without a break.

Workshop and bench machines (fixed installations)

Fixed installations should only be operated by competent personnel. The operator should check a machine every time before use and ensure that all safety guards and devices are in position and operative, that all tool pieces (eg drill bits, cutting blades) are in good condition, and that the work area is adequately lit and free from clutter.

No machine should be used when a guard or safety device is missing, incorrectly adjusted or defective or when it is itself in any way faulty. If any defect is identified, the machine should be isolated from its source of power until it has been repaired.

During operations, personnel should ensure that work pieces are correctly secured in position, machine residues (eg swarf, sandings) do not build up excessively, and are disposed of in a correct and safe manner.

Whenever machinery is left unattended, even if only briefl y, the power supply should be switched off and isolated, and the machinery and any safety guards should be rechecked before resuming work.

Abrasive wheels

Abrasive wheels should be selected, mounted and used only by competent persons and in accordance with manufacturer's instructions. They are relatively fragile and should be stored and handled with care.

Manufacturers' instructions should be followed on the selection of the correct type of wheel for the job in hand. Generally, soft wheels are more suitable for hard material and hard wheel for soft material.

Before a wheel is mounted, it should be brushed clean and closely inspected to ensure that it has not been damaged in storage or transit. The soundness of a vitrified wheel can be further checked by suspending it vertically and tapping it gently. If the wheel sounds dead it is probably cracked, and should not be used.

A wheel should not be mounted on a machine for which it is unsuitable. It should fi t freely but not loosely to the spindle; if the fi t is unduly tight, the wheel may crack as the heat of the operation causes the spindle to expand.

The clamping nut should be tightened only sufficiently to hold the wheel firmly. When the flanges are clamped by a series of screws, the screws should be first screwed home with the fingers and diametrically opposite pairs tightened in sequence.

The speed of the spindle should not exceed the stated maximum permissible speed of the wheel.

A strong guard, enclosing as much of the wheel as possible, should be provided and kept in position at every abrasive wheel (unless the nature of the work absolutely precludes it use)

both to contain wheel parts in the event of a burst and to prevent an operator having contact with the wheel.

Where a work rest is provided, it should be properly secured to the machine and should be adjusted as close as practicable to the wheel, the gap normally being not more than 1.5 mm.

The side of a wheel should not be used for grinding; it is particularly dangerous when the wheel is appreciably worn.

The work piece should never be held in cloth or pliers.

When dry grinding operations are being carried on or when an abrasive wheel is being trued or dressed, suitable transparent screens should be fitted in front of the exposed part of the wheel or operators should wear properly fitting eye protectors.

Hydraulic/pneumatic/high pressure jetting equipment

Personnel using hydraulic/pneumatic/high pressure systems should have received adequate instruction and be competent to use such equipment. Manufacturers' operating guidelines should be followed at all times. Equipment should not be operated at pressures that exceed manufacturers' recommendations.

Before starting work, personnel should ensure that the equipment and supply systems are in sound condition and that incorporated safety devices are in place and functioning correctly.

Where equipment is defective or suspect, systems should be shut down, isolated and depressurised to allow effective replacement or repair. Competent personnel should carry out such repairs using approved components only.

Before activating a pressure system, and also when closing down, the recommended checks should be made to ensure that no air pockets or trapped pressure are in the system, as these may cause erratic operation.

When handling hydraulic fluid, personnel should ensure that:

- the correct grade is used, when topping up systems
- spills are cleaned up immediately
- any splashes of such fluid onto the skin are cleaned off immediately – many such fluids are mineral based
- naked lights are kept away from equipment during service/test periods – hydraulic fluids may give off vapours which may be flammable.

Operators using high pressure jetting equipment should wear the correct protective equipment. Such systems may involve use of a heated supply source and protection against splashing and scalding may be needed. Warning notices should be displayed on approaches to areas where such work is being undertaken to warn other personnel. Care should be taken to ensure that the direction of such jetting is safe.

When compressed air is used, the pressure should be kept no higher than is necessary to undertake the work.

Compressed air should not be used to clean the working space, and in no circumstances should it be directed at any part of a person's body.

Hydraulic jacks

Jacks should be inspected before use to ensure that they are in a sound condition and that the oil in the reservoir reaches the minimum recommended level.

Before a jack is operated, care should be taken to ensure that it has an adequate lifting capability for the work for which it is to be used and that its foundation is level and of adequate strength.

Jacks should be applied only to the recommended or safe jacking points on equipment.

Equipment under which personnel are required to work should be properly supported with chocks, wedges or by other safe means – never by jacks alone.

Jack operating handles should be removed if possible when not required for raising or lowering the jack.

Ropes

The safety of the ship or an individual crew member is often dependent on the rope that is being used.

There are many types of rope available (both man-made and natural fibre) each with different properties and resistance to contamination by substances in use about the ship that may seriously weaken the rope.

The following table is a guide to the resistance of the main rope types but is indicative only of the possible extent of deterioration. In practice, much depends on the precise formulation of the material, the amount of contamination the rope receives and the length of time and the temperature at which it is exposed to contamination. In some cases, damage may not be apparent even on close visual inspection.

Resistance to chemicals of rope made of:

SUBSTANCE	MANILA OR SISAL	POLYAMIDE (NYLON)	POLYESTER	POLYPROPYLENE
Sulphuric (battery) acid	None	Poor	Good	Very good
Hydrochloric acid	None	Poor	Good	Very good
Typical rust remover	Poor	Fair	Good	Very good
Caustic soda	None	Good	Fair	Very good
Liquid bleach	None	Good	Very good	Very good
Creosote, crude oil	Fair	None	Good	Very good
Phenols, crude tar	Good	Fair	Good	Good
Diesel oil	Good	Good	Good	Good
Synthetic detergents	Poor	Good	Good	Good
Chlorinated solvents, eg trichloroethylene used in some paint and varnish removers	Poor	Fair	Good	Poor
Other organic solvents	Good	Good	Good	Good

Ropes should be stored away from heat and sunlight, if possible in a separate compartment that is dry and well ventilated, away from containers of chemicals, detergents, rust removers, paint strippers and other substances capable of damaging them.

Mooring ropes should be covered by tarpaulins or, if the ship is on a long voyage, stowed away.

Any accidental contamination should be reported immediately for cleansing or other action.

Man-made fibre ropes have high durability and low water absorption and are resistant to rot. Mildew does not attack man-made fibre ropes but moulds can form on them. This will not normally affect their strength.

Polypropylene ropes, which have the best all round resistance to attack from harmful substances, are generally preferred. However, they may be subject to degradation in strong sunlight ("actinic degradation"), and should not be exposed for long periods. They should also be of a type providing grip comparable to that of manila or sisal ropes.

