Maintenance system assessment:
Guidance document

Prepared by Poseidon Maritime UK Ltd for the Health and Safety Executive 2004

RESEARCH REPORT 237
A Maintenance System can be assessed by looking at the output - at the end results it achieves, or by assessing it as a process whose elements are defined and managed in accordance with some standard or some established procedures. Whilst the end result cannot be ignored as a measure of the effectiveness of a Maintenance System this handbook concentrates on the assessment of the process itself.

It is the Maintenance System that forms the primary focus of concern of this handbook and other issues are regarded as inputs, outputs or sub-routines operating on that central process.

This Handbook gives advice and guidance on fundamental structural and organisational elements involved in a Maintenance System and on methods to establish their existence, their degree of sophistication and their effectiveness.

At the practical level of maintenance tasking, this Handbook concerns itself with machinery systems and related services, such as instrumentation, rather than with structural, process or electrical system maintenance, but the general principles concerning Maintenance Systems are relevant to all.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.
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EXECUTIVE SUMMARY

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This Handbook gives advice and guidance on fundamental structural and organisational elements involved in a Maintenance System and on methods to establish their existence, their degree of sophistication and their effectiveness.

At the practical level of maintenance tasking, this Handbook concerns itself with machinery systems and related services, such as instrumentation, rather than with structural, process or electrical system maintenance, but the general principles concerning Maintenance Systems are relevant to all.

For the purpose of this Handbook, a Maintenance System is regarded as concerning itself with the ‘as is’ equipment inventory under the operational control of installation staff and also the introduction and deletion of equipment to and from the System. The processes of upgrades and modification themselves are regarded as being the province of separate project management and control procedures.

The Handbook is arranged in sections, which discuss the various issues relating to Maintenance Systems and their assessment and which may be studied separately as required. The text is supported by appended tables documenting relevant points of interest and lines of enquiry.
1 MAINTENANCE - AN OVERVIEW

A Maintenance System may be regarded as the process intended to regulate the organisation, scheduling, conduct, recording and analysis of maintenance tasks.

A Maintenance System is one of the primary building blocks for the safe, successful management of capital assets in the Marine/Offshore Environment and the existence of a Maintenance System is fundamental to the ability of an organisation to satisfy financial, operational, regulatory and safety goals.

To best achieve satisfactory results, a Maintenance System should not be regarded as just a means to an end but should be viewed as a valuable, dynamic business process in its own right, built on the foundation of the required output. It may be argued that the output is more important than the process but, without the process, the output has no firm foundation, is subject to the priorities, practices and availability of individuals and loses the benefits of regulated management, record keeping and ‘closing the loop’ through analysis of the output being used to improve the maintenance programmes.

Maintenance Systems interact with other business processes but are centred on technical concerns and considerations. Whilst they should take into account other business concerns such as the availability of resources, production plans, usage levels, design lifetimes and machinery depreciation, the primary output should be defined requirements for the maintained condition, functionality and operability of structures, plant, machinery and equipment.

Important reasons for the management of maintenance tasks under the authority of a Maintenance System are shown in the pyramid below. The reasons are graded from the essential at the bottom through to worthwhile at the top.

![Figure M1 Reasons for a maintenance system](image-url)
A Maintenance System incorporates various fundamental elements which require development, organisation and integration. These may be represented as below:

![Figure M2 Maintenance system elements](image)

The elements of a Maintenance System must be successfully integrated to achieve the required objectives. Such objectives include the following:

1) Maintaining the condition, functionality and operability of the machinery inventory
2) Reducing failure incidence or Mean Time Between Failures (MTBF)
3) Reducing downtime after failure or Mean Time To Repair (MTTR)
4) Reducing critical incidents/near miss incidents
5) Increasing maintenance personnel skills/work experience
6) Increasing plant/systems/equipment reliability and availability

A Maintenance System provides the process for management and control of a maintenance programme, i.e. the set of maintenance tasks and their schedules that are applied to the equipment inventory operated on by the Maintenance System.
Historically within the Marine Environment, maintenance programmes have been prescriptive, based on Classification Society requirements for survey and overhaul of structures, plant, machinery and equipment, normally within a five year cycle.

Fixed offshore installations however are subject to the Safety Case regime. Significant aspects of an offshore installations maintenance programme are derived from the process of risk analysis, Safety Critical Element (SCE) definition, Performance Standard definition and Verification Scheme development. The coverage of a Maintenance System therefore is not rigidly demarcated across the industry but may vary within practical limits according to particular evaluations of risk, assessments of the safety criticality of component parts of an installation and differing emphases on the importance of different aspects of the functionality of component parts of an installation.

Maintenance programmes may be based on various maintenance methodologies. For the purpose of this handbook, maintenance methodologies may be classified and characterised as follows:

<table>
<thead>
<tr>
<th>CORRECTIVE MAINTENANCE</th>
<th>Locally centred, ad hoc, reactive, breakdown repair and ‘end-of-life’ replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>This approach to maintenance consists of the application of safe, recognised, accepted or approved industry work and repair practices to restore defective or damaged equipment to full operational capability and reliability and ‘as built’ condition.</td>
</tr>
<tr>
<td>Corrective maintenance may also be taken to include end of lifetime replacement of equipment. This involves the continual operation of equipment until it has reached the end of its useful life, or fails in service beyond economical repair, and is then replaced with a new or reconditioned unit. Equipment may be replaced on failure or greatly diminished performance rating, reliability or operability.</td>
<td></td>
</tr>
<tr>
<td>Corrective Maintenance by its very nature cannot be scheduled and may present management, control and safety issues that are more complex than those presented by routine maintenance tasks. Whilst Corrective Maintenance tasks should be included within the scope of a Maintenance System, they should not form the basis for the maintenance Policy or exceed a reasonable percentage of the maintenance workload.</td>
<td></td>
</tr>
<tr>
<td>Corrective Maintenance may be applied to stand alone, non-critical assets, after cost-effectiveness review and justification, and also to assets which are no longer in production and where the cost of spares and service would be prohibitive.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PLANNED MAINTENANCE</th>
<th>Centrally administered, programmed inspection and overhaul of functional machinery based on scheduled periodicity or on running hours or on other operational measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>This approach to maintenance consists of regularly scheduled inspections, lubrication, oil changes, parts replacement, adjustments, alignments, cleaning, etc. The maintenance is scheduled at pre-determined intervals, which can be based on time, operating hours or work cycles.</td>
<td></td>
</tr>
<tr>
<td>The application of this type of maintenance can reduce unexpected failures but can be expensive as it is often carried out without regard to equipment condition.</td>
<td></td>
</tr>
<tr>
<td>Planned Maintenance may be taken to include Healthcare Packages. This form of planned maintenance is based on the concept of a complete package of care by external contractors, usually for a specific equipment type, e.g. power plant gas turbines, cranes, large volume and pressure compressors, etc. The contractor may be the manufacturer himself, or maintenance companies trained and licensed by the manufacturer to conduct the required tasks. The contractual arrangements for Healthcare Packages should address any potential conflicts in requirements between a manufacturer and an operator.</td>
<td></td>
</tr>
<tr>
<td>The package normally includes providing specialist labour, special tools and overhaul equipment, spare parts and consumables, test equipment, transport to and from the site, and all workshop facilities necessary for the overhaul, repair and functionality tests prior to, and subsequent to, overhaul/repair.</td>
<td></td>
</tr>
</tbody>
</table>
Predictive Maintenance is also known as condition monitoring and can be an effective tool for diagnosing the symptoms of impending equipment and machinery failures. It may include sampling and analysis, vibration monitoring, operating parameter measurement, NDT techniques and electrical testing procedures.

Generic monitoring strategies may be applied to all units where applicable, but some units may be design specific and outwith the generic strategy for a particular equipment type. Monitoring strategies for such units should be developed within the Maintenance System. A key factor in condition monitoring is consistency in procedures and application.

A major benefit is the availability of trend analysis of deteriorating condition and early warning of equipment failure, which may reduce the number of breakdowns.

Trend analysis is dependent on having established baseline data for original or satisfactory running condition so that deviations may be compared against a fixed reference. Limits for allowable degrees of deviation should be defined as trigger points for action within the maintenance programme. The limits should be based on justifiably valid criteria.

RELIABILITY CENTRED MAINTENANCE (RCM) is a business and function orientated system employing analytical techniques to improve the maintenance programme on the basis of analysis of the consequences of failures. RCM is more concerned with the maintenance of system function than the maintained condition of individual components. The focus on preserving system function acknowledges design limitations and is dependent on equipment redundancy levels and alternate process path availability, directing the maintenance programme to prioritise prevention of significant failure modes.

A Maintenance System based on statistical analysis techniques should use valid data and analytical tools. The application of RCM requires specialist knowledge and experience, to properly evaluate the validity of data inputs, to apply appropriate statistical analysis and to properly evaluate the results. RCM may be a consideration in the development of Healthcare packages and may utilise equipment changeout as opposed to in-situ overhaul.

Maintenance conducted during shut downs and campaigns may be either Planned or Corrective, involving closure of part or all of the plant, machinery or equipment to maximise accessibility for overhaul, refurbishment, upgrade, restoration or replacement of components and equipment.

A shut-down may utilise in-house maintenance staff and contractual labour for the repair/maintenance period, and should be pre-planned in detail with input from HSE Advisors, Planning Engineers and Operations Staff.

Re-commissioning may again use in-house maintenance and operations staff, with contractual personnel drafted where necessary for the various levels of pre and re-commissioning of systems and equipment. Shut Down and/or Campaign Maintenance should be included within the scope of a Maintenance System and may form a major part of it. In addition to an organisation’s maintenance, operations and HSE personnel, Contractor’s representatives and supervisors should be included in the planning, safety instruction and task assignment, prior to a work team arriving on site to commence assigned tasks.
Passive and active preservation may be required during various stages of a plant or installation working lifetime, including the following:

1) On completion of new build or refurbishment final commissioning of system, sub-system, or unit awaiting plant start up
2) Plant or installation closure or shut down
3) System, sub-system or equipment/asset shut down

The methods of preservation may depend on many variables, reviewed and advised on a case-by-case basis, and dictated by standard practice and manufacturers recommendations for preservation and re-activation of the equipment. The method, type, and scheduling of preservation practices are largely design specific.

Preservation techniques should not invalidate any warranties.

Surveys and inspections are conducted by regulatory, statutory and Classification Society bodies including:

1) Health and Safety Executive - In addition to regular scheduled visits to offshore installation for inspections the HSE has the function and authority to carry out investigations of incidents or issues where safety, health, and the environment are compromised.

   Where scheduled HSE visits are made for the purpose of checking and reviewing procedures, and functional tests are to be conducted, sufficient notice should be given to ensure that the required equipment is available for testing.

2) Classification Society - In the event that an installation is maintained in Class the appointed Classification Society should conduct the prescribed inspections and surveys necessary to ensure that the structures, plant, machinery and equipment are maintained in good order.

   Inspections and surveys are carried out where the installation may have been registered at new building with a Classification Society or a change of society has occurred during service life, or at change of Owner, and regularly during the five-year cycle of maintenance.

   All Classification Societies are required to publish rules and regulations and are available for consultation and guidance to organisations.

   All of the original documentation pertaining to construction, alteration, upgrade, refurbishment, and new equipment installation should be filed and controlled and made available for visiting Surveyors.

3) Independent Competent Body (or Person) - The ICB is appointed by an organisation to conduct inspections and tests of Safety Critical Equipment on behalf of the organisation. Inspections and tests should be arranged in accordance with Verification Schemes and to establish the maintained condition of particular items of interest.

   The ICB should conduct external audits of operating procedures, functionality and operability of equipment, function tests and other means of verification of plant and equipment. All of the records of in-house tests and internal audits may be required to complete the audit of documentation, and should be readily available.

   The ICB may be called upon to conduct ad hoc investigations into failures of equipment.
A primary objective of a Maintenance System is to maintain the condition, functionality and operability of the component parts of an installation. Different Maintenance Systems may place differing emphases on these three aspects of the end product but for offshore installations they may be objectively ranked in importance as below:

<table>
<thead>
<tr>
<th>End product</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>Condition is often the basis of function. Structural components, coating systems, electrical cabling, pipework, pressure vessels, watertight closures, wires and bolts all derive their functionality from the degree of integrity of their maintained condition. If a component is in good condition then there is a high likelihood that it will fulfil its function. There may be redundancy of component provision which will allow continued system functionality despite the poor, or failed, condition of a particular component but a Maintenance System should include the facility to detect that poor or failed condition and institute a process of evaluation and rectification.</td>
</tr>
<tr>
<td>Functionality</td>
<td>Functionality is the desired output of a component, providing the reason for its inclusion within a machinery system. Redundancy of provision, alternate process paths and generous design factors may allow continued functionality of an installation system in the event of poor maintained condition, but a point may be reached where redundancy is lost, perhaps without detection, and the next failure step results in a loss of function. Dependence on observation of functionality as a measure of acceptable maintained condition depends on:</td>
</tr>
<tr>
<td></td>
<td>1) Accurate knowledge of the degree of design redundancy</td>
</tr>
<tr>
<td></td>
<td>2) Accurate knowledge of possible single point failure modes</td>
</tr>
<tr>
<td></td>
<td>3) Accurate knowledge of potential hidden failure modes</td>
</tr>
<tr>
<td></td>
<td>4) Accurate knowledge of the condition of process measuring instrumentation</td>
</tr>
<tr>
<td></td>
<td>A Maintenance System should not use loss of functionality as the principal trigger for equipment inspection and overhaul.</td>
</tr>
<tr>
<td>Operability</td>
<td>Operability denotes the range of methods and locations which are available to monitor and control a system or equipment item. Equipment items may have several remote and local operating stations and the loss of one may not critically affect the continued functionality of the equipment. Lack of operability may manifest itself in a range of ways from a loss of functionality to a requirement for potentially unsafe control methods. A Maintenance System should include regular testing of normal, standby and emergency control systems to establish their integrity.</td>
</tr>
</tbody>
</table>
2 MAINTENANCE SYSTEM ELEMENTS

To form an accurate assessment of the effectiveness of a Maintenance System all the fundamental elements, as figured in Diagram M2, should be evaluated. During familiarisation with a Maintenance System consideration should be given to the following:

1) Are all the elements present within the organisation of the Maintenance System?
2) Is the management of particular elements adequately defined and functioning?
3) Is the management of elements effectively integrated and directed to the achievement of the required objectives?

2.1 POLICY, STRATEGY, AUTHORITIES & RESPONSIBILITIES

When assessing a Maintenance System it is central to a proper understanding of its effectiveness to review the organisations Policy and Strategy and evaluate the standards and objectives defined within them. It is also important to have a clear understanding of the defined Authorities and Responsibilities controlling the Maintenance System and the lines of reporting.

The Policy should define the scope and nature of the task to be addressed by the Maintenance System, what it is intended to achieve and the fundamentals of it is to be directed.

The Strategy should define how the Maintenance System will be developed, structured, administered and assessed.

Within an organisation, and within the Maintenance System, it should be clearly defined which personnel have the authority and responsibility for particular functions. This information may be available in Organograms, Job Descriptions and Maintenance System procedures. Interfaces and responsible persons within sub-contractors and other related organisations should also be clearly defined.

2.2 MAINTENANCE SYSTEM ADMINISTRATION

In many ways the organisation and management of the administration of a Maintenance System is a separate enterprise from the conduct of maintenance tasks. Both activities require knowledge of the objectives, methodologies and procedures for technical maintenance but there is a separation of skills and focus. Where possible, the responsibilities for routine administration of a Maintenance System should be separated from responsibilities for maintenance tasking so as to incorporate a check and review provision between the requirements of the Maintenance System and the concerns involved in undertaking the maintenance programme.

The organisation required for administering a Maintenance System may be planned around infrastructure issues, such as the number of work sites operating maintenance programmes and the number of software database locations.
Various combinations of worksites and Maintenance Systems may be operating within an organisation, some possibilities are shown below:

![Diagram](image_url)

**Figure M3** Possible Maintenance System Topographies

The management requirements for the administration of a Maintenance System should address operational issues such as responsibilities and procedures for assigning access rights and data entry.

The administration of Maintenance Systems can vary so greatly that it is not worthwhile to detail specific examples. Each Maintenance System should be assessed separately against Policy, Strategy and procedures.

The size and complexity of the supporting infrastructure and logistics should be able to sustain the size and complexity of the Maintenance System administration.
2.3 MAINTENANCE TASK MANAGEMENT

The management of maintenance tasks should address two key areas:

1) Operational issues, including resource requirements, simultaneous work scopes, Health and Safety, etc.
2) Scheduling issues, including maintenance task frequencies, linking of tasks, task backlog management, etc.

The conduct and supervision of maintenance tasks should be undertaken by appropriately skilled personnel in accordance with defined procedures.

The interface between ‘maintainers’ and the Maintenance System databases should be properly managed with defined responsibilities and procedures for history and data recording and for the management of inputs and outputs from Maintenance System software programmes.

The scheduling of a maintenance programme should be based on relevant factors including manufacturers’ recommendations, operating experience and equipment criticality.

2.3.1 Safety Critical Elements (SCE)

A Maintenance System should be directed to maintain the integrity of Safety Critical Elements, including the following considerations:

1) To ensure a continuous appreciation of the running condition of all SCE.
2) To direct the maintenance programme so as to keep all SCE in a satisfactory, functional, reliable, safe state of repair.
3) To ensure the safe conduct of all maintenance tasks on SCE.
4) To direct the scheduling of SCE equipment running hours and maintenance so as to maximise the MTBF
5) To direct the management of defective SCE equipment so as to minimise the MTTR
6) To optimise the performance ratings of relevant SCE.
7) To ensure accurate and complete recording of SCE maintenance findings and histories. Records should contain all the necessary data to compare the performance of equipment with original Factory Acceptance Test (FAT) data and with final commissioning test data, as accepted at handover to operating personnel.

Conformance to Performance Standard requirements should be verified by scheduled maintenance tasks including:

1) Operators’ checks and tests during routine processes and ad hoc operation of plant.
2) Routine watch keeping inspections
3) Scheduled maintenance tasks
4) Campaign maintenance programmes
5) Independent Competent Body [ICB] Verification Scheme
2.4 SUB-CONTRACTOR MANAGEMENT

A Maintenance System should incorporate appropriate management and control of all those involved in the maintenance of an offshore installation.

Sub-contractors are generally employed for specific maintenance tasks to assist and/or supplement the operational maintenance team for a variety of reasons including:

1) To bring the maintenance programme back on track where incomplete or deferred tasks have reached a degree where maintained condition, functionality or operability has reached a level which is unsafe, environmentally unsound, or unacceptable for plant/installation efficiency.

2) Cost-effective maintenance tasking, where a specialised work force, special tools and procedures, temporary equipment, safety precautions, etc., are required to progress the maintenance programme in an acceptable time frame.

3) Corrective or Campaign maintenance tasks where the workload is beyond the normal capabilities of the operational maintenance team or where specialised equipment and procedures with trained personnel are necessary.

4) Installation of replacement units and upgrade of plant and systems, restoration of existing assets to original operating condition and reliability.