New rope, 3-strand fibre rope and wire should be taken out of a coil in such a fashion as to avoid disturbing the lay of the rope.

Rope should be inspected internally and externally before use for signs of deterioration, undue wear or damage.

When using steel wire rope the following characteristics should be taken into consideration:

- strength
- rotation resistance
- fatigue resistance
- resistance to wear and abrasion
- resistance to crushing
- resistance to corrosion
- rope extension.

It is important that wires are properly installed, maintained and lubricated as appropriate to their use.

Where eyes are formed they should be made by eye splicing or using appropriate compression fittings (using swages or ferrules).

Characteristics of man-made fibre ropes

Safe handling of man-made fibre ropes requires techniques that differ from those for handling natural fibre ropes.

Man-made fibre ropes are relatively stronger than those of natural fibre and so for any given breaking strain have appreciably smaller circumferences, but wear or damage will diminish strength to a greater extent than would the same amount of wear or damage on a natural fibre rope.

Recommendations for substitution of natural fibre ropes by man-made fibre ropes are given in the following table (diameter given for 3-strand, size no for 8-strand plaited).

MANILA		POLYAMIDE (NYLON ETC)		POLYESTER (TERYLENE ETC)		POLYPROPYLENE	
Dia	Size	Dia	Size	Dia	Size	Dia	Size
48 mm	(6)	48 mm	(6)	48 mm	(6)	48 mm	(6)
56 mm	(7)	48 mm	(6)	48 mm	(6)	52 mm	(6.5)
64 mm	(8)	52 mm	(6.5)	52 mm	(6.5)	56 mm	(7)
72 mm	(9)	60 mm	(7.5)	60 mm	(7.5)	64 mm	(8)
80 mm	(10)	64 mm	(8)	64 mm	(8)	72 mm	(9)
88 mm	(11)	72 mm	(9)	72 mm	(9)	80 mm	(10)
96 mm	(12)	80 mm	(10)	80 mm	(10)	88 mm	(11)
112 mm	(14)	88 mm	(11)	88 mm	(11)	96 mm	(12)

Careful inspection of man-made fibre ropes for wear externally and internally is necessary. A high degree of powdering between strands indicates excessive wear and reduced strength. Ropes with high stretch suffer greater inter-strand wear than others. Hardness and stiffness in some ropes, polyamide (nylon) in particular, may also indicate overworking.

Unlike natural fibre ropes, man-made fibre ropes give little or no audible warning of approaching breaking point.

Rope of man-made material stretches under load to an extent that varies according to the material. Polyamide rope stretches the most.

Stretch imparted to man-made fibre rope, which may be up to double that of natural fibre rope, is usually recovered almost instantaneously when tension is released. A break in the rope may therefore result in a dangerous back-lash and an item of running gear breaking loose may be projected with lethal force. Snatching of such ropes should be avoided; where it may occur inadvertently, personnel should stand well clear of the danger areas.

The possibility of a mooring or towing rope parting under the load is reduced by proper care, inspection and maintenance and by its proper use in service.

Man-made fibre ropes may easily be damaged by melting if frictional heat is generated during use. Too much friction on a warping drum may fuse the rope with the consequential sticking and jumping of turns, which can be dangerous. Polypropylene is more liable to soften than other material.

To avoid fusing, ropes should not be surged unnecessarily on winch barrels. For this reason, a minimum of turns should be used on the winch barrel; three turns are usually enough but on whelped drums one or two extra turns may be needed to ensure a good grip; these should be removed as soon as practicable.

The method of making eye splices in ropes of man-made fibres should be chosen according to the material of the rope.

- Polyamide (nylon) and polyester (terylene) fibre ropes need four full tucks in the splice each with the completed strands of the rope followed by two tapered tucks for which the strands are halved and quartered for one tuck each respectively. The length of the splicing tail from the fi nished splice should be equal to at least three rope diameters. The portions of the splice containing the tucks with the reduced number of fi laments should be securely wrapped with adhesive tape or other suitable material.
- Polypropylene ropes should be at least three but not more than four full tucks in the splice. The protruding spliced tails should be equal to three rope diameters at least.
- Polythene ropes should have four full tucks in the splice with protruding tails of three rope diameters at least.

Mechanical fastenings should not be used in lieu of splices on man-made fibre ropes because strands may be damaged during application of the mechanical fastening and the grip of the fastenings may be much affected by slight unavoidable fluctuations in the diameter of the strands.

Man-made fibre stoppers of like material (but not polyamide) should be used on man-made fibre mooring lines, preferably using the "West Country" method (double and reverse stoppering).

Work with visual display units (VDUs)

Personnel should be given adequate individual training in the use and capabilities of VDUs. This training should be adapted to the needs and ability of the person and the type of equipment.

Any person using VDUs regularly or frequently and for lengthy periods should be given an eye test by a qualified person before beginning such work and at regular intervals thereafter. If either the eye test of examination by an ophthalmologist shows that the person needs special glasses for this work these should be provided.

VDUs should be so positioned that there is sufficient room to move, as necessary, around the equipment. Care should be taken to ensure that cables and wiring do not cause a hazard by obstructing movement.

Lighting should be adequate for the task, with glare and reflection cut to a minimum, and the display on screen should be clear and easy to read. The operator should adjust the brightness and contrast to suit the lighting. When appropriate the operator should be given short rest periods away from the equipment.

There should be adequate leg room and the chair should be comfortable and stable, with adjustable seat height and back rest. The chair should be adjusted by each user to a comfortable position for working – arms approximately horizontal and eyes at the same level as the top of the screen. The keyboard and screen should be adjusted to a comfortable position for keying and viewing.

Exceptionally, certain forms of medication may impair working efficiency on a VDU. Personnel should be aware of this possibility and should seek medical advice if necessary.

Personnel lifts and lift machinery

Before a lift is put into normal service it must be tested and examined by a competent person and a certificate or report issued.

Regular examination must be carried out by a competent person thereafter and a certificate or report issued. More detailed examination and testing of parts of the lift installation must be carried out at periodic intervals.

A person chosen to act as a competent person must have such practical experience and theoretical knowledge and actual experience of the type of lift which they have to examine, as will enable them to detect defects or weaknesses and to assess their importance in relation to the safety of the lift.

An initial hazard identification process must be made to identify hazards associated with work on each lift installation, including work requiring access to the lift trunk. Safe working

procedures must be drawn up for each lift installation. Persons who are to be authorised to carry out work on or inspection of the lift installation must comply with these procedures.

The specific areas that the hazard identification process should address should include, as appropriate:

- whether there are safe clearance above and below the car at the extent of its travel
- whether a car top control station is fitted and its means of operation
- the working conditions in the machine and pulley rooms.

Based on the findings of the hazard identification process, it is recommended that a permitto-work system, as described in Chapter 16, be adopted when it is necessary for personnel to enter the lift trunk or to override the control safety systems. It is strongly recommended that no person should work alone on lifts.

Any work carried out on lifts must only be performed by authorised persons familiar with the work and the appropriate safe working procedures. These procedures must include provision for both the safety of persons working on the lift and others who may also be at risk such as intending passengers.

Appropriate safety signs must be prominently displayed in the area and also on control equipment such as call lift buttons. Barriers must be used when it is necessary for lift landing doors to remain open to the lift trunk.

Experience indicates that the most important single factor in minimising risk of accidents is the avoidance of misunderstanding between personnel. A means of communication to the authorising officer and between those involved in working on the lift must be established and maintained at all times. This might be by telephone, portable-hand held radio or a person-to person chain. Whatever the arrangement, action should only be taken as a result of the positive receipt of confirmation that the message is understood.

Before attempting to gain access to the trunk, whenever possible the mains switch should be locked in the OFF position (or alternatively the fuses should be withdrawn and retained in a safe place) and an appropriate safety sign must be positioned at the point of such isolation. This should include both main and emergency supplies.

In addition, the landing doors should not be allowed to remain open longer than necessary; the machine room should be protected against unauthorised entry and after completion of work a check must be made to ensure that all equipment used in the operation has been cleared from the well.

When it is necessary for personnel to travel on top of a car, safety can be enhanced considerably by the use of the car top control station (comprising a stopping device and an inspection switch/ control device). Account should be taken of the arrangement and location of the control station, ie whether the stopping device can be operated before stepping on to the car top. Persons must not travel on the top of the lift car if no stopping device is fitted.

Laundry equipment

All personnel required to work in the laundry or use any part of the equipment there must be fully instructed on the proper operation of the machinery. A person under 18 years of age should not work on industrial washing machines, hydro-extractors, calendars or garment presses unless they are fully instructed as to precautions to be observed, and have received sufficient training in work at the machine or are under close supervision by a suitably experienced person.

Equipment should be inspected before use for faults and damage. Particular attention should be paid to the automatic cut-off or interlocking arrangements on washing machines, hydroextractors etc and the guards and emergency stops on presses, calendars, mangling and wringing machines.

Any defect or irregularity found during inspection, or apparent during operation of the equipment, should be reported immediately and the use of the machine discontinued until any necessary repairs or adjustments have been carried out. A notice warning against use should be displayed prominently on the defective machine.

Frequent and regular inspection, with thorough checking of all electrical equipment and apparatus, is also necessary to ensure the standard of maintenance essential for laundries.

Machines should not be overloaded and loads should be distributed uniformly.

Reliance should not be placed entirely on interlocking or cut-off arrangements on the doors of washing machines, hydro-extractors and drying tumblers etc; doors should not be opened until all movement has ceased.

3.3.1.13 Lifting plants

To ensure their stability when lifting, lifting appliances should be:

- securely anchored, or
- adequately ballasted or counterbalanced, or
- supported by outriggers.

If counterbalance weights are moveable, effective precautions should be taken to ensure that the lifting appliance is not used for lifting in an unstable condition. In particular all weights should be correctly installed and positioned.

Lifting appliances with pneumatic tyres should not be used unless the tyres are in a safe condition and inflated to the correct pressures. Means to check this should be provided.

The operator should check safety devices fitted to lifting appliances before work starts and at regular intervals thereafter to ensure that they are working properly.

<u>Controls</u>

Controls of lifting appliances should be permanently and legibly marked with their function and their operating directions shown by arrows or other simple means, indicating the position or direction of movement for hoisting or lowering, slewing or luffing etc.

Make-shift extensions should not be fitted to controls nor any unauthorised alteration made to them. Foot-operated controls should have slip-resistant surfaces.

No lifting device should be used with any locking pawl, safety attachments or device rendered inoperative. If, exceptionally, limit switches need to be isolated in order to lower a crane to its stowage position, the utmost care should be taken to ensure the operation is completed safely.

Operation

A powered appliance should always have a person at the controls while it is in operation; it should never be left to run with a control secured in the ON position.

If any powered appliance is to be left unattended with the power on, loads should be taken off and controls put in "neutral" or "off" positions. Where practical, controls should be locked or otherwise inactivated to prevent accidental restarting. When work is completed, power should be shut off.

The person operating any lifting appliance should have no other duties which might interfere with their primary task. They should be in a proper and protected position, facing controls and, so far as is practicable, with a clear view of the whole operation.

Where the operator of the lifting appliance does not have a clear view of the whole of the path of travel of any load carried by that appliance, appropriate precautions should be taken to prevent danger.

Generally this requirement should be met by the employment of a competent and properly trained signaller designated to give instructions to the operator. A signaller includes any person who gives directional instructions to an operator while they are moving a load, whether by manual signals, by radio or otherwise.

The signaller should have a clear view of the path of travel of the load where the operator of the lifting appliance cannot see it.

Where necessary, additional signallers should be employed to give instructions to the first signaller.

Every signaller should be in a position that is:

- safe; and
- in plain view of the person to whom they are signalling unless an effective system of radio or other contact is in use.

All signallers should be instructed in and should follow a clear code of signals, agreed in advance and understood by all concerned in the operation.

If a load can be guided by fixed guides, or by electronic means, or in some other way, so that it is as safely moved as if it was being controlled by a competent team of driver and signallers, signallers will not be necessary.

Use of lifting equipment

Loads should if possible not be lifted over a person or any access way, and personnel should avoid passing under a load that is being lifted.

No person should be lifted by lifting plant except where the plant has been designed or especially adapted and equipped for the purpose or for rescue or in similar emergencies.

All loads should be properly slung and properly attached to lifting gear, and all gear properly attached to appliances.

The use of lifting appliances to drag heavy loads with the fall at an angle to the vertical is inadvisable because of the friction and other factors involved and should only take place in exceptional circumstances where the angle is small, there is ample margin between the loads handles and the safe working load of the appliance, and particular care is taken. In all other cases winches should be used instead. Derricks should never be used in union purchase for such work.

Any lifts by two or more appliances simultaneously can create hazardous situations and should only be carried out where unavoidable. They should be properly conducted under the close supervision of a responsible person, after thorough planning of the operation.

Lifting appliances should not be used in a manner likely to subject them to excessive overturning moments.

Ropes, chains and slings should not be knotted.

A thimble or loop splice in any wire rope should have at least three tucks with a whole strand of rope and two tucks with one half of the wires cut out of each strand. The strands in all cases should be tucked against the lay of the rope. Any other form of splice, which can be shown as efficient as the above, can also be used.

Lifting gear should not be passed around edges liable to cause damage without appropriate packing.