5) Changes to comply with new legislative or operating conditions.

Sub-contractors should be subject to all the HSE requirements which are in force and, in addition to these standing procedures, should adhere to all other procedures applicable to their tasks and to other related work.

The sub-contractor should have an approved and qualified HSE advisor on site, who may be part of the work team but should have the authority and knowledge applicable to the work scope. The sub-contractor HSE Advisor should be aware of all aspects of the work in hand, all safety procedures in force and their relevance to the PTW, which should be co-signed by all parties necessary to the issuance of a PTW and its accompanying Work Order.

Sub-contractors should have access to all relevant manuals, documents, procedures, tests and examinations necessary to successfully complete the work but commercially sensitive information may be restricted until authority for access is approved by an organisation.

Sub-contractors’ Senior Representative and other co-opted members of their team should be included in planning, daily, weekly, and review meetings for work in hand, progress, and safety considerations.

Members of the sub-contractor staff attending meetings should be noted for the minutes and issued with a copy of the minutes of any meeting.

The outcomes of maintenance tasks undertaken by sub-contractors should be recorded in the Maintenance System databases and any hard copy records filed in accordance with the document control procedures of an organisation. The minutes of any close out meeting held to capture relevant ‘lessons learnt’ from maintenance tasks should also be held on record and assimilated into future work scopes.
2.5 SOFTWARE PROGRAMMES

The choice of maintenance software programme should be subject to specified criteria and a managed selection process. The function of the software is to manage maintenance and its ability to achieve this in a satisfactory manner should be the primary consideration. The choice of software programme should be referable to the prioritisation of the particular drivers influencing the judgement.

The software programme should provide all the required data retention, scheduling, record sorting, report creation and information transfer functions required. Some of these functions may be provided by other office software programmes, if required, but they should be properly integrated into management procedures.

Only authorised personnel should be sanctioned to change any text or data base entry within the Maintenance System; access rights to databases should be clearly defined in procedures, and unauthorised personnel should be prevented from access to ‘locked’ database field data and text.

2.6 H S & E

The risks involved in maintenance tasks should be evaluated and understood. This particularly applies to Corrective Maintenance. An organisation should have a regulated process for determining potential hazards for particular maintenance tasks and implementing mitigating measures on the ALARP principle.

2.6.1 Risk assessment

Every company is under a statutory duty to carry out an assessment of the risks present in the workplace, and the risk assessment should be documented.

Legislation requires that the assessment be carried out by a “competent person” and include examination of all of an organisation’s activities to identify any hazards involved, the likelihood of these hazards causing harm and the steps required to eliminate or minimise the risks. It is essential that a judgement of risk is made as to whether a hazard is significant and whether it is covered by satisfactory precautions to minimise the risks.

The Regulations for risk assessment require that records be maintained of the significant findings of an assessment and that risk assessments are reviewed and revised as necessary, especially when the assessment is no longer valid or there has been a significant change in the workplace conditions.

A judgment should be made as to whether a hazard is significant and whether covered by satisfactory precautions so that the risks are small. The control of risks must be judged to be at least “adequate” or “suitable and sufficient”.

A risk assessment may cover relevant areas, including:

1) Evaluation of the degree to which a particular item of equipment has been subject to function tests, including protective devices alarm systems and shut-down systems.
2) Evaluation of the potential risk if a particular item of equipment, or maintenance equipment failed during maintenance work or testing.
3) Verification that design, construction, commissioning and maintenance have met all specifications and procedures as a means of demonstrating that the equipment is fit for purpose.

4) Evaluation of operating procedures and compliance with relevant manuals, guidance documentation and publications.

5) Evaluation of possible impacts on defined major hazards that a maintenance activity may have.

A bibliography of the more useful sources is documented in the HSE Publication L30 - A guide to the Offshore Installations (Safety Case) Regulations 1992.

The standard range of risk assessment methods may all be applied, including:

<table>
<thead>
<tr>
<th>Method</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAZID</td>
<td>HAZIDS are high level reviews of potential hazards, often based on hazard checklists such as risk control hierarchal studies.</td>
</tr>
<tr>
<td></td>
<td>HAZID is the first and, in many ways, the most important step in risk assessment. If a hazard is not identified, its contribution to the risk cannot be estimated and it will be omitted from the overall risk profile.</td>
</tr>
<tr>
<td></td>
<td>Only the hazards that are identified are able to be controlled with any confidence and they should be identified in a formal, systematic and comprehensive procedure with application of established methodology.</td>
</tr>
<tr>
<td>HAZOP</td>
<td>Involves concept and detailed studies, for continuous or batch processes, or procedural operations, to identify potential hazards and problems with operability, identifying possible consequences, safeguards, and corrective action to alterations in process control parameters.</td>
</tr>
<tr>
<td>Job Safety Analysis (JSA)</td>
<td>Involves detailed, sequential itemisation of work steps, identification of hazards and development of mitigating measures. Documented in a standard format for use in the workplace.</td>
</tr>
<tr>
<td>COSHH</td>
<td>The use of chemical and hazardous substances should be subject to the required assessment and control documented in the Control of Substances Hazardous to Health Regulations 1994 as amended and superseded by the 1997 Regulations.</td>
</tr>
</tbody>
</table>

Assessment of the various records of risk assessment procedures may provide evidence of the degree of application and compliance within an organisation.
## 2.6.2 Safety procedures

Standard safety procedures should be documented and the tasks to which they apply identified. Such standard procedures include:

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permit to Work (PTW) including:</td>
<td>A PTW system is a formal written system used to control certain types of work which are identified as potentially hazardous. It is also a means of communicating safety requirements between site/installation management, plant supervisors, contractors and operators and those who carry out the work.</td>
</tr>
<tr>
<td>hot work</td>
<td>A PTW system should ensure that proper planning and consideration is given to the risks of a particular task. The permit is a written document which authorises certain people to carry out specific work, at a certain time and place, and which sets out the main precautions needed to complete the task safely.</td>
</tr>
<tr>
<td>work at heights</td>
<td>An organisation should assess the risks involved in activities and define specific operations and types of work which should be subject to PTW systems.</td>
</tr>
<tr>
<td>confined spaces</td>
<td>PTW should be considered wherever it is intended to carry out any work which may adversely affect the safety of personnel, the environment or the plant. It is also advisable to use a PTW system when two or more individuals or groups of people, from different trades or different contractors, need to co-ordinate their activities to ensure that their work is completed safely.</td>
</tr>
<tr>
<td>electrical systems</td>
<td>Methods of electrical and process/mechanical isolations should be implemented, understood, practiced, reviewed and updated as required at regular intervals.</td>
</tr>
<tr>
<td>stored energy systems</td>
<td>All personnel involved in maintenance and repair should be familiar with the systems and should adhere to the instructions pertaining to isolation of equipment undergoing tests, maintenance, repair or replacement.</td>
</tr>
<tr>
<td>safety systems</td>
<td>Procedures for pressure testing should be implemented, understood, practised, reviewed and updated as required at regular intervals.</td>
</tr>
<tr>
<td>Isolations, Lock Out, Tag out</td>
<td>All pressure testing procedures, including PTW, whether in the workshop or in the field, should adhere to HSE and Factories Act regulations applicable to this work.</td>
</tr>
<tr>
<td>(LOTO)</td>
<td>Reference the Pressure System Safety Regulations SI2000 and ACOP L-122 and HSE Guidance Note GS4 Safety in Pressure Testing</td>
</tr>
<tr>
<td>Pressure tests</td>
<td>Procedures for electrical testing should be implemented, understood, practised, reviewed and updated as required at regular intervals.</td>
</tr>
<tr>
<td></td>
<td>All electrical testing procedures, including PTW, whether in the workshop or in the field, should adhere to HSE and Factories Act Regulations applicable to this work.</td>
</tr>
<tr>
<td></td>
<td>Reference the Pressure System Safety Regulations SI2000 and ACOP L-122 and HSE Guidance Note GS4 Safety in Pressure Testing</td>
</tr>
<tr>
<td>Electrical tests</td>
<td>Lifting operations should be conducted in accordance with Lifting Operations and Lifting Equipment Regulations 1998. Lifting plans should be developed for applicable maintenance tasks.</td>
</tr>
<tr>
<td>Lifting plans</td>
<td>Maintenance work involving asbestos should be conducted in accordance with the Control of Asbestos at Work Regulations 1987.</td>
</tr>
</tbody>
</table>
Assessment of the various records of standard procedures may provide evidence of the degree of application and compliance within an organisation and of the nature of historical problems.

### 2.6.3 Safety system and equipment maintenance

Maintenance of life saving equipment, fire fighting equipment, safety systems, alarm systems, emergency stops, etc. should be subject to regulated management and control procedures. The procedures should be documented or referenced in Work Orders and include such considerations as:

1) Standby systems operation  
2) Inadvertent alarm and shutdown operation  
3) Inadvertent activation  
4) Loss of functionality during shutdown  
5) Unsafe procedures

All safety equipment including portable and fixed gas detection monitors, heat and smoke sensors and indicating alarm panels, portable and fixed fire extinguishing equipment, fire blankets, fire hydrants, pumps and system piping/valves, fire hoses, audible and visible fire alarms, water douche and eyewash stations, first aid kits, breathing apparatus and cylinder re-filling compressors and medical oxygen cylinders should be maintained on a regular basis and subjected to rigorous function tests and simulations where applicable as part of the maintenance programme.

### 2.7 RESOURCES

To achieve its defined objectives a Maintenance System is reliant on the scale of resources applied being matched to the scope of the maintenance programme.

A judgement as to whether sufficient resources are being deployed for the programmed tasks may be evaluated by assessing a Maintenance System for evidence of possible problems arising from failures in resourcing. Sources of evidence may include the following:
<table>
<thead>
<tr>
<th>Evidence</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical inspection of the maintained equipment</td>
<td>Provides evidence of proper completion of work scopes and appropriate</td>
</tr>
<tr>
<td></td>
<td>management of the work area</td>
</tr>
<tr>
<td>Witnessing of staff undertaking maintenance activities</td>
<td>Provides evidence of the competencies of maintenance staff</td>
</tr>
<tr>
<td>Examination of completed Work Orders</td>
<td>Provides evidence as to whether time and manpower originally allocated</td>
</tr>
<tr>
<td></td>
<td>were sufficient for the job description</td>
</tr>
<tr>
<td>Collection and collation of man-hours expended on Planned and Corrective</td>
<td>A comparison of the ratio of these two maintenance workloads may act as</td>
</tr>
<tr>
<td></td>
<td>guide to the effectiveness of the Maintenance System</td>
</tr>
<tr>
<td>Physical inspection of maintenance equipment</td>
<td>Provides evidence of the ability to properly conduct maintenance tasks</td>
</tr>
<tr>
<td>Inspection of personnel and training records</td>
<td>Provides evidence of the ability of personnel to conduct maintenance tasks</td>
</tr>
<tr>
<td></td>
<td>and procedures</td>
</tr>
</tbody>
</table>

### 2.7.1 Manpower and skills

A maintenance programme requires the employment of a number of man-hours over any given period, deployed over a range of skills. The availability of the required man-hours and skills should match a reasonable estimation of the man-hours required by the maintenance programme during any given period.

The experience of relevant personnel is also a considerable influence on the effective conduct of a maintenance programme.

A distinction should be made between man-hours spent on the conduct of maintenance tasks and man-hours spent on administration of the System. Estimated times for maintenance tasks do not necessarily include the time required for mobilisation and de-mobilisation, for recording the completion of Work Orders and for filing records. These activities are all required to complete a maintenance task. Adequate man-hours should be available to facilitate administration of the System and for the recording and input of maintenance history and data.

The necessary time and skills should be made available to conduct any analysis and review of Maintenance System performance indicators, data and history that may be required by an organisation.

Personnel deployed should have the necessary skills to undertake the tasks assigned, and again an inspection and assessment of plant and equipment condition may provide evidence as to the need for additional skills in any areas affected. Specialist manpower may be required from time-to-time on a cost-effective basis and this should be managed within the Maintenance System.

To optimise the availability of necessary skills training requirements for personnel should be identified and provided. Training programmes for in-house staff may alleviate any need for contractual specialists, especially where skill only is required and no expensive special equipment is necessary for a task.
2.7.2 Spare parts

Spare parts may be held centrally and at each work site. The inventory of spare parts should identify the storage location and be complete, accurate and up-to-date. Stock data should be readily available to maintenance staff and supervisors and the day-to-day management of the spare parts management system should be user friendly for all personnel authorised for access to the database.

Whenever any item of stock is removed, the spare parts management system database should be updated. A minimum and maximum system of re-ordering of spares, if used, should automatically “flag” the spare part for re-ordering when the minimum level has been reached.

Spare parts level should be adequate for routine maintenance and may include vital or “insurance” spares which would not normally be carried as stock items for cost reasons. These may be held, even though the equipment is not normally prone to failure, because the location of the installation and the vital nature of these spare parts(s) may make urgent supply difficult.

Spare parts should be of specified quality, certificated as required and sourced from reputable suppliers. The Maintenance System should define the process for disposition of used spare parts.

Audit and inspection of spare parts stock should be conducted regularly to ensure that stock levels are accurate, that spare parts are in good condition and to provide an assessment of the housekeeping standards as well as safety and environmental management. The shelf life of degradable items should be monitored. All spare parts should have adequate protection from accidental damage, from detrimental environmental conditions and, where necessary, be stored in a controlled atmosphere with heating, forced ventilation, air conditioning and humidity control, as may be required. Electronic equipment spare parts may have a temperature limit for operation and storage and, in extreme temperature areas, a separate section of the store room may be dedicated to the storage of these items with air conditioning and humidity control.

Spare parts storage facilities should have clear and safe access to all bays and levels of spare parts and any office facility should be appropriately sited and equipped with any necessary facilities.

2.7.3 Consumable items

Consumables may be held centrally and at each work site. The inventory of consumables should identify the storage location and be complete, accurate and up-to-date. Stock data should be readily available to maintenance staff and supervisors.

Whenever any item of the stock is removed the management system database should be updated. A minimum and maximum system of re-ordering should automatically “flag” the spare part for re-ordering when the minimum level has been reached.

The consumable items stock level should be adequate for routine maintenance and for planned corrective maintenance where additional stock levels may be required.

Audit and inspection of consumables stock should be conducted regularly to ensure that stock levels are accurate, that consumables are in good condition and to provide an assessment of the housekeeping standards as well as safety and environmental management. The shelf life of degradable items should be monitored. All consumables should have adequate protection from accidental damage, from detrimental environmental conditions and, where necessary, be stored...
in a controlled atmosphere with heating, forced ventilation, air conditioning and humidity control, as may be required.

Where petroleum based products, chemicals and other hazardous material are stored within the facility, or adjacent to the facility, the respective areas should be enclosed with a locked access. All of the contents within these hazardous areas should have the manufacturer’s product identification notices clearly posted. An eyebath station, protective clothing and full screen visor should be placed within the hazardous area and warning/instruction notices posted.

The use of rags and waste and cleaning materials should be monitored and controlled. Items should be used appropriately, in accordance with health and safety requirements, and prevented from contaminating machinery and spaces.

2.7.4 Workshops

Mechanical and electrical workshop construction and layout should conform to all statutory requirements as detailed under current Health & Safety legislation.

Areas of special attention to HSE include the following:

1) High Pressure Test Bench for calibration and testing of valves, casings, etc
2) High Pressure Test Bench for calibration and testing of pressure transmitters and analogue gauges
3) High Pressure Water washing machines, possibly with steam jet facility
4) Electric Motor cleaning and re-varnishing area
5) Manual and pressure spray painting areas
6) Gas and electric welding equipment location and work places.
7) Machine tool guarding and safety devices
8) Grinding wheels

The workshops should have adequate facilities to support the Maintenance System. All areas should be adequately illuminated and ventilated, with forced ventilation and extraction fans fitted where necessary. Heating/air conditioning may be necessary depending on installation location; also acoustic barrier insulation may be required at some locations.

Where workshops have an office for administration, it should be well insulated from workshop noise, be appropriately sited and fitted with necessary facilities. The workshops should have clear and safe access for transport to all machinery rooms and to toilet and wash facilities. First aid stations should be sited as required to satisfy applicable regulations.

A section of the workshop may be allocated to instrumentation maintenance and repair and contain all the necessary special equipment for simulation, repair and maintenance, calibration and function testing of the majority of instruments on the site. Some instruments, e.g. flow meters for fiscal calculations, may require attention by specialist service companies.

Regular inspections should be made of the workshops to provide evidence of the general condition of machinery, to provide an assessment of the housekeeping standards as well as safety and environmental management etc.

Machine tools within the workshop should be operated by qualified and authorised personnel only and all safety guards and facilities should be fitted in good order.
PPE, including special protective clothing, work gloves, goggles and visors, should be placed within the workshops, as should relevant safety and warning notices for the operation of machinery and equipment.

2.7.5 Maintenance equipment

An effective Maintenance System should retain, or have access to, a sufficient inventory of tools and maintenance equipment to facilitate the proper conduct of the tasks included within the maintenance programme.

Maintenance tools and equipment should be included within the Maintenance System inventory and programme. The organisation of specialist maintenance equipment procurement and delivery arrangements should be managed within the Maintenance System. Equipment manufacturer supplied tool inventories should be catalogued, maintained and segregated during storage, usually in supplied containers.

All the necessary hand tools required to support the Planned and Corrective maintenance tasks should be available, with a stock of replacement tools carried as part of the stock of consumable items if required, stored so that they are kept in good condition. The tools in use should be maintained in good, safe, working condition. Use of tools and equipment should conform to Health and Safety requirements as referenced in PUWER 98 regulations and H&SE ACOP - L22.

Hand tools should be checked after use, before return to storage, and any deficiencies remedied.

Power tools should be used safely in accordance with statutory and industry guidelines and safety features of power tools should be operational and regularly tested. Cable and hose runs should be planned and should be laid out safely in a way that minimises exposure to damage.

Measuring equipment items should be of good quality. They should be stored so that they are kept in good condition and should be used appropriately and replaced when their condition is so damaged or worn that accuracy is compromised.

A procedure should exist within the Maintenance System to check and approve the use of maintenance equipment supplied by third parties. Considerations may include the following:

1) Equipment safety
2) Requirements for supply from installation services
3) Equipment lifting requirements
4) Equipment calibration

Lifting tackle should be subjected to the regular proof load tests as required by regulation. A register of all lifting tackle, including hoisting wires, and power lifting apparatus should be maintained and presented when required for inspections and audits as referenced in LOLER 98 regulations and H&SE ACOP L-113.

All the necessary specialist tools required to support the Planned and Corrective maintenance tasks should be readily available to the work force. All machine tools, specialist and power operated tools should be checked on a regular basis and maintained in good working condition. If it is found that a tool is beyond economical repair, it should be replaced and the original removed from the work place for eventual disposal to an onshore facility.
Unique tools made for particular applications should be manufactured to conform to appropriate specifications and design factors and used in accordance with set procedures.

Assessments of the workshop contents should be based on physical inspections conducted to check the condition of the equipment for evidence of condition, calibration, cleanliness, safety and environmental management, etc.