Where a particular type of load is normally lifted by special gear, such as plate clamps, other arrangements should only be substituted if they are equally safe.

The manner of use of natural and man-made fi bre ropes, magnetic and vacuum lifting devices and other gear should take proper account of the particular limitations of the gear and the nature of the load to be lifted.

Wire ropes should be regularly inspected and treated with suitable lubricants. These should be thoroughly applied so as to prevent internal corrosion as well as corrosion on the outside. The ropes should never be allowed to dry out.

Lifting operations should be stopped if wind conditions make it unsafe to continue with them.

Cargo handling equipment that is lifted onto or off ships by crane or derrick should be provided with suitable points for the attachment of lifting gear, so designed as to be safe in use. The equipment should also be marked with its own gross weight and safe working load.

Before any attempt is made to free equipment that has become jammed under load, every effort should first be made to take off the load safely. Precautions should be taken to guard against sudden or unexpected freeing. Others not directly engaged in the operation should keep in safe or protected positions.

When machinery and, in particular, pistons are to be lifted by means of screw-in bolts, the eyebolts should be checked to ensure that they have collars, that the threads are in good condition and that the bolts are screwed hard down on to their collars. Screw holds for lifting bolts in piston heads should be cleaned and the threads checked to see that they are not wasted before the bolts are inserted.

Safe working load (SWL)

A load greater than the safe working load should not be lifted unless:

- the weight of the load is known and is the appropriate proof load
- the lift is a straight lift by a single appliance
- the lift is supervised by the competent person who would normally supervise a test and carry out a thorough inspection
- the competent person specifies in writing that the lift is appropriate in weight and other respects to act as a test of the plant, and agrees to the detailed plan of the lift no person is exposed to danger thereby.

Any grab fitted to a lifting appliance should be of an appropriate size, taking into account the safe working load of the appliance, the additional stresses on the appliance likely to result from the operation, and the material being lifted.

In the case of a single sheave block used in double purchase the working load applied to the wire should be assumed to equal half the load suspended from the block.

The safe working load of a lift truck means its actual lifting capacity, which relates the load which can be lifted to, in the case of a fork lift truck, the distance from the centre of gravity of the load from the heels of the forks. It may also specify lower capacities in certain situations, eg for lifts beyond a certain height.

Use of winches and cranes

The drum end of wire runners or falls should be secured to winch barrels or crane drums by proper clamps or U-bolts. The runner or fall should be long enough to leave at least three turns on the barrel or drum at maximum normal extension. Slack turns of wire or rope on a barrel or drum should be avoided as they are likely to pull out suddenly under load.

When a winch is changed from single to double gear or vice versa, any load should first be released and the clutch should be secured so that it cannot become disengaged when the winch is working.

Steam winches should be so maintained that the operator is not exposed to the risk of scalding by leaks of hot water and steam.

Before a steam winch is operated, the cylinders and steam pipes should be cleared of water by opening the appropriate drain cocks. The stop valve between winch and deck steam line should be kept unobstructed. Adequate measures should be taken to prevent steam obscuring the driver's vision in any part of a working area.

Ships' cranes should be properly operated and maintained in accordance with manufacturers' instructions. Companies, employers and masters, as appropriate, should ensure that sufficient technical information is available including the following information:

- length, size and safe working load of falls and topping lifts
- safe working load of all fittings
- boom limiting angles
- manufacturers' instructions for replacing wires, topping up hydraulics and other maintenance as appropriate.

Power operated rail mounted cranes should have the following facilities incorporated in their control systems:

- facilities to prevent unauthorised start-up
- an efficient braking mechanism that will arrest the motion along the rails, and where safety constraints require, emergency facilities operated by readily accessible controls or automatic systems should be available for braking or stopping equipment in the event of failure of the main facility
- guards that reduce as far as possible the risk of the wheels running over persons' feet, and which will remove loose materials from the rails.

When a travelling crane is moved, any necessary holding bolts or clamps should be replaced before operations are resumed.

Access to a crane should be always by the proper means provided. Cranes should be stationary while accessing.

Use of derricks

Ships' derricks should be properly rigged and employers and masters should ensure that rigging plans are available containing the following information:

- position and size of deck eye-plates
- position of inboard and outboard booms
- maximum headroom (ie permissible height of cargo hook above hatch coaming)
- maximum angle between runners
- position, size and safe working load of blocks
- length, size and safe working load of runners, topping lifts, guys and preventers
- safe working load of shackles
- position of derricks producing maximum forces
- optimum position for guys and preventers to resist maximum forces as above

- combined load diagrams showing forces for a load of 1 tonne or the safe working load
- guidance on the maintenance of the derrick rig.

The operational guidance in the remainder of this section applies generally to the conventional type of ship's derrick. For other types, such as the "Hallen" and "Stulken" derricks, manufacturers' instructions should be followed.

Runner guides should be fitted to all derricks so that when the runner is slack, the bight is not a hazard to persons walking along the decks. Where the rollers are fitted to runner guides, they should rotate freely.

Before a derrick is raised or lowered, all persons on deck in the vicinity should be warned so that no person stands in, or is in danger from, bights of wire and other ropes. All necessary wires should be flaked out.

When a single span derrick is being raised, lowered or adjusted, the hauling part of the topping lift or bull-wire (ie winch end whip) should be adequately secured to the drum end.

The winch driver should raise or lower the derrick at a speed consistent with the safe handling of the guys.

Before a derrick is raised, lowered or adjusted with a topping lift purchase, the hauling part of the span should be flaked out for its entire length in a safe manner. Someone should be available to assist the person making fast to the bitts or cleats. Where the hauling part of a topping lift purchase is led to a derrick span winch, the bull-wire should be handled in the same way.

To fasten the derrick in its final position, the topping lit purchase should be secured to bitts or cleats by first putting on three complete turns followed by four crossing turns and finally securing the whole with a lashing to prevent the turns jumping off due to the wire's natural springiness.

When a derrick is lowered on a topping lift purchase, someone should be detailed for lifting and holding the pawl bar, ready to release it should the need arise; the pawl should be fully engaged before the topping lift purchase or bull-wire is released. The person employed on this duty should not attempt or be given any other task until this operation is complete; in no circumstances should the pawl bar be wedged or lashed up.

A derrick with a topping winch, and particularly one that is self-powered, should not be topped hard against the mast, table or clamp in such a way that the initial heave required to free the pawl bar prior to lowering the derrick cannot be achieved without putting an undue strain on the topping lift purchase and its attachments.

A heel block should be secured additionally by means of a chain or wire so that the block will be pulled into position under load but does not drop when the load is released.

The derrick should be lowered to the deck or crutch and properly secured whenever repairs or changes to the rig are to be carried out.

If heavy cargo is to be dragged under deck with ship's winches, the runner should be led directly from the heel block to avoid overloading the derrick boom and rigging. Where a heavy load is to be removed, a snatch block or bull wire should be used to provide a fair-lead for the runner and to keep the load clear of obstructions.

Use of derricks in union purchase

When using union purchase the following precautions should be strictly taken to avoid excessive tensions:

- the angle between the married runners should not normally exceed 90º (or 120º in special circumstances)
- the cargo sling should be kept as short as possible so as to clear the bulwarks without the angle between the runners exceeding 90º (or 120º in special circumstances)
- derricks should be topped as high as practicable consistent with safe working
- the derricks should not be rigged further apart than is absolutely necessary.

The following examples will show how rapidly loads increase on derricks, runners and attachments as the angle between runners increases:

- at 60º included angle, the tension in each runner would be just over half the load;
- at 90º the tension would be nearly three-quarters of the load;
- at 195º the tension would be nearly 12 times the load.

When using union purchase, winch operators should wind in and pay out in step, otherwise dangerous tensions may develop in the rig.

An adequate preventer guy should always be rigged on the outboard side of each derrick when used in union purchase. The preventer guy should be looped over the head of the derrick, and as close to and parallel with the outboard guy as available fittings permit. Each guy should be secured to individual and adequate deck or other fastenings.

Narrow angles between derricks and outboard guys and between outboard guys and the vertical should be avoided in union purchase as these materially increase the loading on the guys. The angle between the outboard derrick and its outboard guy and preventer should not be too large and may cause the outboard derrick to jack-knife. In general, the inboard derrick guys and preventer should be secured as nearly as possible at an angle of 90º to the derrick.

Use of stoppers

Where fitted, mechanical topping lift stoppers should be used. Where chain stoppers are used, they should ALWAYS be applied by two half-hitches in the form of a cow hitch suitably spaced with the remaining chain and rope tail backed round the wire and held taut to the wire.

A chain stopper should be shackled as near as possible in line with the span downhaul and always to an eye plate, not passed round on a bight which would induce bending stresses similar to those in a knotted chain.

No stopper should be shackled to the same eye plate as the lead block for the span downhaul; this is particularly hazardous when the lead block has to be turned to take the downhaul to the winch or secure it to bitts or cleats.

The span downhaul should always be eased to a stopper and the stopper should take the weight before turns are removed from the winch, bitts or cleats.

Overhaul of cargo gear

When a cargo block or shackle is replaced, care should be taken to ensure that the replacement is of the correct type, size and safe working load necessary for its intended use.

All shackles should have their pins effectively secure or seized with wire.

A special check should be made on completion of the work to ensure that all the split pins in blocks etc have been replaced and secured.

On completion of the gear overhaul, all working places should be cleaned of oil or grease.

3.3.1.14 Maintenance of machineries

Before machinery is serviced or repaired, measures should be taken to prevent it being turned on or started automatically or from a remote control system:

- electrically-operated machinery should be isolated from the power supply
- steam-operated machinery should have both steam and exhaust valves securely closed and, where possible, the valves locked or tied shut or some other means employed to indicate that the valves should not be opened. The same care is required when dealing with heated water under pressure as is required when working on steam-operated machinery or pipe work
- in all cases, warning notices should be posted at or near the controls giving warning that the machinery concerned is not to be used.

Where valves or filter covers have to be removed or similar operations have to be performed on pressurised systems, that part of the system should be isolated by closing the appropriate valves. Drain cocks should be opened to ensure that pressure is off the system.

1.16 Hot work

Welding and flame-cutting elsewhere than in the workshop should generally be the subject of a “permit-to-work”.

Operators should be competent in the process, familiar with the equipment to be used and instructed where special precautions need to be taken.

Where portable lights are needed to provide adequate illumination, they should be clamped or otherwise secured in position, not hand-held, with leads kept clear of the working area.

Harmful fumes can be produced during these operations from galvanising paint and other protective materials. Oxygen in the atmosphere can be depleted when using gas cutting equipment and noxious gases may be produced when welding or cutting.

Special care should therefore be taken when welding and flame-cutting in enclosed spaces to provide adequate ventilation. The effectiveness of the ventilation should be checked at intervals while the work is in progress, and if appropriate local exhaust ventilation should be considered.

In confined spaces, breathing apparatus may be required.

Personal protective equipment

Personal protective equipment complying with the relevant Standard specifications or their equivalent must be worn by the operator and by those assisting with the operation to protect them from particles of hot metal and slag, and their eyes and skin from ultraviolet and heat radiation.

The operator should normally wear:

- welding shields or welding goggles with appropriate shade of filter. Goggles are only recommended for gas welding and flame cutting
- leather gauntlets
- leather apron (in appropriate circumstances)
- (long-sleeved natural fibre boiler suit or other approved protective clothing.

Clothing should be free of grease and oil and other flammable substances.

Pre-use equipment check

Welding and flame-cutting equipment should be inspected by a competent person before it is used to ensure that it is in a serviceable condition.

In cold weather moisture trapped in the equipment may freeze and, for example, cause valves to malfunction. It is recommended that equipment be thawed out with hot water and cloths, never with naked flames.

Precautions against fi re and explosion

Before welding, flame-cutting or other hot work is begun, a check should be made that there are no combustible solids, liquids or gases, at, below or adjacent to the area or work, which might be ignited by heat or sparks from the work.

Such work should never be undertaken on surfaces covered with grease, oil or other flammable or combustible materials.

Where necessary, combustible materials and dunnage should be moved to a safe distance before commencing operations. Such places should also be free of materials that could release flammable substance for example if disturbed.

When welding is to be done in the vicinity of open hatches, suitable screens should be erected to prevent sparks dropping down hatchways or hold ventilators.

Port holes and other openings through which sparks may fall should be closed where practicable.

Where work is being done close to or at bulkheads, decks or deckheads, the far side of the divisions should be checked for materials and substances which may ignite, and for cables, pipelines or other services which may be affected by the heat.

Cargo tanks, fuel tanks, cargo holds, pipelines, pumps and other spaces that have contained flammable substances should be certified as being free of flammable gases before any repair work is commenced.

The testing should include, as appropriate, the testing of adjacent spaces, double bottoms and cofferdams. Further tests should be carried out at regular intervals and before hot work is recommenced following any suspension of the work. When preparing tankers and similar ships all tanks, cargo pumps and pipelines should be thoroughly cleaned and particular care taken with the draining and cleaning of pipelines that cannot be directly flushed using the ship pumps.

Welding and flame-cutting operations should be properly supervised and kept under regular observation. Suitable fi re extinguishers should be kept at hand ready for use during the operation. A person with a suitable extinguisher should also be stationed to keep watch on areas not visible to the welder that may be affected.