Calibration equipment, diagnostic equipment, measuring equipment and maintenance tools intended for the accurate application of specified forces should be included in a calibration programme. The calibration of installation equipment and maintenance equipment should be included within the maintenance programme and the calibration programme should address the following considerations:

1) A register should be kept of included equipment.
2) The register should note previous and due calibration dates.
3) Information regarding calibration accuracy should be referenced and available.
4) Calibration should be made against calibration equipment traceable to a national standard.
5) Calibrated equipment should be marked to identify calibration status and due date.

2.7.6 Computer workstations

Sufficient computer workstations should be available for effective administration of the Maintenance System. They should be sited at appropriate locations, including:

1) Installation office containing technical manuals library, procedural documents, certification files etc.
2) Spare Parts stores if the Maintenance System is linked to spare parts management.
3) Installation control stations or workshops requiring access to Maintenance System data.

Sufficient computer workstations and access time should be available to allow timely administration of the maintenance programme, including Work Order issuance, completion and reporting and unscheduled maintenance task management. Consideration should be given to any limit on concurrent users of the maintenance software and to speed of data transfer on internet or intranet systems.

2.7.7 Waste disposal

Sufficient and proper facilities should be available for maintenance waste disposal. This should include used parts, chemical, oil, electronic, plastic, machining, slag and packaging waste. The collection, segregation, stowage and disposal of waste in all its forms are subject to regulatory and statutory requirements which should be adhered to in all aspects. A clear, accurate auditable record of waste product disposal should be documented.

2.8 PROCEDURES

A Maintenance System may be regulated by documented or by established procedures. Whilst the objectives of the Maintenance System may be to achieve outcomes defined by an organisation, the process itself requires regulation and prescription, to satisfactorily manage and control the work involved. Procedures should be based on a review of the processes they are
intended to control and should be established, implemented and maintained so that the relevant activity corresponds to the defined requirements.

Procedures should be subject to internal review and audit to establish their continued relevance and observance. A procedure should be followed, amended, superseded or withdrawn. Where working practices are controlled by a procedure they should not deviate from it. Where the procedure is inadequate, outdated, absent or no longer required then the procedure itself should be under review and modification.

Alterations to procedures should be subject to a Management of Change procedure.

2.8.1 Management of change

All changes to, and within, a Maintenance System should be subject to a standard evaluation process to judge the necessity for its management under the control of a Management of Change Procedure.

The procedure should facilitate proposals for change from all concerned personnel.

Changes made within a maintenance programme concerning SCE require use of the Management of Change procedure and should be referred to the ICB for information in case of possible impact on Verification Schemes.

The Maintenance System should address the initial and continuing suitability of the maintenance programme and where changes are required in the light of field operating experience this should be accomplished through a Management of Change procedure. Information should be recorded in the change procedure documents to justify and explain the alteration to original task frequency, nature of task, testing methods, etc.

Changes to maintenance tasks should be based on valid criteria obtained from operating experience or manufacturer’s recommendations, or other valid sources, and, when changes are made they should be subject to on-going scrutiny to prove their continuing suitability. Changes should be recorded in the Maintenance System work history and in other documentation as may be required.

2.8.2 Documentation

Documentation necessary for the management of a Maintenance System should include procedures, manufacturers’ documentation, machinery system drawings, machinery certification, analysis and review records and management records.

Hard copy documentation may be maintained in a central library or dispersed around worksites. Every collection should hold a catalogue detailing the list of available titles, and revision number, with the designated technical library reference number if allocated. An organisation should hold an up-to-date technical library register at each main location for maintenance management.

Recent practice for manufacturer’s manuals and spare parts list for new equipment is to provide two hard copies and one electronic [CD-ROM] copy. Information contained in manufacturers’ documentation should be subject to informed review prior to use or transcription, to minimise the possibility of the introduction of errors into maintenance task procedures. Manuals may have identifier codes which can be quoted on Work Orders.
All documentation relevant to the Maintenance System may be sampled for compliance with organisational document control procedures and for relevance, accuracy, clarity and lack of contradiction between documents.

The types of document to be evaluated include the following:

<table>
<thead>
<tr>
<th>Document type</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedural documents</td>
<td>Established procedures governing critical management issues, including:</td>
</tr>
<tr>
<td></td>
<td>1) Management of Change</td>
</tr>
<tr>
<td></td>
<td>2) Sub Contractor management</td>
</tr>
<tr>
<td></td>
<td>3) Maintenance System review</td>
</tr>
<tr>
<td></td>
<td>4) Software access, security, data input and management</td>
</tr>
<tr>
<td></td>
<td>5) Maintenance Task supervision</td>
</tr>
<tr>
<td></td>
<td>6) Root Cause analysis</td>
</tr>
<tr>
<td>Manufacturer’s documents</td>
<td>1) Maintenance Manuals</td>
</tr>
<tr>
<td></td>
<td>2) Spare Parts Catalogue</td>
</tr>
<tr>
<td></td>
<td>3) Functional Description</td>
</tr>
<tr>
<td></td>
<td>4) Service Centre Catalogue</td>
</tr>
<tr>
<td>Drawings</td>
<td>1) General Arrangement drawings</td>
</tr>
<tr>
<td></td>
<td>2) Pipework and Instrumentation diagrams</td>
</tr>
<tr>
<td></td>
<td>3) Pipework schematics</td>
</tr>
<tr>
<td></td>
<td>4) Electrical schematics</td>
</tr>
<tr>
<td>Certificates</td>
<td>1) Type approval certificates</td>
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<tr>
<td></td>
<td>2) Statutory certificates</td>
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<td></td>
<td>3) Classification Society certificates</td>
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<td></td>
<td>4) Test and Acceptance certificates</td>
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<tr>
<td></td>
<td>5) Calibration certificates</td>
</tr>
<tr>
<td></td>
<td>6) Warranty certificates</td>
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</tbody>
</table>

2.8.3 Meetings

Administration of the Maintenance System and management of the maintenance programmes and maintenance tasks may be organised at scheduled, official meetings at which minutes are taken and action lists produced.

Documentation relating to meetings may be evaluated for conduct, resultant actions and closeouts, safety issues arising and problems within the Maintenance System.

2.9 TRAINING

A Maintenance System requires the work of skilled and knowledgeable personnel who should receive the training required to work safely and effectively.

A Maintenance System should be provided with the support of whichever organisational department identifies and supplies training requirements, manages training and maintains training and skills records. All these issues may be evaluated to judge their impact on the effectiveness on a Maintenance System.
2.10 BUDGETING

Costing of a Maintenance System may be an integral function of the software used to manage the Maintenance System or it may be calculated by another function from data recorded as part of Work Order completion.

Costing information provides valuable data about the historical costs required to operate a Maintenance System. It does not provide any direct guidance as to the value of particular maintenance tasks or to the cost benefit of minimising Corrective Maintenance by the operation of a given scheduled maintenance programme.

The costs of a Maintenance System should primarily be judged on a technical assessment of the maintenance requirements of an installation.

Many maintenance software programmes provide modules that integrate with Work Order management to document spares inventory and to manage spare part ordering and receipt.

Maintenance budgeting may include the following:

1) The cost of the man-hours necessary to complete the routine and Corrective maintenance tasks as scheduled and allocated in the Maintenance System. The man-hours should include all trade disciplines, technicians, supervisors and maintenance management personnel including managers also ex-officio people assigned to the maintenance department, e.g., planning engineer, maintenance system administrator. The man-hours allocated, and the actual man-hours, should reflect the assets being maintained and should be accurate and realistic.

2) The cost of training staff by classroom/field instruction; computer based training [CBT] and mentoring processes.

3) The costs of specialist technician services for work outwith the capabilities of the normal in-house maintenance personnel, including the costs of transport and accommodation onshore, if required.

4) The costs of contract labour for the various trade skills and disciplines, including transport and accommodation onshore costs, if required.

5) The costs of inspection and assessment staff from industry inspection services, visits of regulatory and statutory bodies for examination of the installation condition and general overall maintenance standard, including the costs of transport and accommodation onshore, if required.

6) The estimated and actual costs of all spare parts and consumables necessary to support the Maintenance System in entirety including special cleaning and treatment chemicals, preservation of fabric material, etc.

7) The estimated and actual costs of the hire or purchase of special tools and equipment including hire of cranes, lifting equipment and specialised examination and recording equipment.

The capital expense budget may include the following:

1) The cost of new equipment including purchase, transport, FAT tests, possible storage onshore until required, delivery, installation and commissioning equipment necessary for pre-commissioning onshore and final field commissioning.

2) The costs of inspectors at vendors’ facilities for FAT and on-going inspections for progress reporting and quality assurance and quality control.
3) The costs of commissioning engineers and technicians for pre-commissioning and final field commissioning. Hire of additional equipment for these commissioning procedures, where necessary.

4) The costs of advisory and supervisory people at commissioning procedures including HSE advisor, Job Safety Analyst, Fire fighting personnel etc.

The purchasing of resources for the Maintenance System may follow any of the following supply paths:

1) In-house sourcing and direct purchase of resources by the buyers within the purchasing group of the parent organisation on advice from the maintenance support group, and approved by the owner of the installation.

2) In-house sourcing and cost of purchase from supply agencies of resources by the buyers within the purchasing group of the parent organisation on advice from the maintenance support group and approved by the owner of the installation.

3) In-house sourcing of any or both of the above, but not requiring the approval of the owner of the installation.

4) The sourcing, purchase, transport and delivery of resources by an agency approved by the owner of the installation on advice from the purchasing group within the parent organisation, and or owner, and with advice from the maintenance group.
3 MAINTENANCE SYSTEM DESIGN

A functioning maintenance programme is constructed from basic defined steps.

These steps are discussed below.

3.1 EQUIPMENT INVENTORY

A Maintenance System is only as complete as the equipment inventory it operates on.

An all inclusive equipment inventory makes development of an equipment numbering system simpler, provides reassurance that the full potentiality for an offshore installation maintenance programme is documented and allows the development of a maintenance programme to take account of conflicts and harmonisation of tasks and of scheduling for mutually supporting equipment and mutually exclusive work.
Equipment Data should include the following:

1) Primary titles as designated by the organisation, e.g. Main Ballast Pump.
2) System or sub-system identifiers for multiple items, e.g., Main Ballast Pump No.1, Main Ballast Pump No.2.
3) Manufacturer’s data, including name and address of manufacturer, year of manufacture, serial number, certification data e.g. LRS, ABS, cross-referenced to original certificate of test, type of unit, e.g. sea water ballast pump, air compressor, test pressures.
4) Safety device settings, such as the set pressure of pressure relief valve(s) or pressure control valves where mounted directly.
5) Equipment Criticality (SCE) rating.
6) Location identifiers.
7) Referenced location on schematic layouts, isometric drawings, and P & IDs.

The equipment inventory should be evaluated for completeness, accuracy, organisation and management control.

3.2 EQUIPMENT NUMBERING

In parallel to, or following the compilation of, an equipment inventory, a numbering system should be developed to provide a unique identifier for each item of equipment.

For many maintenance software programmes this is an obligatory process as the identifier provides the mechanism by which the software interlinks information in differing databases. This is a beneficial process for any Maintenance System however, as it provides a simplified, integrated equipment identification system that significantly prevents the practical mis-identification of referenced equipment and allows quick tagging of both documentation and of the equipment itself.

Numbering systems are usually an assembly of alphanumeric characters divided into groups, with each group identifying a ‘family’ of items from within the inventory. The complexity of a numbering system and the number of available integers should adequately address the size and scope of the equipment inventory.

Equipment Codes may be linked to spare parts numbering and equipment component inventories may provide a link to the Maintenance System for the equipment item.

Where numbering has been assigned at the design stage to schematic and isometric drawings and P &IDs, these may be utilised as equipment codes.

Where a set of a particular component type, e.g. a fuel injector, may be transferred between several machinery items, the maintenance software may allow each component to be numbered individually and linked to whichever machinery item it is presently fitted. This facility allows an accurate history of component use to be maintained.

Equipment numbering should be evaluated for derivation, functionality, logicality and consistency.
3.3 **MAINTENANCE TASKS**

Items included in the equipment inventory and identified within the numbering system should be allocated a programme of maintenance tasks.

Maintenance tasks should normally be issued as Work Orders from the Maintenance System. The Work Order may include a variety of information specified by the organisation and define the data required for inclusion in the maintenance history.

Maintenance task descriptions may be specifically tailored to an item of equipment or drafted as generic tasks which can be applied to a range of the same type of equipment item. Maintenance software programmes that provide the facility for allocating generic tasks should have a database of pre written tasks allocated unique identifiers which are then linked to equipment Work Orders as required. The generic tasks may have the facility to be allocated manhours, spares parts required etc., as well as a task description. It is essential that the information included within a generic task is applicable to every Work Order to which it is attached, so a particular activity may have several task database entries individually tailored for specific equipment items.

Maintenance recommendations and guidelines contained within manufacturers’ manuals should be consulted when compiling initial tasks but previous experience of equipment type or manufacturer, coupled with field operating conditions, should influence the task compilation for a Planned, Predictive or RCM Maintenance System.

The preamble to a task description should quote the relevant instruction manual, page number reference and any figures or sketches, where necessary or applicable.

The preamble may also include a Safety Notice/Instruction which co-relates with the Permit To Work [PTW] system emphasising all safety and environmental aspects of the task before, during and on completion.

Tasks may be designated as an ‘on condition’ or OC Task where the outcome is to determine the condition of the equipment item, i.e. check for, look for, calibrate, etc. OC Tasks may not necessarily be included as condition monitoring.

The task description should be clear, precise, complete, informative and include all the relevant references to special tools, accompanying documentation, e.g. alignment check list, dynamic balancing record reference, etc. The description should be based on several factors, including, but not limited to, the following:

1) Equipment manufacturer maintenance recommendations (task description)
2) Traditional (time-directed) overhaul tasks and guidelines/instructions. Owner instructions to sub-contracting company where applicable
3) Operational conditions and field experience
4) Previous experience of equipment/asset type and quality
5) Criticality and maintenance rating or ranking
The Work Order should show the primary task with any sub-operations necessary following on from the main task description. Sub-operations could include isolations, safety checks, third party inspection, start up checks etc.

The number of personnel required for each maintenance and support task should be shown with planned man-hours allocated to each trade, person or department involved in the task, as required for maintenance analysis.

Compilation of maintenance tasks should take into account the requirements of all statutory and regulatory bodies. The Work Order for SCE should provide information to allow maintenance staff to confirm that the SCE meets Performance Standard criteria that may be verifiable during the conduct of the maintenance activity.

Maintenance System task descriptions should be evaluated for included information, safety instructions and detail of task description.

Compilation of, and assignment of tasks within the Maintenance System should take input from the following:

1) Recommended tasks from manufacturer’s manuals maintenance section, also FMEA and FAT functional test data from the relevant sections. The text may be generic for a rating or group of assets, and/or it may be design specific for singular units or equipment which is not covered by a generic maintenance task description.

2) Organisation or industry experience of equipment type, also field mechanical completion and final commissioning functional test observations and recommendations.

3) Quality of process medium, changes in operating parameters of process medium from original FAT and commissioning medium.

4) Statutory and Regulatory bodies requirements, and other external requirements, for examinations, inspections and functional tests.

5) Maintenance programme requirements defined by SIL allocation, in accordance with IEC 61508, for programmable controllers with safety functions

Any changes to original text or safety procedures preamble should be under control of the Management of Change procedure and the change notified to all interested parties, including ICB if required.

Authorised personnel should assign tasks to the various sections within the maintenance group.

### 3.3.1 Equipment manufacturers’ recommendations

Whatever the style of Maintenance System adopted, the equipment manufacturers’ recommended maintenance programme provides a good reference point for development of maintenance tasking and equipment manufacturers’ operating, maintenance and testing procedures should form the initial basis for the conduct of maintenance tasks.

Equipment manufacturers’ specified clearances, tolerances and operating conditions should form the basis for the requirements of maintenance tasks.

Manufacturers’ information may be supplied in various forms of media and should be stored and maintained so as to be readily retrievable by the relevant personnel. Updated information from manufacturers should be registered and distributed to relevant worksites.
Procedures and data should be linked to Work Orders either by transcription into Work Orders or by reference within Work Orders. If information is referenced then the relevant material should be available and the references updated to reflect any new information.

### 3.3.2 Maintenance and repair processes

The various maintenance processes should be managed and controlled appropriately to ensure their safe conduct and acceptable outcomes.

Maintenance processes requiring particular controls include the following:

<table>
<thead>
<tr>
<th>Process</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Welding</strong></td>
<td>All welding procedures should be carried out by qualified and authorised personnel only, using the PTW system. No exceptions are made in this field of maintenance and repair.</td>
</tr>
<tr>
<td></td>
<td>Where welding procedures are made in, or adjacent to, a workshop where other trades are engaged in non-welding work, a designated area for the welding should be set aside and conform to all regulations pertaining to welding areas and equipment.</td>
</tr>
<tr>
<td></td>
<td>Where welding procedures are performed outwith the designated workshop areas, a full and complete Job Safety Analysis and Risk Assessment should be completed prior to issuance of the PTW.</td>
</tr>
<tr>
<td></td>
<td>The area where the welding work is being conducted should be constantly monitored for personnel safety, safe access and retreat, hazardous fumes and fire in accordance with best safety and work practices.</td>
</tr>
<tr>
<td></td>
<td>All weld repairs should be carried out to the applicable weld and pipe/fabrication standards as detailed in numerous procedural pamphlets, books, and manuals.</td>
</tr>
<tr>
<td></td>
<td>Temporary ‘patching’ of pipes, tanks, structures, wasted foundations etc should not be accepted as a permanent repair. Full repairs and renewals should be made at the first practicable opportunity and to the relevant standards and good work practices.</td>
</tr>
<tr>
<td><strong>Pipe clamps, fibreglass, resin or plastic metal patches, coatings or surface build up</strong></td>
<td>All these processes should be carried out by trained and experienced personnel only, after suitable evaluation and risk assessment of the repair procedure.</td>
</tr>
<tr>
<td></td>
<td>The underlying structural integrity of the parent structure must be carefully assessed and any process of continuing degradation understood and controlled.</td>
</tr>
<tr>
<td></td>
<td>The area where the work is being conducted should be subject to monitoring for personnel safety, safe access and retreat, hazardous fumes and fire as may be required for best safety and work practices.</td>
</tr>
<tr>
<td></td>
<td>All repairs should be carried out in accordance with manufacturers’ instructions, in suitable environmental conditions to the required standard and tested in accordance with a defined protocol developed after suitable evaluation and risk assessment.</td>
</tr>
<tr>
<td></td>
<td>The repair should be subject to ongoing inspection in accordance with a defined procedure, developed after suitable evaluation and risk assessment. Inspections should be included within the maintenance programme.</td>
</tr>
<tr>
<td></td>
<td>Temporary ‘patching’ of pipes, tanks, structures, wasted foundations etc. should not be accepted as a permanent repair. Full repairs and renewals should be made at the first practicable opportunity and to the relevant standards and good work practices.</td>
</tr>
<tr>
<td></td>
<td>Repair procedures for SCE should be subject to ICB review and approval.</td>
</tr>
</tbody>
</table>
3.4 MAINTENANCE SCHEDULING

After the equipment inventory has been created and the maintenance task programme for each equipment item has been defined a schedule for performing the maintenance tasks should be worked out.