In view of the risk of delayed fi res resulting from the use of burning or welding apparatus, frequent checks should be made for at least two hours after the work has stopped.

Electric welding equipment

In order to minimise personal harm from electric shock, electric welding power sources for shipboard use should have a direct current (DC) output not exceeding 70V, with a minimum ripple. Further information on DC power sources is given later in this chapter.

When DC equipment is not available, then AC output power sources may be used providing they have an integral voltage limiting device to ensure that the idling voltage (the voltage between electrode and work piece before an arc is struck between them) does not exceed 25V rms.

The proper function of the device (which may be affected by dust or humidity) should be checked each time a welding set is used. Some voltage limiting devices are affected by their angle of tilt from the vertical, so it is important that they are mounted and used in the position specified by the manufacturers. This requirement can be affected by adverse sea conditions.

A “go-and-return” system using two cables from the welding set should be adopted the welding return cable should be fi rmly clamped to the workpiece.

Earthing of the workpiece is used to provide protection against internal insulation failure of the welding transformer, by keeping the workpiece at or near earth potential until the protective device (eg a fuse) operates to cut off the main supply.

Where the welding circuit is not adequately insulated from the earthed referenced mains supply, the workpiece should be earthed. The "return" cable of the welding set and each workpiece should be separately earthed to the ship's structure. The use of a single cable with hull return is not recommended.

The workpiece earthing conductor should be robust enough to withstand possible mechanical damage and should be connected to the workpiece and a suitable earth terminal by bolted lugs or secure screw clamps.

Note: some manufacturers may recommend earthing as one of their measures to reduce the electrical interference. This is not a safety related measure, but the manufacturers' advice should be followed.

If an alternative method of protecting against welding transformer insulation failure is used, the hazards caused by stray welding currents can be avoided by not earthing the workpiece or the welding output circuit. It should be noted, that other equipment connected to the workpiece may require earthing for safe operation (eg electrical pre-heating systems).

The lead and return cables should be of the minimum length practicable for the job and of an appropriate cross-section to avoid voltage drop in transmission

Cables should be inspected before use; if the insulation is impaired or conductively reduced, they should not be used.

Cable connectors should be fully insulated when connected, and so designed and installed that current carrying parts are adequately recessed when disconnected.

Electrode holders should be fully insulated so that no live part of the holder is exposed to touch, and, where practicable, should be fitted with guards to prevent accidental contact with live electrodes and as protection from sparks and splashes of weld metal.

A local switching arrangement or other suitable means should be provided for rapidly cutting off current from the electrode should the operator get into difficulties and also for isolating the holder when electrodes are changed.

The direct current output from power sources should not exceed 70V open circuit. The ripple on the output from the power source should not exceed the values of the table below. The ripple magnitudes are expressed as percentages of the DC, and the ripple peak is that with the same polarity as the DC.

RIPPLE FREQUENCY HZ	50/60	300	1200	2400
Max. RMS O/C voltage ripple (%)	5	6	8	10
Max. peak O/C voltage ripple (%)	10	12	16	20

The conditions in the table above are normally met by DC generators incorporating commutators and by rectifier power sources having a 3 phase bridge rectifier operating from a 3 phase 50/60 Hz supply. Rectifier power sources should not be operated from a power supply of less than 50Hz.

Should it be necessary to use a power source with a DC output having a ripple magnitude in excess of those stated in the table, for example a single phase rectifier power source, then a voltage limiting device should be incorporated in the power source to ensure that the idling voltage does not exceed 42V.

Precautions to be taken during electric arc welding

In addition to the protective clothing the welding operator should wear nonconducting safety footwear. Clothing should be kept as dry as possible as some protection against electric shock – it is particularly important that gloves should be dry as wet leather is a good conductor.

An assistant should be in continuous attendance during welding operations. The assistant should be alert to the risk of accidental shock to the welder, and ready to cut off power instantly, raise the alarm and provide artificial respiration without delay. It may be desirable to have a second assistant if the work is to be carried out in difficult conditions.

Where persons other than the operator are likely to be exposed to harmful radiation or sparks from electric arc welding, they should be protected by screens or other effective means.

In restricted spaces, where the operator may be in close contact with the ship's structure or is likely to make contact in the course of ordinary movements, protection should be provided by dry insulating mats or boards.

There are increased risks of electric shock to the operator if welding is done in hot or humid conditions because body sweat and damp clothing greatly reduce body resistance. Under such conditions, the operation should be deferred until such time that an adequate level of safety can be achieved.

Under no circumstances should welders work while standing in water or with any part of their body immersed.

The electrode holder should be isolated from the current supply before a used electrode is removed and before a new electrode is inserted. This precaution is necessary because some

electrode coatings have extremely low resistance. Even a flux coating that is normally insulating can become damp from sweating hands and thus potentially dangerous.

When the welding operation is completed or temporarily suspended, the electrode should be removed from the holder.

Hot electrode ends should be ejected into a suitable container; they should not be handled with bare hands.

Spare electrodes should be kept dry in their container until required for use.

Compressed gas cylinders

Compressed gas cylinders should always be handled with care, whether full or empty. They should be properly secured and stored in a location appropriate to their intended use and risks which inadvertent release of gas may present.

The cylinders should be so secured as to be capable of quick and easy release, for example, in the case of fire. If available, cylinder trolleys should be used to transport cylinders from one place to another.

The protective caps over the valve should be screwed in place when the cylinders are not in use or are being moved. Valves should be closed when the cylinder is empty.

Where two or more cylinders of either oxygen or a fuel gas (such as acetylene) are carried the oxygen and the fuel gas should be stowed in separate, well-ventilated compartments that are not subject to extremes of temperature.

The space in which acetylene or other fuel gas cylinders are stowed should have no electrical fittings or other sources of ignition and prominent and permanent NO SMOKING signs should be displayed in the entrance and within the space. Empty cylinders should be segregated from the full ones and so marked.

The following special precautions need to be taken in the case of cylinders of oxygen and acetylene or other fuel gases:

- cylinders valves, controls and associated fittings should be kept free from oil, grease and paint; controls should not be operated with oily hands
- gas should not be taken from such cylinders unless the correct pressure reducing regulator has been attached to the cylinder outlet valve
- cylinders found to have leaks that cannot be stopped by closing the outlet valve should be taken to the open deck away from any sources of heat or ignition and slowly discharged to the atmosphere.

Gas welding and cutting

While this section deals almost exclusively with oxygen and acetylene, other fuel gases may be used and similar precautions should be taken.

The pressure of oxygen used for welding should always be high enough to prevent acetylene flowing back into the oxygen line.