A major factor influencing maintenance task scheduling is the operating philosophy and regime for plant, machinery and equipment. The scale of the maintenance requirements for individual items should be dependent on such considerations as:

1) Normal operational loading
2) Maximum operational loading
3) Length of running periods
4) Length of idling/warming through periods
5) Start/stop cycles
6) Vibration
7) Fatigue
8) Contamination of fuel, coolant, intake air etc
9) Environmental conditions
10) Electrical supply spikes and fluctuations
11) Process fluid, gas or mixture quality, and flow operating conditions, including steady state flow, variable flow, and possibility of surge incident.

Task frequency should also depend on several factors, including the following:

1) Maintenance methodology, i.e. Corrective/Planned/Predictive/RCM/Campaign
2) Equipment manufacturers recommended maintenance intervals
3) Established good engineering practice and previous history of equipment type.

Maintenance System task scheduling should be evaluated for frequency assignments, measurement of due interval and management of the scheduling of Work Order issue.

Compilation of, and assignment of tasks within the Maintenance System should take account of the following:

1) Schedule recommendations from manufacturers’ manuals maintenance section.
2) Organisation or industry experience of equipment type, also field mechanical completion and final commissioning functional test observations and recommendations.
3) Quality of process medium, changes in operating parameters of process medium from original FAT and commissioning medium.
4) Statutory and Regulatory bodies, ICB verification scheme requirements, and other external requirements, for examinations, inspections and functional tests.

For corrective and/or campaign maintenance HSE personnel, Contractor’s Representatives and Supervisors should be included in the planning and task scheduling.
3.5 MAINTENANCE PROGRAMME

The scheduled maintenance programme should initially be formulated by responsible personnel from technical, operational and planning disciplines and depend on the methodology, strategy and objectives adopted for the Maintenance System.

Corrective and/or Campaign maintenance may be a major section of the Maintenance System and should be integrated into the maintenance programme. The Maintenance System should be capable of managing Work Orders for Corrective or Campaign maintenance when repairs are necessary, or the equipment is part of a Campaign maintenance work scope.

The maintenance software may issue Corrective/Campaign Work Orders or they may be issued separately as part of dedicated Work Packs. The maintenance programme may therefore be integrated within the maintenance software functions or amalgamated with Corrective/Campaign tasks in association with the organisation planning discipline.

The maintenance programme should be directed to even the distribution of tasks over any given period and avoid clashes and duplication. Safety and Environmental considerations should be factored in and the programme should be reviewed at regular intervals within a defined planning group of sufficient authority.

The maintenance programme should regulate the maintenance effort, prioritising the most beneficial tasks and limiting tasks that may be evaluated as inefficient, potentially disadvantageous, or unnecessary.

The maintenance programme should strive for maximum reliability of equipment and ensuring continued performance of intended function with reference to Performance Standards, vendors’ FAT data and final commissioning function tests.

All plant and machinery should have reasonable objectives that the maintenance programme is intended to achieve. These objectives should be acceptable to ICB and operational requirements and allow for the age of units and plant. The objectives should be reasonable and should take account of overall condition. The acceptable limiting criteria for SCE should be defined in the Performance Standards and regular reference and comparison should be made and recorded.

If the maintenance is contracted out then the maintenance programme should comply with Owner’s requirements for frequency and detail of tasks in all respects.

The maintenance programme should not only be safety, condition and function oriented but also business oriented, regulating the ongoing task to provide:

1) Operations efficiency
2) Quality and reliability
3) Cost effective technical maintenance
4) Safety and environmental integrity
Possible inputs into the design of a maintenance programme may be depicted as below:

Subjects to be considered during evaluation of a maintenance programme include items 3.5.1 to 3.5.10.

Failure Modes and Effects Analysis (FMEA), Reliability, Availability and Maintainability Study (RAMS), Pareto Analysis and Fault Tree Analysis are all tools that may be applied to target and refine a maintenance programme. They provide methods of identifying and prioritising failure modes and mitigating measures.

The International Marine Contractors Association (IMCA) publication IMCA M166, April 2002 - ‘Guidance on Failure Modes and Effects Analyses’ provides an outline for usage of this analytical tool.

These analytical tools are essential for a Reliability Centred Maintenance System.
3.6 MAINTENANCE RECORDING

On completion of a Work Order the outcomes, data and history should be recorded.

Equipment history should contain as much as is possible of the original design parameters including FAT function tests, vibration and noise level base signatures etc and any existing history collated prior to the development of a Maintenance System.

On completion of a maintenance task, the Work Order history should be completed by the responsible person as defined by procedures. The Work Order should then be subject to an established process including such actions as review, sign off, information transcription to software databases and hard copy filing, by defined persons.

The Maintenance System software may include a section for spare parts which may automatically upload data from maintenance section history to spares section stock keeping. In such a case, it is essential that all references to spares used be accurate in description, reference number, quantity used, etc.

If components removed are required for ICB or other inspection, they should be labelled with reference to asset, component part number, date removed, etc., and, if possible, accompanied by relevant photographs with date inclusion.

Maintenance task recording should be evaluated for outcomes, methods and included information.

3.7 MAINTENANCE REVIEW & ANALYSIS

The maintenance records should be subject to systematic review and analysis to improve the effectiveness of the Maintenance System and to identify issues benefiting from remedial action. Maintenance history and data should be used to assess:

1) The level of achievement of Maintenance System objectives and performance indicators
2) Trend analysis of condition monitoring data
3) Equipment failure mode frequencies
4) Root causes of failures

Maintenance record review and analysis should be evaluated for usages, methods and resultant actions.

3.8 MAINTENANCE SYSTEM ASSESSMENT & REVIEW

A Maintenance System should benefit from regular review and assessment of its performance and methods of working.

Reference may be made to the H&SE publication HSG 65, including the ‘POPMAR’ methodology.
Senior management commitment to the Maintenance System should be reflected in ongoing support and in review and evaluation of:

1) Performance and relevance of the maintenance programme  
2) Resources required  
3) Management effectiveness  
4) Health and safety

A maintenance programme can only maintain the level of reliability inherent in the system design therefore the knowledge acquired should be available to be fed back to equipment manufacturers to improve designs and to assist future organisation projects.

The full benefit of a Maintenance System is best achieved when operations and maintenance experience is continuously subject to assessment and review. The results should be fully documented for circulation to all interested parties and actions implemented and monitored within the management structure, offshore and onshore.

A Maintenance System may be subject to internal and third party audits, organisational management review, statutory body inspection and review and verification scheme inspection.

Maintenance System assessment and review should be evaluated for inputs, methods and resultant actions.
4 SCHEDULED MAINTENANCE

Scheduled Maintenance may be regarded as that portion of a Maintenance System that incorporates routine and pre-scheduled maintenance tasks.

Scheduled Maintenance includes surveillance, inspection and testing as much as it does overhaul. An effective Maintenance System is entirely dependent on the firm foundation of an understanding of the condition, functionality and operability of the equipment.

This understanding starts from knowledge of the design and the capability of the equipment gained from training and familiarisation.

The following sections describe good working practice for manned installations, whilst these may not be universally applicable to unmanned installations they provide a sound basis for the conduct of a maintenance programme.

Maintenance tasking on unmanned installations requires specific, rigorous application of risk assessment and health and safety measures.

4.1 WATCHKEEPING

The essential first step in a maintenance programme is a schedule of daily inspection. This is critical to fault prevention and damage limitation.

Continuous monitoring of machinery system running condition from a control room is critical for plant operation and for prompt response to alarm conditions but it cannot substitute for the benefits of regular visual inspection of spaces and machinery.

Watch keeping inspections should be conducted at least twice daily and incorporate all routinely accessible spaces containing running machinery. The various functions onboard an installation may conduct a more focused regular inspection schedule looking at the equipment under their control but a routine general inspection should allow installation staff to maintain a continuously updated and current overview of general condition and the status of defects. The inspections also provide the occasion for manual checking of machinery operating parameters that may not be covered by remote monitoring and recording of running hours, fuel consumptions etc.

A checklist is a useful guide and recording tool for such inspections, which can be formatted to follow a prescribed inspection route around the installation. Watch keeping inspections should include tests of particular alarm and safety functions and the results should be recorded either on the checklist or in the official log. These inspections need not be incorporated into the Maintenance System as maintenance tasks with Work Orders issued, but may be recorded into the maintenance history if required.

Safety measures should be observed during Watch keeping inspections, particularly if conducted single handed. The whereabouts of the individual should be monitored and appropriate precautions taken in such instances as hazardous environment, automatic doors, auto-start machinery etc.
4.2 ROUTINE TESTS, INSPECTIONS AND MAINTENANCE

After Watch keeping inspections, the second level in a maintenance programme includes those frequent and routinely required non invasive tasks that contribute to a more complete assessment of machinery system condition and to prevention of abnormal running conditions.

Such tasks would include:

1) Greasing and lubrication
2) Oil changing
3) Oil sampling and analysis
4) Water sampling and chemical analysis
5) ‘Run/standby’ equipment changeover
6) Test running
7) Safety equipment testing
8) Engine compression tests/indicator diagrams
9) Drive belt tension checking
10) Vibration monitoring
11) Clearance measurements

These tasks should be controlled and recorded but not necessarily from within the maintenance task Work Order system. They may be managed through independent sub routines with their own procedural and record keeping documentation.

Procedures for such tasks should include all required safety precautions.

The results should be subject to appropriate trend analysis and there should be a mechanism for reporting identified defects and anomalies into the Maintenance System defect reporting system.

Routine checklists for condition monitoring, operability and functionality tests should generally be subject to an organisation’s document control procedures.

Routine sampling of sump lube oils, hydraulic oil, cooling water, and other fluids may be scheduled as Work Orders and the results recorded. Tests may include:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reciprocating engines sumps</td>
<td>Sampling of lube oil for water contamination, viscosity, TBN, possible fuel mixing, and solids build-up [TDS] and additive concentrations.</td>
</tr>
<tr>
<td>Gear Boxes and Hydraulic Transmission Boxes</td>
<td>Sampling of lube/cooling oil for water contamination and solids build-up [TDS], also possible discoulouration due extreme pressure and temperature operational conditions, and additive concentrations.</td>
</tr>
<tr>
<td>Hydraulic Oil Sumps</td>
<td>Sampling for water contamination, solids build-up [TDS] and additive concentrations.</td>
</tr>
<tr>
<td>Brake Fluid Sumps</td>
<td>Sampling for water contamination and solids build-up [TDS].</td>
</tr>
<tr>
<td>Water cooling systems</td>
<td>Sampling for ph, also checks of total dissolved solids [TDS], treatment and anti-freeze concentrations.</td>
</tr>
<tr>
<td>Equipment</td>
<td>Remarks</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Boiler water</td>
<td>Sampling of feed and condensate for ph, chemical dosage levels and impurities.</td>
</tr>
<tr>
<td>Bunkers</td>
<td>Sampling of delivered fuel and bulk lube oil as precautionary measure to establish baseline condition and agreement with specification.</td>
</tr>
<tr>
<td>Oil storage tanks</td>
<td>Sampling for water build-up, and microbial contamination.</td>
</tr>
<tr>
<td>Potable water</td>
<td>Sampling for contamination and purity.</td>
</tr>
</tbody>
</table>

In addition to routine analyses, periodic analyses may be made by onshore laboratories for more detailed analysis, e.g. Ferro graphic analysis of engine and gear box system lube oil, catalytic fine inclusion in fuel oil, and the results filed and retained for a defined period.

Routine checklists may also be used for condition monitoring, vibration and noise level monitoring and analysis.

### 4.3 WORK ORDER ISSUING

The source for Work Orders may be local at a worksite, or remotely from a central main office. Work orders may be issued and processed electronically at computer workstations or in hard copy. The source for issuing Work Orders should be properly authorised in accordance with Maintenance System procedures.

The database of Work Orders should include the provision to view a list of those due for issue. It should ordinarily be possible to sort and view tasks according to:

1) Date range  
2) Equipment number  
3) Running hours  
4) Other units of machinery activity measurement, e.g. tonnes, kilometres

The list of due tasks should then form the basis for the maintenance programme work scope over the next period.

Cancellation, postponement or amendment of a Work Order should be permitted only to defined personnel with the required authority and should be controlled by defined procedure. The maintenance history should log such actions.

Work Orders may be issued individually or in batches. Dependent on the size and scope of the maintenance programme, it may be preferable to permit individuals to issue due Work Orders on an ad hoc basis to suit their work schedule or it may be more efficient to issue all Work Orders due in the next reporting period and distribute them to the personnel concerned.
Work Orders should include all the necessary information to:

1) Correctly identify the equipment to be maintained
2) Identify required safety precautions and procedures
3) Identify resources required
4) Identify parts required to be routinely changed out
5) Document or reference the working procedures
6) Identify any observations/measurements required and any pass/fail criteria
7) Identify any checks and tests to be conducted prior to recommencing machinery operation

It is common practice to print off a hard copy of a Work Order form for guidance and for logging of required information for the maintenance history. It may be a requirement for the responsible person to sign off a hard copy Work Order on completion.

Information contained in a Work Order may include the following:

1) Work site identifier/location
2) System and sub-system
3) Identifier/location of system or sub-system
4) Person who authorized the Work Order
5) Other related personnel including maintenance planner, OIM, onshore maintenance team, etc.

Work Orders should be issued to the relevant personnel in accordance with defined procedures. Where necessary, and especially where multi-trade discipline tasks are involved, prior to commencing the task, a tool-box-talk may be conducted and PTW procedures applied.

A Work Order should be fully understood by the person(s) assigned to the task and as such should reflect the capability of the person(s) to undertake the task. If multi-discipline trades are necessary to undertake the task then each person may be given a complete copy of the Work Order so that all persons involved are aware of the major tasks and attendant sub-operations at the beginning and end of the major task. This should be explained at the tool-box-talk by the supervisors involved in the overall work assignment.

The above should also apply to Work Orders for Corrective or Campaign maintenance.

Where outside Contractors are working alongside or separate from organisation maintenance staff the following should apply:

1) Work Orders should be issued to the contractors’ maintenance supervisors for distribution to the relevant trade disciplines in accordance with the agreed repair, and/or maintenance, plan, previously formulated and agreed. Where necessary, and especially where multi-trade discipline tasks are involved, prior to commencing the task, the organisation HSE department representative should be in attendance, in addition to the person assigned for site safety by the contractor to accompany the supervisors when tool-box-talks are presented.
2) A Permit to Work should not be issued until all precautionary measures have been concluded and signed off by designated supervisors.
3) A Work Order should not be issued until the signatory supervisors have checked and signed off that all is ready and safe for work to commence.
4.4 MAINTENANCE TASKS

A simplified process map for undertaking a maintenance task is shown below.

**Figure M6** Maintenance task process

### 4.4.1 Maintenance task mobilisation

Proper mobilisation is essential for the successful, safe completion of a maintenance task. The priorities are to:

1) Ensure safety  
2) Allocate sufficient appropriate resources  
3) Organise timely, necessary arrangements
Person(s) responsible for the management of the task, in association with installation Health and Safety personnel, should evaluate the measures needed and ensure the necessary preparatory and precautionary steps are taken. Safety measures include all those relevant to:

1) Location
2) Environment, including noise
3) Equipment criticality
4) Equipment service and control systems
5) Maintenance procedures, equipment and consumables
6) Concurrent local and interrelated system work
7) Shutdown and start up

Necessary control measures may include

1) HAZIDs and risk assessments
2) JSA and toolbox talks
3) PTW
4) Isolations, electrical/pressure/fluid
5) Safety attendants, barriers, safety equipment and emergency escape routes
6) Lifting plan
7) Weather monitoring
8) Maintenance equipment and consumable organisation and usage

Person(s) responsible for the management of the task should evaluate the requirements and ensure the necessary hardware and consumables are available prior to start and that the availability of the required personnel and time is optimised, with allowance for contingencies.

Necessary resources include

1) Personnel, including skills, familiarisation and experience
2) Time
3) Tools and equipment, including proper specification, condition and calibration
4) Consumables
5) Spare parts

Person(s) responsible for the management of the task should ensure that any necessary arrangements have been organised prior to commencing the work. Necessary arrangements may include:

1) Standby system test and changeover
2) Third party surveyor attendance
3) Maintenance equipment services provision
4) Safety overrides
4.4.2 Maintenance task execution

Maintenance tasks should be conducted in accordance with the terms of the Work Order. It may be necessary to amend the defined method or arrangements for the conduct of a maintenance task but this should only be permitted under controlled circumstances, with appropriate consultation and with the agreement of the responsible persons. Given sufficient time an official Management of Change procedure should be adopted. Significant deviations from defined procedures should be noted and recorded in the maintenance history.

It is preferable for the same personnel to conduct a maintenance task from shutdown to start up, to minimise the possibility of errors of omission and oversight. If there is a change of personnel during a maintenance task then a formal procedure of hand over should be used, which may be aided by a checklist to minimise the possibility of errors being made.

Complex maintenance tasks involving multiple disciplines and sub routines should be subject to appropriate management and control, with a single, principal planning and oversight role.

If concurrent maintenance tasks impact on each other there should be regular reviews of status, potential clashes and hold points. Mutually exclusive operations should be scheduled and managed to eliminate problems.

Intrusive maintenance work is a significant direct cause of equipment failures. Care and appropriate expertise are required to minimise faulty and poor workmanship. Care and the proper use of tools reduces the possibility of damage due to maintenance work. It is good practice to inventory all tools used and monitor their return after use. Care should also be taken with the use of rags and waste, plastic wrappers etc. Manufacturers documented parameters should be used as the basis for machinery set up and any deviations or alternate settings properly recorded and detailed in the maintenance history.

The use of workshop machinery should be restricted to competent personnel in accordance with defined safety and operating procedures.

Maintenance services requiring temporary cables, hoses, storage containers etc. should be organised so as to minimise the risks due to failure and intrusion in workspaces.

Safety requirements including PTW actions, fire watches and out of work hours inspections should be rigorously observed.

Good housekeeping and waste disposal is an essential part of maintenance management and worksites should be kept clean and tidy with appropriate arrangements made for the disposal of waste consumables and scrap items.

Used spare parts required for future inspection should be identified and stored appropriately. In the event of third party inspection the equipment should be prepared in accordance with the surveyors requirements.

Weather dependent maintenance tasks should be monitored to allow adequate time for demobilisation and protection in case of unsuitable weather conditions developing.

Good housekeeping is a major factor in hazard and accident prevention and spaces should be kept tidy, clean, dry and well lit with decks, walkways, stairs and handrails in good order, secure and unobstructed.
Tasks involving interference with access ways should include assessment and provision of appropriate cordons, barriers, temporary railings etc. All items removed for access should be properly reinstated on completion.

4.4.3 Maintenance task completion

On completion of a maintenance task, the equipment should be safely returned to operation. Specified checks and tests should be conducted by competent personnel. Alarm and safety trip functions should be tested as required. The required condition of upstream and downstream elements of a machinery system should be established before restarting equipment.

Equipment start up and steady state running should be monitored both remotely and locally and inspections conducted during any running in period, as may be specified in manufacturers recommendations. Operating parameters should be logged to allow early detection of any deviation from normal.

The maintenance task site should be cleaned and tidied on completion and all maintenance tools and equipment cleaned, checked and returned to appropriate storage.

Waste disposal procedures should be safe and environmentally acceptable.

4.5 HISTORY RECORDING

A primary function of a Maintenance System is the collection of maintenance history and data to allow fault analysis and refinement of the maintenance programme.

A Maintenance System with inadequate recorded history wastes the potential benefits to be derived from the use of time and resources. A major element in the design of a Maintenance System is the provision of adequate time and opportunity to record the outcomes of maintenance tasks. This requires adequate computer workstation access, adequate hard copy filing facilities and adequate man-hour availability.

Maintenance software programmes may provide a facility to create a database of repair codes which can be attached to completed Work Orders. This facility is a useful tool for integrated financial packages, allowing costing for the various modes of failure and maintenance procedures. It does not replace a detailed description of findings.

The maintenance records should include all of the work done on the equipment inventory and should incorporate reference to FAT and Final Commissioning documentation which include examinations and function tests for periods prior to inclusion in the Maintenance System. Subsequent maintenance tasks for either scheduled or unscheduled work history may classify equipment function test results in the two following categories:

1) Primary function results: speed, output, operating quality (e.g. vibration level)
2) Secondary function results: safety, comfort (e.g. noise level), environmental integrity
In addition to the above the maintenance history may record all relevant findings, including:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>Visual examinations and checks prior removal or dismantling equipment for maintenance task</td>
<td>This examination could include checks for leakage, security of foundation, attachment of unit to bedplate, anti-vibration mountings between foundation and bedplate, fabric/preservation condition, alignment checks and vibration level recording.</td>
</tr>
<tr>
<td>Condition of unit and components on examination at site or in workshop on dismantling for maintenance or repair</td>
<td>All necessary calibrations should be recorded on controlled documents, and these documents noted for cross-reference in work history database. Where applicable, comment on effectiveness of routine and specific analyses of oils and cooling mediums in assisting with maintenance planning.</td>
</tr>
<tr>
<td>Condition of all components of the unit, parts being replaced and parts being re-conditioned and re-fitted</td>
<td>The part numbers being commented upon within the work history should correspond to the manufacturer’s nomination on spare parts list or other section within the instruction/maintenance manual parts list in all cases. In some cases parts lists may contain part numbers and ordering code numbers in which case part numbers only are to be used from manufacturers’ manuals. Dedicated company spare parts management systems linked to Maintenance Systems may have computer generated parts identification allocated in addition to manufacturer part numbers. These component numbers are for access to databases and as such are not used primarily for ordering purposes. If these computer database access numbers are quoted in addition to manufacturer’s component numbers, this should be made very clear in the spare parts management and Maintenance System.</td>
</tr>
<tr>
<td>Condition of the unit on re-assembly and findings of function test runs, in work shop and/or work site</td>
<td>All alignment, vibration and noise level, security and anti-vibration arrangements, etc. required should be checked and recorded.</td>
</tr>
</tbody>
</table>

Routine maintenance records should include the history of any associated items which do not have separate tag identifiers.

Routine operational records should include information such as pump suction and discharge pressures, flow rates, operating conditions, running temperatures of machinery, running amperage where applicable, etc. all taken from both remote monitoring instrumentation and from local gauges where fitted.

To facilitate recording of particular machinery readings specifically designed record sheets may be used for the different types of measurement. A maintenance software programme may:

1) Have the facility to layout such sheets internally to print out as part of a Work Order
2) Have the facility to import spreadsheets or report formats drafted by other standard office software programmes
3) Import scanned documents
4) Have no facility, requiring such records to be filed separately as hard copy. In this case the Work Order history should clearly identify and locate the relevant document(s).

The same considerations also apply to photographs, either digital or hard copy. History and data from tasks may be recorded on the printed Work Order, spreadsheets or purpose written record format and then copied into the maintenance system databases when the Work Order, including any sub-operation tasks, is closed out. Alternatively history and data may be entered directly into databases at computer workstations.
Where history is recorded at a central location from the completed Work Orders of several installations particular procedures should be in place to manage the transfer of information. The transfer of history and data may be by hard copy documents or electronically. The input of this information to the maintenance software requires sufficient competent manpower, care and checking to ensure data is matched to the correct installation databases and is entered correctly. The data records should be documented in a way that ensures that they are easily understood by the people who may refer to the history section of the maintenance system.

Where daily, weekly, monthly, or other time based inspections and test routines, especially function tests as opposed to visual examinations, are included in the maintenance programme, the results of the function tests should be recorded.

The facility for filing hard copy records should comply with defined organisational standards for document retention and safe keeping. Records should be referenced in the maintenance history database and filed in an organised, retrievable manner. Hard copy documentation may be filed either onshore or offshore, or both.

Official logbooks form part of the maintenance history and should be retained as hard copy records. Critical information should be recorded in the maintenance history database but a logbook may contain important operating condition data that can be analysed to establish trends in equipment performance to give early indication of the development of fault conditions.

Personnel may keep personal Workbooks recording useful information on maintenance routines and equipment histories. Critical information should be recorded in the maintenance history database but a Workbook may provide a useful overview of particular activities and equipment.

Computerised control systems may be provided with an alarm condition recording facility which may provide useful information on fault conditions which have arisen, and their frequency.

Clear distinction should be made between Planned and Corrective maintenance as this is essential for maintenance analysis.

4.6 HISTORY ANALYSIS

A maintenance software programme may provide facilities to process inputted Work Order completion data and produce standard reports. Alternatively, raw data may be extracted and processed in some other way.

The results of such analysis is dependent on the quality and frequency of the data input and this should be monitored to ensure that data is valid and that a sufficient percentage of data has been entered to provide a meaningful result. Analysis should evaluate the findings against the actual requirements of the Maintenance System, not against an unidentified benchmark.

The analysis of maintenance tasks should be directed to investigate how equipment fails and to define the optimal maintenance programme to minimise the consequences of failure.
The following technical subjects may be considered for analysis:

<table>
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<tr>
<th>Subject</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational efficiency at failure</td>
<td>This should include aspects of speed, power, output, reliability, and any changes to the operating conditions of equipment.</td>
</tr>
<tr>
<td>Condition of equipment related to age</td>
<td>The physical condition of the equipment at failure, also relative condition due to its operating age</td>
</tr>
<tr>
<td>Cost of maintenance</td>
<td>With frequent failure or reduction in performance the investigation should be focused on cost of maintenance for expected life of asset, cost of replacement (Gresham’s Law of diminishing returns)</td>
</tr>
<tr>
<td>Safety considerations</td>
<td>Where failure has resulted in unsafe operating conditions, e.g. release of high pressure fluid or gas; release of hydrocarbons etc., the analysis should result in a permanent solution to the problem.</td>
</tr>
<tr>
<td>Environmental considerations</td>
<td>Elevated levels of vibration and noise should be thoroughly investigated and a permanent solution should be found and applied.</td>
</tr>
</tbody>
</table>

When it has been established why the failure or diminished performance occurred, analysis should provide a solution to prevent failure in the same mode at some future period, or physically fix the root cause of failure.

All maintenance tasks should be collated on a regular basis into their respective categories, i.e. Corrective/Planned/Predictive maintenance tasks and the total man-hours, cost, time lost, etc, tabulated.

The ratio of Planned to Corrective maintenance should be established as this gives a clear indication of the effectiveness of the Maintenance System in controlling maintained condition, functionality and operability of the machinery inventory.

### 4.7 OVERDUE TASK MANAGEMENT

Reasons for the development of a backlog in preventive maintenance tasks may include:

1) Imbalance between maintenance programme scale and available resources
2) Unforeseen scale of Corrective maintenance tasks
3) Inability to access or maintain equipment due to external factors
4) Reassignment of maintenance tasks to future defined work periods

The Maintenance System should include the facility to maintain a register of overdue maintenance tasks. This is normally a facility of maintenance software programmes.

The Maintenance System should incorporate a process of analysis, control and remedy of maintenance task backlogs. This may be triggered by a defined action level for overdue tasks.
The process may usefully include the following:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined authorities and responsibilities</td>
<td>The responsibility and authority for remedy of maintenance task backlogs should rest with defined personnel.</td>
</tr>
<tr>
<td>Procedure for provision of necessary resources</td>
<td>A procedure should exist for the review of maintenance task backlogs and the initiation of required remedial action.</td>
</tr>
<tr>
<td>Logging of remedial actions and final disposition of overdue maintenance tasks</td>
<td>An organisation may usefully log the ongoing level of maintenance task backlog, causes and closeout actions required to complete tasks as an input to management review of the Maintenance System.</td>
</tr>
</tbody>
</table>
5 UNSCHEDULED MAINTENANCE

A simplified process map for defect repair is shown below.

A defect may be defined as any sub-standard functional or maintained condition which cannot be tolerated indefinitely. A ‘quick fix’ repair may still be a defect.

A Maintenance System should address the issues of defects and Corrective maintenance. There should be a clear distinction between the issue of routine, pre-scheduled maintenance task Work Orders, and the issue of corrective, unscheduled repair task Work Orders, to control the management of defects.
A Maintenance System should be in such a position that it only includes defect repair to the extent that unscheduled Work Orders:

1) Form no greater a share of the maintenance programme than may be defined in the Maintenance System Policy objectives
2) Do not detract from the completion of scheduled Work Orders to the extent that the level of identified defects rises above whatever magnitude may be defined in the Maintenance System Policy objectives.

An organisation should document guidance as to which faults should be addressed by the Maintenance System as defects. Sub standard functional or maintained condition may be regularly identified but not all need necessarily be treated as defects. The Maintenance System should include a process for the evaluation of identified faults and their allocation to:

1) The maintenance programme as a dedicated Work Order
2) A future, scheduled routine maintenance task Work Order
3) A new monitoring and inspection routine maintenance task

Catastrophic failures may initially be subject to an organisation’s Emergency Response procedures.

5.1 DEFECT EVALUATION

Defects may be repaired in-house or by external contractors. Third party authorisation and acceptance may be required for safety critical repairs.

Evaluation of a Defect Report should determine essential repair criteria, including the following:

1) Urgency, including durability of any temporary repair, risks to continued safe operation, etc
2) Approved repair techniques
3) Resources required, including external approvals, specialist assistance, spare parts, etc
4) Timetable, including scheduling of necessary shutdowns, lead time for parts, etc
5) Repair H S & E issues, including monitoring until permanently repaired.

Defects may be subject to ad hoc repair or accumulated into a maintenance campaign or a shut down period.

Defects should be evaluated for their degrading effect on the outcomes of machinery system studies, such as FMEAs. Defects may significantly reduce safety factors and future single failure consequences without themselves being a major fault.

To the extent that defects accumulate while awaiting repair, it is important that a regulated process exists for evaluating the impact of defects upon each other, to prevent a significant reduction in safety factors throughout a machinery system.
5.2  DEFECT REPORTING

Identified defects should be reported in a standard format to facilitate evaluation of the required corrective action and provide the start point for an auditable trail of the defect repair.

The Defect Report may be entered directly into the maintenance software or may be drafted as a hard copy format. Whichever method is used all relevant information should be recorded, including the following:

1) Defect Report identification number
2) Date
3) Worksite identification, defect location and machinery system(s) affected
4) Identification number of affected items
5) Criticality of affected items and criticality of the defect
6) Description of defect, including dimensioned drawings, sketches, photographs as necessary
7) Description of any temporary corrective action taken
8) Cause, if known

An organisation should designate the authorities and responsibilities for the management of defects and have in place a system for their control and repair.

Once a Defect Report is filed it should be evaluated, actioned and the process of repair documented to closeout.

An organisation should maintain a log of Defect Reports showing essential management information such as reporting date, criticality and close out status.

5.3  UNSCHEDULED WORK ORDERS

When a defect has been evaluated and a repair strategy has been agreed, the work may be entered into the Maintenance System as an unscheduled Work Order. This is often a facility of maintenance software programmes and should include all the information described for scheduled Work Orders.

Such unscheduled Work Orders are usually linked directly to the affected equipment item in the software equipment database and not to the maintenance task schedule.

An unscheduled Work Order should then be issued, prior to undertaking the repair, to those responsible for the task.

The management of unscheduled Work Orders should then follow the principles described for scheduled Work Orders.

5.4  WORK PACKS

Corrective and Campaign maintenance tasks may also be documented in Work Packs. These may cover single maintenance tasks or groups of related tasks. The purpose of a Work Pack is to provide an integrated specification of all operational, technical and safety requirements for the workscope.
The creation of a Work Pack should be defined by procedure and provide a guide to the steps required for proper management of a repair or a campaign work scope. Information which may be included in a Work Pack includes the following:

1) Specification of present maintained condition of affected equipment
2) Specification of any temporary repair
3) Specification of any required investigation/pre condition prior to commencement of work scope
4) Specification of required work scope
5) Work force competencies required
6) Authorities and responsibilities
7) Risk assessment
8) Safety requirements
9) Isolations/dismantling/back up systems required
10) Lifting plan
11) Drawings
12) Equipment/Parts lists
13) Material/Tools list
14) Hook up/Commissioning/Inspection and Test requirements
15) Certification requirements
16) Weight control/delivery/access requirements
17) Progress/completion report formats

5.5 TEMPORARY REPAIR MANAGEMENT

Temporary defect repairs should be completed to rigorous defined specifications. Definition of the standard required may involve equipment manufacturers, regulatory authorities, insurance providers, specialist repair companies etc. The process of specification should be documented and auditable.

In an emergency the installation Emergency Response procedures should control the organisation and arrangement of temporary repairs. A stock of materials and standard repair gear should be available on the installation.

Safety during the temporary repair of defects should be subject to the appropriate level of management, including risk analysis, JSA, precautionary measures etc.

After completion a temporary repair should be subject to the appropriate process of reactivation, test and inspection to ensure proper and continuing integrity and functionality. Defects that are subject to a temporary repair should be subject to appropriate monitoring. Such monitoring should be managed and controlled within the Maintenance System by technical and H S & E departments as required.

Defect repair by specialist companies should be subject to warranty conditions.

Temporary repairs to SCE should involve review and authorisation by the ICB of repair techniques, repair specifications, repair management and control and monitoring of repair condition.
The ICB should also review related issues such as welder qualifications, welding processes, and witness NDT, pressure tests or functional tests etc.

5.6 HISTORY RECORDING

Completion of unscheduled Work Orders should follow the principles described for scheduled Work Orders.

Corrective and/or Campaign maintenance history may usefully include the following information and data:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure mode</td>
<td>What went wrong</td>
</tr>
<tr>
<td>Failure cause</td>
<td>Identify the events which caused the failure:</td>
</tr>
<tr>
<td></td>
<td>1) Normal wear</td>
</tr>
<tr>
<td></td>
<td>2) Out of specification operating condition and loading</td>
</tr>
<tr>
<td></td>
<td>3) Human error</td>
</tr>
<tr>
<td></td>
<td>4) Design</td>
</tr>
<tr>
<td></td>
<td>5) Incorrect procedure</td>
</tr>
<tr>
<td></td>
<td>6) Accident/damage</td>
</tr>
<tr>
<td>Rectification</td>
<td>Temporary repairs, repair specification</td>
</tr>
<tr>
<td>Cause analysis</td>
<td>Identify remedies/patterns of failures</td>
</tr>
</tbody>
</table>

5.7 HISTORY ANALYSIS

Defects should be subject to an appropriate level of root cause analysis. Unforeseen failure effects should also be evaluated.

Defects should be evaluated for any requirement to amend or add to the scheduled maintenance programme to minimise the possibility of recurrence.
6 MAINTAINED EQUIPMENT CONDITION

A judgement on the effectiveness of a Maintenance System as a process, resulting from an assessment may be weighed against the evidence provided by a physical inspection of an installation.

A physical inspection should judge against relevant criteria including, best engineering practice, manufacturer defined requirements, Maintenance System objectives and the declared equipment status as documented by Maintenance System records.

Records may also be evaluated for evidence of ‘out of specification’ equipment status, including the following:

1) Temporary repairs
2) Overdue maintenance tasks
3) Defect reports
4) Stable fault conditions subject to a long term monitoring programme
5) Scheduled future campaign maintenance work scopes
6) Near miss/incident/Safety Meeting items concerning faulty equipment condition.
7) Personal workbook notes on fault conditions

Selected equipment may be assessed for adequacy of control and remedial action under the management of the Maintenance System.

Records may be evaluated for evidence of completion of Work Orders and selected equipment assessed for evidence of the proper conduct of maintenance tasks.

Selected equipment may be operated under normal running conditions and performance verified against specified requirements and values.

Potential evidence of failings in equipment status and Maintenance System operation include the following:

- Physical damage, cracks
- External/internal coating in poor condition, blistering, cracking
- External/internal pitting, corrosion, external wastage
- Internal ‘grooving’ of pipes, due to erosion and excessive flow rates, erosion at changes of shape or section, thinning of wall thickness, scale/growth build up
- Pipework distortion, kinking, crimping
- Blanked off pipe fittings
- Pressure test markings out of date
- Leakage/weeping from flange, pipe wall, weld seam heat affected zone, tapping point, valve gland, gaskets
- Loose/broken pipe supports, worn rubbing strips
- Manual valve stiff to operate/spinning free, missing hand wheels, painted glands, faulty position indicator
- Valve does not have full range of travel, does not operate from all available control positions. Including equipment isolation valves
- Valve does not fail to specified position
- Extended spindles stiff to operate/spinning free, faulty position indicator
- Control, indicating wire/pulley systems corroded, painted, inoperative
- Drain valves, test cocks inoperative
- Pressure relief valve leak by, corrosion
- Excessive anode wastage, no anode material loss
- Patches/repairs/inoperative equipment
- Lagging removed, in poor condition, soiled
- Corroded/fretted/loose foundations and chocks
- Loose bolts/screws - ‘hammer test’, missing locking arrangements
- Rusted, painted bolts/screws
- Noise, vibration
- Overheating, fumes, exhaust leaks, sooting
- Leaks, stains, dirty drip trays and savealls
- Broken, rusted watertight closure hinges, latches, dogging arrangements. Faulty, missing gaskets.
- Damaged, worn gearing
- Shaft play, misalignment, worn, sticky, chattering, discoloured bearings
- Loose, worn, chaffed drive belts
- Loose, sticky, unevenly operating control linkages
- Lack of lubrication
- Damaged, dry, painted grease nipples
- Dirty, damaged air filter elements/vent gauze
- Dirty, damaged strainer/filter mesh, cartridge
- Metallic particles on magnetic filters
- Excessive leakage/return system flow
- Excessive differential pressures
- Calibration marking incorrect
- Service date marking overdue
- Integral calibration device fault
- Damaged, faulty meters, instrumentation
- Loose earth bonding cables
- Incorrect fuse ratings
- Hydraulic ram seals leaking, ram surface scored, pitted, tarnished
- Hydraulic hoses chaffed, kinked, damaged
- Water, sludge, discoloration of drain/test cock discharge
- Damaged/dirty sight glasses, flow glasses
- Damaged/loose railings, steps, floor plates
- Damaged/loose/removed guards
- Lack of full functionality, operability from all equipment operating positions
- Alarm indication deactivated. Alarm test failure

Spare Parts and consumables usage may be evaluated as part of an assessment of the conduct of a maintenance programme.