Acetylene should not be used for welding at a pressure exceeding 1 atmosphere gauge as it is liable to explode, even in the absence of air, when under excessive pressure.

Non-return valves should be fitted adjacent to the torch in the oxygen and acetylene supply lines.

Flame arrestors should be provided in the oxygen and acetylene supply lines and will usually be fitted at the low pressure side of regulators although they may be duplicated at the torch.

Should a back fire occur (ie the flame returns into the blowpipe and continues burning in the neck or mixing chamber) the recommended first action is to close the oxygen valve on the blowpipe– to prevent internal burning – followed immediately by shutting off the fuel gas at the blowpipe valve.

Items 3-6 of the shutting down procedure in Annex 23.1 may then be followed. When the cause of the back fi-re has been discovered, the fault rectified and the blowpipe cooled down, the blowpipe may be re-lit.

If there is a flash back into the hose and equipment, or a hose fi re or explosion, or a fi re at the regulator connections or gas supply outlet points, the first action should be to isolate the oxygen and fuel gas supplies at the cylinder valves or gas supply outlet points – but only if this can be done safely. Further action should follow in accordance with the vessel's fire drill requirements.

A watch should be kept on acetylene cylinders to ensure they are not becoming hot. If they are, this could be a sign of acetylene decomposition and there is increased risk of explosion. The cylinder stop valve should be closed immediately, which may limit or reduce the decomposition but is unlikely to stop it.

Emergency action, such as evacuating the area and prolonged cooling by immersion or with copious amounts of water will still be required. Consideration should be given to jettisoning the cylinder overboard although movement of the cylinder can promote rapid decomposition, and cooling should continue while it is being moved. Any acetylene cylinder suspected of overheating should be approached with extreme caution because an impact could set off an internal ignition which might cause an explosion

Only acetylene cylinders of approximately equal pressures should be coupled.

In fixed installations, manifolds should be clearly marked with the gas they contain.

Manifold hose connections including inlet and outlet connections should be such that the hose cannot be interchanged between fuel gases and oxygen manifolds and headers.

Only those hoses specially designed for welding and cutting operations should be used to connect any oxy-acetylene blowpipe to gas outlets.

Any length of hose in which a flashback has occurred should be discarded.

The connections between hose and blowpipe, and between hoses should be securely fixed.

Hoses should be arranged so that they are not likely to become kinked or tangled or be tripped over, cut or otherwise damaged by moving objects or falling metal slag, sparks etc; a sudden jerk or pull on the hose is liable to pull the blowpipe out of the operator's hands or cause a cylinder to fall or a hose connection to fail. Hoses in passageways should be covered to avoid them becoming a tripping hazard.

Soapy water should be used for testing leaks in hoses. If there are leaks that cannot easily be stopped, the gas supply should be isolated and the leaking components taken out of service, replaced or repaired.

If the leak is at a cylinder valve or pressure regulator ("bull-nose") connection, the cylinder should be removed to a safe place in the open air. If it is a fuel-gas cylinder, it should be taken well clear of any source of ignition.

Excessive force should never be used on cylinder valve spindles or hexagon nuts of regulator connections in an attempt to stop a leak. Neither are sealing tape nor other jointing materials recommended for use in an attempt to prevent leaks between metal-metal surfaces that are designed to be gas tight. With an oxygen cylinder this could result in initiation of a metal-oxygen fire.

Blowpipes should be lit with a special friction igniter, stationary pilot flame or other safe means.

Should a blowpipe-tip opening become clogged, it should be cleaned only with the tools especially designed for that purpose.

When a blowpipe is to be changed the gases should be shut off at the pressure-reducing regulators.

To prevent a build-up of dangerous concentrations of gas or fumes during a temporary stoppage or after completion of the work, supply valves on gas cylinders and gas mains should be securely closed and blowpipes, hoses and moveable pipes should be removed to lockers that open on to the open deck.

Oxygen should never be used to ventilate, cool or blow dust off clothing.

3.3.1.15 Painting

General

Paints may contain toxic or irritant substances, and the solvents may give rise to flammable and potentially explosive vapours, which may also be toxic. Paints containing organic pesticides can be particularly dangerous.

Personnel using such paints should be warned of the particular risks arising from their use. If the manufacturer's instructions are not given on the container, information should be obtained at the time of supply about any special hazards, and also whether special methods of application should be followed.

The following precautions should always be taken.

Preparation and precautions

Painted surfaces should always be rubbed down wet to reduce dust from the old paint that may be toxic if inhaled. Where the dust is known to contain lead, other dust treating methods should be used. Dust masks should be worn as protection against other dusts.

If the surface to be rubbed down is known to contain lead, then methods that do not create dust should be adopted. It is safer to avoid or minimise dust creation than to try to clean up the dust afterwards. Sanding or abrasive blasting should be avoided. Lead-based paint should never be burnt off as fumes will contain metallic lead in a readily absorbed form.

Rust removers are acids and contact with unprotected skin should be avoided. Eye protection should be worn against splashes. If painting aloft or otherwise near ropes, care should be taken to avoid splashes on ropes, safety harnesses and lines.

Interior and enclosed spaces should be well ventilated, both while painting is in progress and until the paint has dried.

There should be no smoking or use of naked lights in interior spaces during painting or until the paint has dried hard. Some vapours even in low concentrations may decompose into more harmful substances when passing through burning tobacco.

When painting is done in the vicinity of machinery or from an overhead crane gantry, the power supply should be isolated and the machine immobilised in such a way that it cannot be moved or started up inadvertently. Appropriate warning notices should be posted. Close-fitting clothing should be worn.

Use of paint spraying equipment

As there are many different types of paint spraying equipment in use, operatives should comply with the manufacturers' instructions for use.

Airless spray-painting equipment is particularly hazardous since the paint is ejected at a very high pressure and can penetrate the skin or cause serious eye injuries. Spray should not be allowed to come into contact with the face or unprotected skin.

Suitable protective clothing such as a combination suit, gloves, cloth hood and eye protection should be worn during spraying.

Paints containing lead, mercury or similarly toxic compounds should not be sprayed in interiors.

A suitable respirator should be worn according to the nature of the paint being sprayed. In exceptional circumstances it may be necessary to use breathing apparatus.

If a spray nozzle clogs, the trigger of the gun should be locked in a closed position before any attempt is made to clear the blockage.

Before a blocked spray nozzle is removed or any other dismantling is attempted, pressure should be relieved from the system.

When blowing through a reversible nozzle to remove a blockage, all parts of the body should be kept clear of the nozzle mouth.

The pressure in the system should not exceed the recommended working pressure of the hose.

The system should be regularly inspected for defects.

As an additional precaution against the hazards of a hose bursting, a loose sleeve, for example a length of 2 to 3 m of old air hose, may be slipped over that portion of the line adjacent to the gun and paint container.

3.3.1.16 Hazardous substances

Many substances found on ships are capable of damaging the health and safety of those exposed to them. They include not only substances containing hazard warning labels (eg dangerous goods cargoes and ships' stores) but also dusts, fumes and fungal spores from goods, plant or activities aboard ship.

The employer's hazard identification process will identify where personnel are working in the presence of substances hazardous to health and safety, and evaluate any risks from exposure.

Appropriate measures should be taken to remove, control or minimise the risk.

Employers should instruct and inform personnel so that they know and understand the risks arising from their work, the precautions to be taken and the results of any monitoring of exposure.

The hazard identification process will also provide information to determine whether health surveillance is appropriate.

As an aid to the identification of hazards and the assessment of risks from dangerous goods, reference may be made to the International Maritime Dangerous Goods Code or to the chemical data sheets contained in the Tanker Safety Guides (Gas and Chemical) issued by the

International Chamber of Shipping. Information concerning hazardous cargoes carried in bulk should be available where applicable to allow the assessment to be made.

In the case of ship's stores, reference should be made to the manufacturers' instructions and data sheets, which may be supplied with the goods.

Prevention or control of exposure

The first consideration should always be to prevent exposure by removing the substance, eg by substituting a less harmful one.

Where this is not practicable, prevention or control of exposure may be achieved by any combination of the following:

- total or partial enclosure of the process and handling systems

- use of plant, processes and systems of work which minimise the generation of, or suppress and contain, spills, leaks, dust fumes and vapour of hazardous substances
- the limitation of the quantities of a substance at the place of work
- keeping the number of persons who might be exposed to a substance to a minimum, and reducing the period of exposure
- prohibiting eating, drinking and smoking in areas that may be contaminated by the substance
- hygiene measures, including providing adequate washing and laundering facilities and regular cleaning of walls/bulkheads and other surfaces
- the designation of those areas that may be contaminated and the use of suitable and sufficient warning signs
- the safe storage, handling and disposal of hazardous substances and use of closed and clearly labelled containers.

These measures should be applied to reduce the risk to the minimum, but where they do not adequately control the risk to health, personal protective equipment should also be provided.

Employers should take reasonable steps to ensure that any control measures are properly used and maintained. Where appropriate, exposure levels should be monitored and recored.

Personnel should comply fully with the control measures in force.

For certain substances very specific control measures apply, eg asbestos, benzene. In cases where failure of the control measures could result in risk to health and safety, or where their adequacy or efficiency is in doubt, the exposure of personnel should be monitored and a record kept for future reference.

Asbestos dust

All types of asbestos have a fibrous structure and can produce harmful dust if the surface exposed to the air is damaged or disturbed. The danger is not immediately obvious because the fibres, which can damage the lungs and can cause lung cancer, are too small to be seen with the naked eye.

Asbestos that is in good condition is unlikely to release fibres, but where the material is damaged or deteriorating, or work is undertaken on it, airborne fibres can be released. Dry asbestos is much more likely to produce dust than asbestos that is thoroughly wet or oil-soaked. Asbestos is particularly likely to occur on older vessels in insulation and panelling, but certain asbestos compounds may also be found on other vessels in machinery components such as gaskets and brake linings.

Ship owners should advise masters of any location where asbestos is known or believed to be present on their ship. Masters and/or safety officers should keep a written record of this information and note any other position where asbestos is suspected, however, they should not probe or disturb any suspect substance. Crew members who work regularly near asbestos or a substance likely to contain it should be warned and report any deterioration in its condition such as cracking or flaking.

The condition of old asbestos may deteriorate and where reasonably practicable consideration should be given to its removal. This should be carried out in port by a specialist removal contractor to ensure adequate protective procedures.

In 1995 the New Zealand Department of Labour produced a booklet entitled Guidelines for the

Management and Removal of Abestos. It should be consulted where work involving asbestos removal is contemplated.

If it is essential to carry out emergency repairs liable to create asbestos dust while the ship is at sea, strict precautions including the use of the appropriate protective clothing and respiratory protective equipment should be observed in accordance with the booklet mentioned above.

Dangerous goods

All dangerous goods and substances carried as cargo on ships have to be classified, packaged and labelled for transport in accordance with the International Maritime Dangerous Goods (IMDG) Code.

Examples of the labels to be affixed to packages and containers of dangerous goods are given in the IMDG Code. These depict by colour, name and pictogram the particular dangers of that substance, eg flammability, toxicity and corrosiveness.

Use of chemical agents

A chemical from an unlabelled package or receptacle should never be used unless its identity has been positively established.

Chemicals should always be handled with the utmost care. Eyes and skin should be protected from accidental exposure or contact.

Manufacturers' or suppliers' advice on the correct use of the chemicals should always be followed. Some cleaning agents, even though used domestically, eg caustic soda and bleaches, may burn the skin.

Chemicals should not be mixed unless it is known that dangerous reactions will not be caused.

Dry-cleaning operations

The principal hazard presented by a dry-cleaning solvent is that it is highly volatile, producing a vapour which is anaesthetic. Effective mechanical ventilation should therefore be provided in any compartment containing dry-cleaning plant. Smoking should be prohibited in compartments when the solvent is present.

Dry cleaning solvent is also a potential cause of skin damage, and suitable personal protective equipment should be worn.

A responsible person should be appointed to take overall responsibility for the security and operation of the dry-cleaning plant, and access should be controlled.

Safe use of pesticides

The following guidance should be read in conjunction with International Maritime Organisation recommendations.

Where pesticides are used in the cargo spaces of ships or cargo units, safety procedures should be in accordance with the IMO publication Recommendations on the Safe Use of Pesticides (1996). A copy of this publication should be retained on board and kept accessible for all crew members.

Where space and surface spraying operations are being carried out by the crew, the master should ensure that the appropriate protective clothing, gloves, respirators and eye protection are being worn.

Ship's personnel should not handle fumigants and such operations should be carried out only by qualified operators. Fumigation should only be carried out with the agreement of the ship's master.

The master should choose to allow an in-transit fumigation only after first referring to the requirements of the ship's own national administration, and seeking the approval of the administration of the state of the vessel's next destination or port of call.

The master should provide safe working conditions and ensure that at least two members of his crew including one officer have received the appropriate training. They should be familiar with the recommendations of the fumigant manufacturer concerning the methods of detection of the fumigant in air, its behaviour and hazardous properties, symptoms of poisoning, relevant first-aid treatment and special medical treatment and emergency procedures.

The "Fumigation Warning" sign should be conspicuously displayed on cargo units or spaces under fumigation. A watchman should be posted to prevent access to areas of risk by unauthorised personnel.