Used and replaced parts may be evaluated as part of an assessment of the conduct of a maintenance programme.
7 MAINTENANCE SOFTWARE PROGRAMMES

7.1 MAINTENANCE SOFTWARE PROGRAMMES

Whilst the heart of a maintenance programme is the equipment inventory, the heart of a Maintenance System is the data recording facility. There is no standard requirement for this facility as long as it addresses the scope and complexity, and fulfils the functions, of the Maintenance System it serves. The facility may be limited to a ‘cardex’ filing system and wall mounted scheduling charts but in the context of this handbook is more likely to be a software programme.

Contemporary maintenance software is normally a series of databases with a user interface designed to facilitate the input and display of information, and programming to produce predefined outputs at specified intervals, collate and analyse data and communicate information in standardised formats.

Maintenance software programmes should be evaluated for customisation and set up.

7.2 PROGRAMME DESIGN

Whether an organisation acquires a standard proprietary software package, with or without modification, or develops a bespoke software system, design considerations that should be addressed include the following:

1) International standards applicable to the design of the software
2) Organisational definition of software functional requirements
3) Software specification for hardware Operating System, configuration, processor, memory and drive space requirements
4) Organisational requirements for system security and access control
5) Organisational specification of computer hardware and software access means by internet, intranet or stand alone workstation
6) Software validation and acceptance criteria
7) Software test requirements for programme modules and their interfaces

The design of a maintenance software programme should also take into consideration other functional aspects which may affect the way it operates. These may include:

1) Integrated or modular arrangement: allowing movement between different functional modules, such as equipment lists, maintenance tasking and spare parts stock control from within each module, or requiring log out and log in transfer between modules.
2) Interfaces with other software: e.g. can blank template word processing or spreadsheet forms, created in another software programme be linked from within a module.
3) Input acceptance from other software programmes: e.g. can completed word processing or spreadsheet documents, PDF files or scanned documents be imported into the history database or provided with a link from within an programme.
4) Limits on individual data entry size
5) Restrictions on code number formats
6) Limits on design of software generated report formats
7) Limits on numbers of concurrent users
The software for a maintenance programme may be a single self-contained installation or it may require installation of database management software and the maintenance software.

The software should have been developed and approved under the control of a recognised Quality Assurance system. The software should be security coded to prevent unauthorised download and tampering.

An organisation may use several software programmes in the management of the maintenance programme. Separate programmes may be used for Work Order issuing and maintenance recording of different engineering systems onboard an installation, and also for maintenance planning and scheduling. Different installations within an organisation may also use different software on a local basis.

Whatever the combination of software programmes may be, the previous considerations can be applied. The more complex the arrangement of interfacing and interacting software the greater the requirement for structured management and control. Data transfer and the coordination of duplicate inputs into different systems require particular care and checking.

7.3 PROGRAMME MODULES

Maintenance software may be part of an integrated set of programme modules managing various business processes. Typical programmes include:

1) Equipment data records
2) Maintenance tasking
3) Spare part stock keeping
4) Purchasing

7.4 PROGRAMME SET UP AND OPERATION

Within an organisation the maintenance software may be managed and controlled by technical departments or IT departments or a combination of both. The arrangements, authorities and responsibilities and departmental interfaces should be clearly defined.

Master copies of software should be kept in secure storage and a software register maintained of version numbers, modifications, upgrades etc.

The way that a maintenance software programme is set up is crucial to successful management of a Maintenance System. The following considerations should be appropriately organized:

1) The various sets of system data should be maintained on dedicated single master databases. Identical data should not be inputted directly to separate unrelated locations without regular, rigorous cross checking and matching procedures.
2) Relevant historical data existing in other software programmes can usually be imported into maintenance software databases. This operation should be done in accordance with the requirements of the software, incorporating appropriate review and checking procedures.
3) The software developer’s procedure for installation, un-installation and reinstallation should be followed.
4) Computer systems should be protected by appropriate virus protection and firewall systems.
The way that a maintenance software programme is operated is crucial to successful management of a Maintenance System. The following considerations should be appropriately organized:

1) Data input and data transcription from hard copy records should be allocated the necessary expertise and man-hours to minimise entry errors. Personnel entering data should have sufficient knowledge to make a reasonable judgement of the accuracy of the data presented.

2) Where there is a requirement to transfer or synchronise data between locations electronically, the controls and procedures should be in place to ensure that the data flow is allowed only in the prescribed direction, that only current data is exchanged and that both sending and receiving locations maintain matching logs of dates and times that data exchange has taken place.

3) Computer workstations may be dedicated to the Maintenance System or multifunctional. Whichever is the case, the necessary availability should be allocated to allow the Maintenance System to be efficiently managed. Other software installed on a workstation running maintenance software should not cause conflicts or crashes.

4) An organisation should have a policy and controls to prevent the installation of unauthorised software on workstations.

5) Proposals for modifications should be subject to, and controlled by, the Management of Change procedure.

7.5 PROGRAMME ACCESS

Maintenance software access should be controlled by an integral system of passwording and permitted operations. This facility should be additional to any workstation log on password requirement.

Passwording should follow standard guidelines in that they are personal, require alphanumeric character combinations and require regular scheduled redefinition.

It is usual for a password access to be set to allow software support personnel unrestricted access to databases and programming. This access level should be available only to personnel with the required authority.

It is usual for a password access to be set to allow software supervisory functions, such as logging on new users, setting permitted operations, organising workstation topography, etc. This access level should not be available to those routinely managing the maintenance programme. Routine access by an individual should only permit those operations he is to perform.

Personnel requiring access for information should be limited to ‘read only’ operation.

7.6 DATA MANAGEMENT

Maintenance System histories and data should be regularly backed up and properly archived. The relevant responsibilities and procedures should be defined.

The software should recognise bad or corrupted data, triggering appropriate error messages.
7.7 PROGRAMME UPGRADES & SUPPORT

Proprietary and internal maintenance software should be subject to appropriate ‘through life’ support. This may include the following:

1) Warranty and service agreements
2) Contact with a dedicated Product Manager
3) Software register, recording versions, modifications, patches etc.
4) User feedback system
5) Software developer modification and upgrade notification system
6) User forums and knowledge bases
7) Software developer website
8) Instruction manuals

In case of hardware failure or software deletion, an organisation should have a developed recovery procedure to manage reinstallation of software and data and to minimise data loss when faults develop.

Minor software downloads and patches may be supplied on disc or floppy or by e-mail. An organisation should have a developed procedure to manage such changes. This may include the following considerations:

1) Updating of software register
2) Storage of upgrade on labelled disc and retention with software master copies. If supplied by e-mail, then email to be deleted to remove spurious software copy.
3) Virus checking

An organisation should ensure appropriate training and familiarisation is provided for maintenance software users. Instruction manuals should be provided by the software developer.

In the event that an organisation undertakes a transfer to a different maintenance software programme the process should be subject to particular project management and Management of Change procedures. The transfer should be organised in conjunction with the software developers and data migration subject to checking and any rationalisation that may be appropriate.
8 MAINTENANCE SYSTEM ASSESSMENT

An assessment can be a policing tool or a proactive business tool providing valuable information and guidance to an organisation.

An assessment may cover four basic areas:

1) An evaluation of the degree to which a Maintenance System provides satisfactory coverage of the maintenance requirements of an installation, considering the equipment inventory, equipment usage levels, equipment reliability and working environment.

2) An evaluation of the performance of a Maintenance System against the defined objectives and procedures which it has adopted.

3) An evaluation of the degree to which the Maintenance System conforms to applicable statutory Rules and Regulations.

4) An evaluation of the maintained condition of an installation.

An assessment of a Maintenance System may incorporate any, or all, of the fundamental elements, and integral processes, inputs and outputs.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>System organisation</td>
<td>Including review of fundamental areas of strategy, policy etc.</td>
</tr>
<tr>
<td>System design basis</td>
<td>Including FMEAs, Performance Standards, SCE definition, external regulations, internal objectives etc.</td>
</tr>
<tr>
<td>System coverage</td>
<td>Including worksites, equipment inventory etc.</td>
</tr>
<tr>
<td>System review</td>
<td>Including management reviews, internal audit, Management of Change proposals</td>
</tr>
<tr>
<td>Document review</td>
<td>Organograms, procedures, work instructions etc.</td>
</tr>
<tr>
<td>Software programme</td>
<td>Including design integrity, modifications, security, support</td>
</tr>
<tr>
<td>Software databases</td>
<td>Including organisation, numbering systems</td>
</tr>
<tr>
<td>System administration</td>
<td>Including access rights, task issuance, history recording etc.</td>
</tr>
<tr>
<td>Resources</td>
<td>Including manpower, equipment, spare parts, consumables, computer systems</td>
</tr>
<tr>
<td>HS &amp; E</td>
<td>Including isolations, lifting, waste disposal etc.</td>
</tr>
<tr>
<td>Scheduled maintenance management and control</td>
<td>Including task preparation, contractor supervision, task backlogs etc.</td>
</tr>
<tr>
<td>Unscheduled maintenance management and control</td>
<td>Including defect reports, temporary repairs etc.</td>
</tr>
<tr>
<td>Sub contractor management and control</td>
<td></td>
</tr>
<tr>
<td>Maintenance history records</td>
<td>For accuracy and completeness</td>
</tr>
<tr>
<td>Maintenance history review and analysis</td>
<td>Including root cause analysis, trend analysis etc.</td>
</tr>
<tr>
<td>Maintained equipment</td>
<td>For condition, functionality, and operability</td>
</tr>
</tbody>
</table>
The scope of an assessment may range from:

1) A complete assessment, considering the existence and acceptability of all elements of the Maintenance System from the Policy right down to the maintained condition of equipment items.

2) A compliance assessment assessing the degree to which implemented procedures agree with those required by the Maintenance System.

3) A partial assessment focusing on a particular element of the Maintenance System.

An assessment may involve:

1) Documentation review
2) Visit to an organisation’s offices
3) Visit to an organisation’s installations
4) Visit to an organisation’s sub contractors
5) Visit to the organisation’s Independent Competent Body

8.1 ASSESSMENT PREPARATION

Possible considerations prior to conducting an assessment include the following:

1) Documents to be reviewed
2) Scope and focus of the assessment, what worksites, what aspects of the Maintenance System?
3) Timescales and schedule
4) Pre prepared checklists

The effectiveness of an assessment may be pictured in the graph below:

![Assessment time/results curve](image)

**Figure M8** Assessment time/results curve
The early phase of an assessment, where an understanding of the Maintenance System is being gained and the knowledge available to evaluate what evidence is required is limited, may be reduced by appropriate preparation. The assessment should generally proceed faster and be more appropriately focused with prior knowledge of how the Maintenance System is designed and is intended to function. Whatever the initial results, however, a time should come when the evidence begins to become repetitive and serves only as reinforcement of previously established findings.

An organisation should be fully aware of the scope of an assessment and have agreed all the details of timescales, schedules, work sites involved and participants prior to commencement. The standard audit practice of Opening and Closing meetings may be of benefit to all parties when visiting work sites.

The worksite to be visited may to some extent limit the scope of the assessment. Whilst the recorded maintenance history of an equipment item may be available at the Head Office, for example, it would not be possible to validate its accuracy without access to the maintained equipment. The area of the Maintenance System which is to be the focus of the assessment should largely determine the organisational and related worksites to be visited.

Timescales and schedules will affect the value of an assessment. Once the scope has been decided, insufficient man-hours spent in preparation and at the worksites will limit the results achieved. An assessment should be tailored to the available man-hours rather than limiting the depth of investigation of a particular work scope to fit the man-hours available.

Checklists are a valuable assessment tool. They provide a logical guide to a line of enquiry and act as an aide memoire to points of interest. A checklist is better suited to its function the more focused it is on the particular work scope of the planned assessment, rather than being a generic catch-all. The basis of an assessment checklist can be created during review of Maintenance System documentation.

The greater the knowledge of the Maintenance System organisation, and the more defined the potential lines of enquiry, prior to starting the process of making a ‘shop floor’ assessment, the more effective the assessment should be.

### 8.2 DOCUMENT REVIEW

There are two aspects to document review:

1) Evaluation of the degree of control of important management and procedural documentation and of conformance with any document control procedures.

2) Gaining an understanding and appreciation of the content of Maintenance System documentation.

Maintenance System documentation should be required to conform to procedures governing the drafting, issue and revision of organisational documentation. It is important that Maintenance System documentation control is carried out in accordance with those procedures.
Document control issues that frequently cause problems include the following:

1) All worksites should be using the same, current revision of a document
2) Obsolete revisions of a document should be protected from inadvertent use
3) Documents should have undergone some process of checking and approval prior to issue
4) Documents should not contradict other documents or include obsolete references - revision of one document may involve revision of others.

External documentation also requires management and control. Within a Maintenance System there should be a facility to ensure the distribution and upkeep of applicable Rules and Regulations revisions, engineering and electrical drawings, manufacturers’ manuals, training material, equipment data, manufacturers’ safety and modification bulletins etc. Applicable material should be defined, available at each worksite and maintained in usable condition.

8.3 ASSESSMENT METHODS

Under the Safety Case regime it is not possible to assess a Maintenance System against some single fixed, universal standard as would be the case, for example with a system certified to ISO9000:2000.

An assessment may therefore address the following five questions:

1) Does the Maintenance System adequately address the scope of the equipment inventory of an installation, and the consequent maintenance programme required to maintain proper condition, functionality and operability?
2) Does the Maintenance System incorporate sufficient organisation and control to manage the scope and workload of the maintenance programme?
3) Does the Maintenance System deploy sufficient resources to undertake the scope and workload of the maintenance programme?
4) Does management of the Maintenance System conform to defined procedures and practices?
5) Does the Maintenance System achieve its objectives?

Questions (1) and (2) cannot be answered purely by reference to the defined internal processes of the Maintenance System. They require judgements to be made from experience and from an appreciation of comparative industry models within the Marine/Offshore Environment and any official standard that may be defined.

A judgement against question (1) may be tested against whatever inputs have been used in the initial definition of the Maintenance System scope, but there should be a judgement as to whether the system improperly fails to address aspects of the legitimate maintenance needs of an installation.

A judgement against question (2) can only be made after assessing the system and evaluating whether the system improperly fails to address a legitimate requirement for the definition of particular procedural and control aspects of System and maintenance management.
The third question can only be answered after assessing the system and evaluating the evidence. The evidence may be judged against the defined requirements of the Maintenance System but there should also be a judgement as to whether those defined requirements are considered adequate to the task. There is also the further judgement as to whether they are adequate to resource the correction of any failings arising from the first question.

To answer the fourth question an assessment should provide objective evidence of the degree of conformance of the aspects of the Maintenance System assessed to the relevant regulations, standards, objectives and procedures which define and govern its organisation and conduct. An Inspector should always evaluate his findings against the actual requirements of the System, not against an undefined benchmark.

If no defined or established procedure exists to regulate the conduct of a particular process then the evidence of the results achieved by the various personnel, at the various worksites, may or may not provide evidence of the need for a standardised procedure but can only be evaluated against any governing statutory regulations and whatever local practices are followed.

To answer the fifth question an assessment should provide objective evidence of poor maintained condition and failed functionality and operability that has:

1) Not been identified by the Maintenance System, or
2) Has been identified and subsequently inadequately managed

Objective evidence includes all documentary and physical items that prove a finding.

Gathering objective evidence inevitably requires an assessment to be based on a sampling process. To examine every single example of a particular record or process input or output is usually neither possible nor necessary. The size of a sample and the failure rate which gives rise to concern are questions of judgement and may vary according to the subject under review. In the case of a perceived failure in an issue concerning Health and Safety, it may be justified to conduct a 100% sampling to get an accurate quantification of the extent of a problem.

A complete Maintenance System assessment and an initial compliance assessment are best conducted systematically from the top down. Basic system documentation should be reviewed first and the central organisation assessed before conducting an assessment of the worksites. Follow up compliance assessments and partial assessments may be targeted at the required level within the organisation.

The findings of internal audits and the resultant corrective actions should be assessed.

Maintenance histories, personal workbooks, logbooks and control system alarm records all provide evidence of the status of an installation’s maintained condition.

Assessment visits to sub contractors should be agreed by all parties concerned.
Work site inspections may include the following items:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completed maintenance task records</td>
<td>Conduct a physical inspection of the equipment to provide evidence of completion of the work</td>
</tr>
<tr>
<td>Defect reports, repair work packs</td>
<td>Conduct a physical inspection of the equipment to provide evidence of the accuracy in detailing of faults and specification of repair methods</td>
</tr>
<tr>
<td>Temporary repairs</td>
<td>Conduct a physical inspection of the equipment to provide evidence of the acceptability of repair methods</td>
</tr>
<tr>
<td>Maintenance equipment</td>
<td>Conduct a physical inspection of the equipment to provide evidence of condition, cleanliness, calibration, etc</td>
</tr>
<tr>
<td>Workshops</td>
<td>Conduct a physical inspection to provide evidence of housekeeping, safety and environmental management etc.</td>
</tr>
<tr>
<td>Spare parts and consumables storage</td>
<td>Conduct a physical inspection to provide evidence of condition, housekeeping, safety and environmental management etc.</td>
</tr>
<tr>
<td>General maintained condition of the installation</td>
<td>Conduct a physical inspection to provide an overview of the end product of the Maintenance System</td>
</tr>
</tbody>
</table>

8.4 SOFTWARE ASSESSMENT

Assessment of software programming is unlikely to form part of the assessment of a Maintenance System. This is a specialist area and the type of assessment under consideration would normally take a pragmatic approach and consider maintenance of software functionality rather than software design.

Legitimate areas of concern affected by software design, however, include the following:

1) Software stability and frequency of programme crashes
2) Download process for patches and upgrades
3) Maintenance software clashes with official and unauthorised installed software
4) Organisational firewall provision
5) Internet or intranet data transfer security
6) Bad or corrupted data recognition
7) Skills and training in software operation

Software may be procured as a result of an individual in-house development project or from a commercial software developer. Whichever may be the source, the provision for fault finding and support should be established and functioning.
8.5 MAINTAINED EQUIPMENT INSPECTION

The end product of a Maintenance System is the condition, functionality and operability of the component parts of an installation.

Whatever the outcomes of an assessment of a Maintenance System an appreciation of the general, and particular, maintained condition of an installation is an essential qualifier of its effectiveness. Physical inspection of the machinery systems, maintenance equipment, spare parts and consumables stock of an installation should normally reinforce the general impression gained or provide evidence of failings in the Maintenance System. An effective Maintenance System should provide reassurance as to the integrity of Safety Critical Elements, and other component parts, which is demonstrable by inspection.

An effective assessment that demonstrates failings within a Maintenance System may indicate the possibility of failings in maintained condition of an installation.

In the event that a poor Maintenance System is delivering acceptable maintained condition, the causes may revolve around the involvement of particular individuals and unofficial practices. As well as concerns over failings in the Maintenance System such a situation would give rise to concerns over the potential loss of those individuals and to the potential consequences of departures from authorised procedures.
9 MAINTENANCE SYSTEM EFFECTIVENESS EVALUATION

The effectiveness of a Maintenance System depends on its performance in relation to the following questions:

1) Does the Maintenance System adequately address the scope of the inventory of the component parts of an installation and the consequent maintenance programme required to ensure proper condition, functionality and operability?
2) Does the Maintenance System include sufficient organisation and control to manage the scope and workload of the maintenance programme?
3) Does the Maintenance System deploy sufficient resources to undertake the scope and workload of the maintenance programme?
4) Does the administration of the Maintenance System and the management of maintenance tasks conform to defined procedures and practices?
5) Does the Maintenance System achieve its objectives?

A Maintenance System may be evaluated against several criteria, including:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>Its own defined objectives, standards and procedures</td>
<td>This criterion can only be accepted as a satisfactory standard if a Maintenance System is first assessed as providing a sound basis for the management of a comprehensive maintenance programme.</td>
</tr>
<tr>
<td>‘Best Practice’ where there is a defined Code of Practice, Regulation or</td>
<td>This criterion is dependent on the existence of applicable standards - which may relate only to particular aspects of the Maintenance System</td>
</tr>
<tr>
<td>industry guideline which performance may be compared against</td>
<td></td>
</tr>
<tr>
<td>Accepted, objectively assessed levels of satisfactory maintained</td>
<td>This criterion requires agreement about what is or is not satisfactory and should involve assessment both of particular deficiencies and of the overall status of the machinery inventory.</td>
</tr>
<tr>
<td>condition, functionality and operability</td>
<td></td>
</tr>
</tbody>
</table>

Findings may be classified as either ‘Non-conformances’ or as ‘Deficiencies’, as defined below:

<table>
<thead>
<tr>
<th>Finding</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>Non-conformance</td>
<td>Procedural or administrational failures, e.g.:</td>
</tr>
<tr>
<td></td>
<td>1) Lack of provision of a basic element of a Maintenance System</td>
</tr>
<tr>
<td></td>
<td>2) Lack of implementation of a basic element of a Maintenance System</td>
</tr>
<tr>
<td></td>
<td>3) Failure to follow procedure</td>
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<tr>
<td></td>
<td>4) Maintenance programme backlog</td>
</tr>
<tr>
<td></td>
<td>5) Poor maintenance history record keeping</td>
</tr>
<tr>
<td>Deficiencies</td>
<td>Hardware or maintenance task failures, e.g.:</td>
</tr>
<tr>
<td></td>
<td>1) Unreported defect</td>
</tr>
<tr>
<td></td>
<td>2) Poorly maintained equipment</td>
</tr>
<tr>
<td></td>
<td>3) Unsafe working practice/environment</td>
</tr>
</tbody>
</table>
Findings should be supported by evidence, including details of sampling volumes and failure rates.

The evidence should provide sufficient information for an organisation to properly identify the failings, and facilitate initiation of analysis of the root causes.

Findings may be ranked based on severity and/or criticality. The final evaluation may be ranked according to the number and importance of all the findings.

Rectification of non-conformances and deficiencies, and the follow up of an assessment should be agreed with the assessed organisation.

Common causes for failings in Maintenance Systems are basic management failures such as:

1) lack of organisation
2) lack of training
3) lack of resources
4) lack of discipline
5) lack of senior management support

A judgement as to the nature of identified failings may be classified as follows:

<table>
<thead>
<tr>
<th>Failings</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>Local</td>
<td>Small numbers of failings in different areas with no identified common cause.</td>
</tr>
<tr>
<td>Procedural</td>
<td>A number of failings within a common area identified as due to inadequate procedure, poor control of procedure, lack of training etc.</td>
</tr>
<tr>
<td>Systemic</td>
<td>Numerous failings throughout an organisation identified as due to lack of procedure, lack of resources etc.</td>
</tr>
</tbody>
</table>

In the commercial field, an assessment of such potential scope as that of a Maintenance System should achieve added value for the assessed organisation.

An evaluation should be based on a comprehensive and proper understanding of an organisation’s Maintenance System. Findings should be reported confidently and consequent discussion of any issues arising should develop from a basis of a mutual understanding of the background to problems and their potential solutions.

To achieve lasting value, in the form of improved maintained condition, functionality and operability, both parties should use an assessment as a collaborative endeavour and a beneficial part of an organisation’s management review of the Maintenance System.
APPENDIX A : ASSESSMENT TABLES
### SECTION 2 : MAINTENANCE SYSTEM ELEMENTS

<table>
<thead>
<tr>
<th>Subject</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Have all elements been developed?</td>
<td>Every element is required for the effective functioning of a Maintenance System</td>
</tr>
<tr>
<td>2.2 Which organisational departments manage and control particular elements?</td>
<td>Elements may be shaped purely by the demands and objectives of the Maintenance System, while some may be primarily arranged by other organisational departments - and their requirements accommodated within the Maintenance System.</td>
</tr>
<tr>
<td>2.3 Is there integrated management of elements, focused on defined objectives?</td>
<td>Management of the Maintenance System should be directed so as to integrate elements and functions and address conflicts and contradictory requirements</td>
</tr>
<tr>
<td>2.4 Is there a defined Policy?</td>
<td>To be more than an unsystematic collection of maintenance tasks without structure, aims or boundaries a Maintenance System should reflect a defined Policy.</td>
</tr>
<tr>
<td>2.5 Is there a defined Strategy?</td>
<td>The day to day management of a Maintenance System should be based on a strategy that addresses the issues defined in the Policy.</td>
</tr>
<tr>
<td>2.6 Are Authorities and Responsibilities and reporting lines defined?</td>
<td>Management of a Maintenance System at all levels should be controlled by identified personnel with relevant defined lines of reporting</td>
</tr>
</tbody>
</table>
| 2.7 What subjects are covered by the Policy? | Subjects to be considered include:  
1) Are the size and nature of the assets to be maintained addressed?  
2) Are the safety and environmental criticality of the assets to be maintained addressed?  
3) Are the regulations and standards to be complied with, both external and internal, identified?  
4) Are objectives and key indicators for maintained condition, functionality and operability defined?  
5) Is it identified whether all the organisation’s assets are covered by an overall integrated system or whether particular areas are covered by stand alone dedicated systems?  
6) Is it defined whether maintenance is to be conducted as an in-house activity or whether it may be conducted by third parties or a combination of both?  
7) Is the methodology for the Maintenance System, whether Planned, Predictive, Corrective, etc., or a combination of methodologies, defined?  
8) Is the policy documented? |
## SECTION 2 : MAINTENANCE SYSTEM ELEMENTS

<table>
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<tr>
<th>Subject</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>2.8</td>
<td>What subjects are covered by the Strategy?</td>
</tr>
<tr>
<td></td>
<td>Subjects to be considered include:</td>
</tr>
<tr>
<td></td>
<td>1) Is the envelope of maintained structures, plant, machinery and equipment defined?</td>
</tr>
<tr>
<td></td>
<td>2) Are the inputs to be used as the basis for design of the Maintenance System, such as Performance Standards, FMEA, manufacturers’ recommendations, etc. identified?</td>
</tr>
<tr>
<td></td>
<td>3) Is the process by which the criticality of maintained structures, plant, machinery and equipment is assigned defined or referenced?</td>
</tr>
<tr>
<td></td>
<td>4) Are the internal and external parties responsible for administration of the Maintenance System identified?</td>
</tr>
<tr>
<td></td>
<td>5) Are the internal and external parties responsible for the physical conduct and supervision of maintenance tasks identified?</td>
</tr>
<tr>
<td></td>
<td>6) Are the documentary, or hardware and software systems, used in the management of the Maintenance System, and the internal and external parties responsible for maintenance and development of them, identified?</td>
</tr>
<tr>
<td></td>
<td>7) Are the methods and factors involved in establishing maintenance programme tasks defined?</td>
</tr>
<tr>
<td></td>
<td>8) Are the ways in which maintenance programmes should be scheduled, and related to production schedules and operational constraints and considerations, defined?</td>
</tr>
<tr>
<td></td>
<td>9) Are the maintenance procedures, from inspection to repair, to be included within the maintenance programme defined?</td>
</tr>
<tr>
<td></td>
<td>10) Are the processes for establishing maintenance budgets and allocating resources defined?</td>
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<tr>
<td></td>
<td>11) Are the processes for establishing key indicator performance defined?</td>
</tr>
<tr>
<td></td>
<td>12) Are review processes for establishing performance against Policy objectives defined?</td>
</tr>
<tr>
<td></td>
<td>13) Are assessment and review processes to establish the continuing effectiveness of the maintenance system defined?</td>
</tr>
<tr>
<td></td>
<td>14) Is it defined how maintenance tools and resources should be sourced and maintained both from internal and external suppliers?</td>
</tr>
<tr>
<td></td>
<td>15) Are the factors controlling design and procurement of structures, plant, machinery and equipment that bear on maintenance requirements, such as factors of safety, design lifetimes and component reliability defined?</td>
</tr>
<tr>
<td></td>
<td>16) Has a Management of Change process been defined?</td>
</tr>
<tr>
<td></td>
<td>17) Is the strategy documented, either centrally or by reference to other organisational standards and procedures?</td>
</tr>
</tbody>
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## SECTION 2 : MAINTENANCE SYSTEM ELEMENTS

<table>
<thead>
<tr>
<th>Subject</th>
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</table>
| 2.9 Are Maintenance System functions adequately organised and defined? | Maintenance System review/analysis : See section 3.7  
  1) Management of Change: See section 2.8.1  
  2) Software administration : See section 7.4 - 7.6  
  3) Maintenance task issuance : See section 4.3  
  4) History recording and data input : See section 3.6 & 4.5  
  5) Hard copy filing/archiving : See section 4.5  
  6) Maintenance task supervision : See section 4.4 & 5.5  
  7) Sub contractor supervision : See section 2.2.2  
  8) Maintenance amendment/cancellation : See section 4.3  
  9) Defect report/repair task drafting : See section 5.1  
  10) Maintenance task backlog control : See section 4.7  
  11) Safety equipment maintenance : See section 2.6.3                                                                                      |
| 2.10 What is the topography of the Maintenance System?                  | Consideration should be given to the following:  
  1) No of work sites operating maintenance programmes  
  2) No of discrete maintenance programmes operating within work sites  
  3) Input/output workstation/filing locations  
  4) Maintenance software programme servers  
  5) History and data transfer routes  
  6) History and data archives  
  7) Links to sub-contractors/resource providers  
  8) Points of contact to external authorities                                                                                           |
| 2.11 If discrete maintenance programmes are operating under the umbrella of a Maintenance System are issues of integration/ segregation addressed? | Multiple work sites may be managed as separate maintenance centres or integrated into a master system. Either way, the maintenance programmes should be administered in site specific databases, using unique site identifiers if required.  
  Each work site may have stand alone computer work stations or they may be networked to a central server running a central database system  
  If maintenance data is passed between work sites then issues of security, data loss, virus infection and information source identification and segregation should be adequately managed. |
| 2.12 Are there adequate facilities, and time for computer access, available to Maintenance System personnel? | A Maintenance System requires adequate administrative resources and capabilities to function effectively.                                                                                       |
| 2.13 Are adequate computer hardware management procedures in place     | Proper management is required for such tasks as:  
  1) Software download and update  
  2) Data backup  
  3) Firewalls and virus protection  
  4) Unauthorised programme installation                                                                                                    |
## SECTION 2 : MAINTENANCE SYSTEM ELEMENTS

<table>
<thead>
<tr>
<th>Subject</th>
<th>Remarks</th>
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</table>
| 2.14 | Are adequate administrative management procedures in place | Proper management is required for such tasks as:  
1) Setting and control of access rights  
2) Equipment inventory, data and identification inputs  
3) Work Order issuance and distribution  
4) Maintenance data recording |
| 2.15 | How does the organisation monitor the proper provision of sub-contractor management? | Relevant management issues include:  
1) Personnel competence  
2) Security  
3) Sub-contractor familiarisation  
4) Third party supplied equipment condition  
5) Computer system access  
6) Reporting formats |
| 2.16 | How does the organisation monitor the performance of sub-contractors? | Relevant performance issues include:  
1) Are Key Performance Indicators defined and measured?  
2) Health & Safety  
3) Contractual requirements  
4) Lessons learnt |
| 2.17 | Are risk assessment procedures applied to maintenance tasks? | |
| 2.18 | Are safety management procedures applied to maintenance tasks? | |
| 2.19 | Is the management of the maintenance of safety systems properly managed? | Specific procedures, controls, checks and tests should be referenced or documented. |
| 2.20 | Are functioning procedures in place to evaluate the adequacy of provision of resources? | Resources to be evaluated include:  
1) Manpower  
2) Spare parts  
3) Consumables  
4) Maintenance equipment  
5) Computer workstations  
6) Waste disposal facilities |
| 2.21 | Are spare parts and consumables properly stored? | Storage issues include the following:  
1) Preservation methods  
2) Shelf life monitoring  
3) Environmental control  
4) Segregation of below standard items  
5) Product data sheet availability |
| 2.22 | Are spare parts resourced from acceptable sources? | |
| 2.23 | Are workshops properly managed and maintained? | |
### SECTION 2: MAINTENANCE SYSTEM ELEMENTS

<table>
<thead>
<tr>
<th>Subject</th>
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<tbody>
<tr>
<td>2.24</td>
<td>Is maintenance equipment properly managed and maintained?</td>
</tr>
<tr>
<td>2.25</td>
<td>Is a calibration programme properly implemented and managed?</td>
</tr>
<tr>
<td>2.26</td>
<td>Are sufficient computer workstations available to allow proper Maintenance System administration?</td>
</tr>
<tr>
<td>2.27</td>
<td>Is a Management of Change procedure covering the Maintenance System defined and implemented?</td>
</tr>
<tr>
<td>2.28</td>
<td>What steps are addressed by the Management of Change procedure? A Management of Change procedure should address the following steps: 1) Evaluation of consequences of change 2) Evaluation of need for change 3) Approval/amendment/disapproval of proposed change 4) Evaluation of how best to implement change 5) Assignment of authorities and responsibilities for implementation of change 6) Monitoring of change process 7) Monitoring of effects of change</td>
</tr>
<tr>
<td>2.29</td>
<td>What types of changes are covered? Any change that has significant impact on methods of working should be subject to the initial stage of evaluation of consequences and further action subject to Management of Change process if required. Administrative issues such as the addition of new equipment to maintenance software databases, and deletion of out-of-service equipment need not be subject to Management of Change but should be subject to control and checking by authorised personnel.</td>
</tr>
<tr>
<td>2.30</td>
<td>How is procedural documentation made available? Documentation may be published as hard copy documents, flowcharts, process maps or as web-based files. Whatever the format the documentation should be subject to formal control procedures.</td>
</tr>
<tr>
<td>2.31</td>
<td>How are procedural documents controlled? Documents should be controlled to the extent required by organisational document control procedures but at least to the degree that new revisions are reviewed and identified and that a list of current documents and revision numbers is kept up to date and distributed within the organisation</td>
</tr>
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### SECTION 2: MAINTENANCE SYSTEM ELEMENTS

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<tr>
<th>Subject</th>
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<tbody>
<tr>
<td>2.32 How is manufacturers’ documentation made available?</td>
<td>A Maintenance System cannot operate effectively without reference to the product documentation of machinery and equipment manufacturers. Manufacturers’ documentation is normally available as hard copy or electronic documents. There should be at least two copies of manufacturers’ documentation available to an organisation. One copy should be available as a working copy for personnel conducting maintenance tasks. Other copies should be kept as defined by procedures or as required by Supervisory and Management functions.</td>
</tr>
<tr>
<td>2.33 How are updates to manufacturers documentation managed?</td>
<td>If the organisation has subscribed to a service of overhaul, safety and modification bulletins and updates from a manufacturer there should be a system for control and distribution in place, to ensure they are read by the relevant personnel. A register should be kept of revision and version numbers of manufacturers manuals and CDs for reference and to track alterations. Websites with relevant information should be accessible to authorised personnel.</td>
</tr>
<tr>
<td>2.34 How are engineering and electrical drawings made available?</td>
<td>These may be available as hard copy, on microfiche or electronically</td>
</tr>
<tr>
<td>2.35 How are engineering and electrical drawings controlled?</td>
<td>These drawings should be controlled to the extent required by organisational document control procedures but at least to the degree that new revisions are reviewed and identified and that a list of current drawings and revision numbers is kept up to date and distributed within the organisation. System modifications should be reflected in revisions to the existing drawings or by the issue of new drawings. The safety and effectiveness of maintenance tasks can be severely compromised if drawings do not show the ‘as is’ configuration of the installation systems.</td>
</tr>
<tr>
<td>2.36 How is machinery certification controlled?</td>
<td>A Maintenance System should generate, and require, significant numbers of certificates. Certification should be controlled to the extent required by organisational document control procedures. Original copies should be appropriately filed for defined retention periods</td>
</tr>
<tr>
<td>2.37 How are external reports, audit and inspection documents controlled?</td>
<td>Documents should be controlled to the extent required by organisational document control procedures but at least to the degree that old revisions are archived, copies are appropriately distributed within the organisation and closeout actions are recorded.</td>
</tr>
<tr>
<td>2.38 How are internal management documents controlled?</td>
<td>Management meetings should issue properly documented minutes and action lists. Proposals and actions should be documented in a clear auditable trail.</td>
</tr>
<tr>
<td>2.39 How is document archival managed?</td>
<td>Archived documents should be filed in safe, secure storage and be readily retrievable. Up to date catalogues of archived material should be available to assist reference.</td>
</tr>
<tr>
<td>Subject</td>
<td>Remarks</td>
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</tr>
<tr>
<td>2.40</td>
<td>Are meetings routinely held - according to schedule?</td>
</tr>
<tr>
<td>2.41</td>
<td>Do meetings have set agendas?</td>
</tr>
<tr>
<td>2.42</td>
<td>Are minutes of meetings recorded and action lists documented?</td>
</tr>
<tr>
<td>2.43</td>
<td>Are action closeouts monitored?</td>
</tr>
<tr>
<td>2.44</td>
<td>Are ‘Safety Moments’ or safety issues raised as set agenda items?</td>
</tr>
<tr>
<td>2.45</td>
<td>Do Safety Meetings discuss maintenance issues?</td>
</tr>
<tr>
<td>2.46</td>
<td>Are there systems in place to identify training requirements?</td>
</tr>
</tbody>
</table>
### SECTION 2 : MAINTENANCE SYSTEM ELEMENTS

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<tr>
<th>Subject</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>2.47 Are there appropriate induction and familiarisation procedures in place?</td>
<td>Personnel should have induction and familiarisation before taking on new or modified equipment, tasks or worksites.</td>
</tr>
<tr>
<td>2.48 What training material is available?</td>
<td>Organisational training may be provided internally or externally and may include an element of assessment. Manufacturers’ training material may provide a useful training tool. This can include factory training courses, simulator training and videos.</td>
</tr>
<tr>
<td>2.49 Are skills and training records maintained?</td>
<td>A record of the skills and the training of personnel allows people to be matched to tasks.</td>
</tr>
</tbody>
</table>
### SECTION 3 : MAINTENANCE SYSTEM DESIGN

<table>
<thead>
<tr>
<th>Subject</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3.1 How complete is the equipment inventory?</strong></td>
<td>The equipment inventory should, as far as practicable, include all structural, plant, machinery, and equipment items. Exclusions should be recorded and the basis for their exclusion noted.</td>
</tr>
<tr>
<td><strong>3.2 Is the equipment inventory made up of a single or several lists?</strong></td>
<td>An installation may have more than one Maintenance System, each one covering a different area of installation maintenance and each one covering a different section of the equipment inventory but if an item is not included somewhere there is a likelihood that its maintenance could be neglected</td>
</tr>
<tr>
<td><strong>3.3 What information is provided in the equipment inventory?</strong></td>
<td>A documented equipment inventory can provide a ‘one stop shop’ for information concerning installed equipment that is routinely required for operational reasons. Such information including: 1) Equipment type and serial number 2) Manufacturers details 3) Date of manufacture 4) Design ratings and operating characteristics 5) Certification 6) Criticality</td>
</tr>
<tr>
<td><strong>3.4 How is the equipment inventory managed and controlled?</strong></td>
<td>Maintenance software programmes frequently use a dedicated database to list the equipment inventory. This is used as a basic information store for software processing and may be accessed independently as an information library. The use of a central database simplifies the process of updating equipment information. If this information is maintained in hard copy issues they should be controlled to the extent required by organisational document control procedures but at least to the degree that new revisions are reviewed and identified and the current revision disseminated within the organisation. Revisions to the equipment inventory should be made in a controlled manner by authorised personnel</td>
</tr>
<tr>
<td><strong>3.5 How has the numbering system been derived?</strong></td>
<td>Numbering systems may be custom made or developed from a commercially available proprietary system. A maintenance software programme may require the use of a particular numbering format or a variant from a range of possible formats</td>
</tr>
<tr>
<td><strong>3.6 How functional is the numbering system?</strong></td>
<td>A numbering system should satisfy the following criteria: 1) be capable of providing a unique identifier for every item requiring inclusion, to within acceptable practical limits 2) be capable of providing a range of ‘families’ of numbers sufficient to group particular linked equipment classes or systems to within acceptable practical limits 3) be capable of being expanded both in total and within identifier ‘families’ to accommodate new entries that may be required</td>
</tr>
<tr>
<td><strong>3.7 What is the logic of the numbering system identifier groups?</strong></td>
<td>Possible logic of a numbering system may include identification of equipment items by machinery system, equipment type, equipment location, equipment criticality etc.</td>
</tr>
</tbody>
</table>
## SECTION 3 : MAINTENANCE SYSTEM DESIGN

<table>
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<tr>
<th>Subject</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>3.8 Is the application of identifier groups to physical systems comprehensive and consistent?</td>
<td>Whatever a numbering system character group may identify all relevant items should have an identifier and they are best ordered logically and consistently according to a structured scheme.</td>
</tr>
<tr>
<td>3.9 Are equipment items physically tagged?</td>
<td>It is good practice to fix an identifier number plate to the specific equipment items.</td>
</tr>
<tr>
<td>3.10 How comprehensive is the information included in Work Orders?</td>
<td>The description of a maintenance task should include the following information: 1) Safety instructions 2) Personnel/skills required 3) Equipment shutdown/isolation requirements and checks 4) Maintenance equipment required 5) Nature of task e.g. statutory, routine, repair, modification 6) Task description 7) Commissioning and start up checks and tests 8) Any specialist environmental/waste disposal requirements 9) Data to be recorded 10) Renewable spare parts and consumable requirements.</td>
</tr>
<tr>
<td>3.11 What safety information is included in Work Orders?</td>
<td>Safety instructions should reference such requirements as: 1) Permit to Work requirement 2) PPE and safety equipment required 3) Lifting plan requirements 4) Isolations required 5) Concurrent related maintenance work, mutually excluded maintenance tasks.</td>
</tr>
<tr>
<td>3.12 How detailed are the procedures provided in the task description in Work Orders?</td>
<td>The task description may include precise step by step instructions or may reference the applicable section of the manufacturers’ manual. Particular points of concern from previous maintenance history may be included and also guidance to particular peculiarities or difficulties involved in the task.</td>
</tr>
<tr>
<td>3.13 Does scheduling follow Manufacturer recommendations and is it design specific?</td>
<td>Running hour schedules may differ for varying running conditions, such as fuel type, load distribution pumping fluid etc, but should reflect Manufacturer’s conservative guidelines and recommendations.</td>
</tr>
<tr>
<td>3.14 Is scheduling based on experience of the unit and operating conditions?</td>
<td>Schedules may be modified on the basis of accumulated operational experience, but changes should be subject to a Management of Change process.</td>
</tr>
<tr>
<td>3.15 Is the criticality of the equipment a contributing factor to scheduling within the maintenance programme?</td>
<td>The Maintenance System should target appropriate time and resources to maintaining the condition, functionality and operability of equipment designated as safety critical.</td>
</tr>
</tbody>
</table>
### SECTION 3: MAINTENANCE SYSTEM DESIGN

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<th>Subject</th>
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<tbody>
<tr>
<td><strong>3.16</strong> What bases are used for assigning task frequency?</td>
<td>Task frequency may be based on any appropriate unit of time, or on some measure of elapsed operation. The scheduled frequency should be based on some objective evaluation, such as manufacturers’ recommendations, historical assessment or reliability calculation. Maintenance tasks may be scheduled in accordance with any of the following criteria: 1) calendar schedule 2) equipment running hours 3) other accumulated operating measure 4) combined into a campaign or shut down programme.</td>
</tr>
<tr>
<td><strong>3.17</strong> If calendar schedule is not used as the basis for assigning task frequency how is scheduling controlled?</td>
<td>Scheduling by criteria other than by calendar date requires that machinery running hours or other operational measurement are recorded and entered into the maintenance software for each equipment item. Machinery systems whose maintained condition may suffer according to load demands and whose operating regime is variable should be subject to the appropriate schedule of monitoring to properly assess the frequency required for a maintenance task.</td>
</tr>
<tr>
<td><strong>3.18</strong> Are tasks scheduled independently or with reference to other tasks?</td>
<td>Maintenance tasks for an equipment item may be sequential, or they may be linked, or they may be dependent on the realisation of some prior condition. Maintenance tasks for different equipment items may be linked or interleaved so that the performance of particular maintenance tasks is scheduled to correspond with the performance of related maintenance tasks. Tasks that may be usefully completed together at one time may be scheduled for the same period, or more major tasks may be scheduled to take the place of more minor tasks at specified intervals. Maintenance software may have the facility of linking equipment hierarchies, or machinery components into linked families. This permits a single machinery running measurement to be applied to a series of equipment items.</td>
</tr>
<tr>
<td><strong>3.19</strong> How are due tasks issued?</td>
<td>The issuing of Work Orders at due times is an essential function of maintenance software programmes and may usually be performed automatically or by manual selection, according to the chosen scheduling criteria. Completion of a Work Order is then the signal for computation of the next Work Order issue point. An organisation may, however use a planning software programme for scheduling maintenance tasks. In such a case, issues of care and completeness of maintenance task transfer and entry should be addressed, to ensure there are no omissions and that interactions between tasks are addressed.</td>
</tr>
<tr>
<td><strong>3.20</strong> Are equipment manufacturers’ recommendations available?</td>
<td>The text and layout should be available in UK English, clearly and unambiguously composed by the manufacturer. Where appropriate, they should be accompanied by identifiable sketches and/or figures showing reference points for condition and monitoring data collection, etc.</td>
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## SECTION 3 : MAINTENANCE SYSTEM DESIGN

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| **3.21** Are equipment manufacturers’ recommendations taken into consideration during development of the maintenance programme? | Manufacturers’ recommendations and guidelines should clearly state the following:  
1) Intervals for inspections, visual checks, internal and external examinations, equipment overhauls, safety device checks and alignment checks  
2) Condition monitoring including vibration and noise levels of rotating equipment where applicable  
3) LO and coolant replacement and analysis in-house and by laboratory (including Ferro graphic analysis), hydraulic and brake fluid checks etc.  
4) The condition of protection fabric, i.e., paint condition, rust prevention and corrosion monitoring frequencies  
Manufacturer’s maintenance recommendations should be followed to avoid conflict with Warranty issues for the period being covered. |
| **3.22** Has the organisation defined standards for equipment maintained condition, functionality and operability? | All equipment items within the Maintenance System should routinely conform to the defined standards. |
| **3.23** Does the SCE inventory include all applicable items? | SCE may be established in relation to major hazards identified in the Safety Case or in relation to hazard criteria defined by an organisation.  
Relevant machinery items may include:  
1) Equipment such as enclosed vessels (pressure and atmospheric), heat exchangers, flare or vent towers/booms, tanks and containers, relief valves, blow down/vent valves, isolation valves and emergency shut down valves.  
2) Fire detection/extinguishing, life saving, watertight containment systems and equipment  
3) Safety critical system equipment  
4) Operating condition indicating instrumentation and controllers for safety and safety critical systems.  
5) Equipment such as engines, turbines, pumps, compressors, HPUs etc. providing services for safety systems.  
UKOOA Guidance CP029, Management of Safety-Critical Elements may be consulted. |
### SECTION 3 : MAINTENANCE SYSTEM DESIGN

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<tr>
<td>3.24</td>
<td>Have SCE been allocated Criticality Ratings? Each SCE should have an allocated Criticality Rating. This criticality number should be allocated to the SCE when it is incorporated into the Maintenance System. Within the Maintenance System a priority ranking may also be allocated to each of the Work Orders which together with the criticality ranking of the equipment drive task priorities. Criticality Ratings may broadly reflect the following categories; 1) Safety Critical: Equipment whose primary function is protection or safeguarding. 2) Vital equipment whose failure is likely to cause extended production deferment or potential loss of life. 3) Essential: equipment whose failure is likely to result in production deferment. 4) Non-essential: equipment that is neither vital nor essential, i.e. equipment whose failure is not likely to cause production deferment or potential loss of life.</td>
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<tr>
<td>3.25</td>
<td>Have Performance Standards been drafted to document SCE management requirements? Performance standards should: 1) Record the essential features of SCEs 2) Set measurable goals that each SCE is to achieve. 3) Specify the nature/frequency of examination and testing. 4) Address the initial and continuing suitability of SCEs 5) Be reviewed by the Independent Competent Person [ICB] and any concerns be properly addressed</td>
</tr>
<tr>
<td>3.26</td>
<td>How are failures to achieve Performance Standards requirements addressed? Arrangements should be in place to deal with any failure to meet the defined objectives of a Performance Standard. These may include such considerations as: 1) Undertaking an assessment of the significance of the non-conformity in relation to the Safety Case and Maintenance System objectives 2) Documenting the assessment, initiating action and tracking actions to close out.</td>
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<tr>
<td>3.27</td>
<td>Has the historical maintenance history been analysed?</td>
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<tr>
<td>3.28</td>
<td>Has feedback from historical maintenance history analysis been used in determining maintenance programmes?</td>
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<td>3.29</td>
<td>Has ‘As built’ data including FAT test results, performance curves etc been included in the historical data?</td>
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| 3.30 Has the operating regime for equipment items been reviewed? | A major factor influencing maintenance task scheduling is the operating philosophy and regime for plant, machinery and equipment. Where redundant provision of equipment is provided the operating routine should be calculated so as to best serve the requirements of the Maintenance System. Various options are possible for scheduling the running times of equipment, including:  
1) Running one machine continuously on load to a major overhaul period, while test running the standby machine at scheduled intervals, then changing over to run another machine.  
2) Running all machines interchangeably to maintain equal running hours.  
3) Running one machine continuously to a specified interim overhaul period to establish a suitable interval between running hours, and then running machines interchangeably to maintain staggered overhaul periods. |
| 3.31 Has the operating regime for equipment items been used to modify maintenance programmes? | The operating regime and the maintenance programme of an equipment item are interdependent in that, within limits either may dictate or may accommodate the other. A harsh operating regime should be supported by a heavier maintenance programme, a less arduous operating regime may facilitate a lighter maintenance programme. |
| 3.32 Are maintenance records sufficiently detailed to facilitate significant analysis? | The importance of accurate, truthful, clear and detailed maintenance records is emphasised. |
| 3.33 Are maintenance records analysed to establish findings such as failure trends, significant failure modes and causes, poor maintenance practices, workloads, costs etc? | |
| 3.34 Has feedback from maintenance records analysis been used in modifying maintenance programmes? | |
| 3.35 Are management reviews sufficiently detailed to facilitate significant analysis? | |
| 3.36 Has feedback from maintenance reviews and verification schemes been used in modifying maintenance programmes? | Assessment of the performance of a maintenance programme forms part of the Verification Schemes managed by the appointed ICB. Verification Schemes are drafted by the ICB to provide the basis for an objective assessment of the maintained condition of the equipment and plant, and to provide an important element in the process of maintaining the equipment to a satisfactory level of condition and functionality. |
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| 3.37 What are the authorised outcomes for Work Orders? | Possible outcomes may include:  
1) Work Order cancelled, to be reissued at next routine issue point, reasons recorded  
2) Work Order rescheduled, for some defined future point, reasons recorded  
3) Work Order task amended prior to execution, task completed and the resultant data and history recorded  
4) Work Order completed and the resultant data and history recorded  
5) Work Order aborted, resultant data and history and reasons reported, corrective actions agreed and initiated |
| 3.38 How is maintenance data and history recorded? | For maintenance software programmes the data and history may be inputted directly by maintenance personnel or recorded on hard copy report formats and transcribed by authorised personnel.  
Hard copy records that may be required should be securely filed, in accordance with organisation document control procedures, for the required retention period so as to be readily retrievable |
| 3.39 What information is recorded? | Maintenance records may include standardised reporting codes to simplify analysis. Information may include ‘as found’ condition, repair classification and measured parameters.  
Logistics data such as man-hours, personnel, spares and consumables used may also be reported.  
Maintenance task histories should include all information relevant to future operation and maintenance of the equipment and to analysis of causes of failure. Histories should also include records of all measured parameters. |
| 3.40 How are measurements logged and recorded? | Any condition monitoring techniques included in the maintenance programme should be conducted with care, and in accordance with established best practice and equipment manufacturers instructions.  
Measurements should be taken at the same optimal reference or sampling position(s) each time, the measuring apparatus should be within calibration and operating conditions within prescribed limits.  
Measurements or samples sent for third party analysis should be subject to defined procedures regarding identification, delivery methods, results required and report formats.  
Measurements may be recorded on purpose designed report forms and hard copy filed. |
| 3.41 What provision is made for conducting Root Cause analysis? | The Maintenance System should include a defined process for identifying categories of failures and defects that should be subject to Root Cause analysis. Failures included within the process should be subject to a regulated, rigorous, documented investigation to determine the root cause(s). The process should include development, authorisation and implementation of appropriate preventive measures. |
| 3.42 What provision is made for analysis of condition monitoring readings? | Condition monitoring readings should be subject to appropriate trend analysis techniques to identify the rate of change of measured parameters as a guide to deterioration of maintained condition. |
## SECTION 3: MAINTENANCE SYSTEM DESIGN

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<tr>
<td>3.43</td>
<td>What provision is made for statistical analysis of maintenance data and history?</td>
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<tr>
<td>3.44</td>
<td>What use is made of the analysis of maintenance data and history?</td>
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<tr>
<td>3.45</td>
<td>What provision is made to analyse the nature of the maintenance programme workload?</td>
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<tr>
<td>3.46</td>
<td>Is the Maintenance System included within an internal audit programme?</td>
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<tr>
<td>3.47</td>
<td>Is the Maintenance System included within an external audit programme?</td>
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<tr>
<td>3.48</td>
<td>Does the organisation hold regular management reviews of the Maintenance System?</td>
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<tr>
<td>3.49 How are changes to the Maintenance System managed and controlled?</td>
<td>Minor changes such as equipment inclusion or deletion is normally managed internally through Maintenance System procedures. Major changes should be subject to a Management of Change procedure. Major changes to a Maintenance Systems’ inputs, such as a Regulation 9(2) change to the Safety Case, Performance Standard amendment or Safety Critical Element revision would form subjects for a System Review. There should be a standardised procedure, either as part of System Review or of Management of Change, to carry forward suggestions for improvement by personnel.</td>
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### SECTION 4 : SCHEDULED MAINTENANCE

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| 4.1 What routine surveillance and observation routines are managed within the Maintenance System? | Routines may include:  
1) Watchkeeping  
2) Routine daily, weekly, monthly rounds  
3) Lubrication rounds  
4) Regular sampling and analysis  
5) Regular function testing  
6) Regular alarm tests |
| 4.2 What records are maintained of routine maintenance tasks | Records may include:  
1) Log books  
2) Alarm record books  
3) Alarm/data logging  
4) Personal work books  
5) Checklists  
6) Test records |
| 4.3 Are the authority and procedure for amendment, postponement or cancellation of a Work Order defined? |  |
| 4.4 Are there records of amended, postponed or cancelled Work Orders? |  |
| 4.5 Are mobilisation and safety measures prior to maintenance work properly managed? |  |
| 4.6 Are maintenance tasks properly executed? |  |
| 4.7 Are completion checks, tests and site restoration properly managed? |  |
### SECTION 4 : SCHEDULED MAINTENANCE

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<td>4.8</td>
<td>Are Work Orders adequately completed with required data and history? This may include: 1) Start/finish date and time 2) ‘As found’ condition/running hours/results of functional tests prior to, and on completion of the task. 3) Full details of work done with observations and comments. 4) Defects identified 5) Measured parameters/readings taken 6) Points of concern/parameters requiring observation 7) Use of spare parts including description and reference number of part. 8) Pertinent observations as to use of tools and equipment/safety/procedures used 9) Personnel/man-hours. The maintenance records should record the number of trade disciplines and supervisors engaged in the tasks, also all man-hours per person and in total should be recorded. 10) Consumables used 11) The numbering identifiers on the asset, also sub-system (if any) and system references should be included in the maintenance history, if necessary, to serve as a cross-check to location and asset work done. 12) Any additional documentation which may be required for internal/external audits, Verification Schemes, Classification Society Surveys, and other regulatory/statutory bodies should be cross-referenced in the work history, with appropriate file reference location, etc. 13) Documentation which may be required for internal/external audits, Verification Schemes and other regulatory/statutory bodies should be cross-referenced in the work history, with appropriate file reference location, etc.</td>
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<tr>
<td>4.9</td>
<td>Are machinery operating logs maintained?</td>
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<tr>
<td>4.10</td>
<td>Is there a functioning process for the management of task backlogs?</td>
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### SECTION 5: UNSCHEDULED MAINTENANCE

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<tr>
<td>5.1 What proportion of the maintenance workload is Corrective maintenance?</td>
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<td>5.2 Are defects properly evaluated?</td>
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<td>5.3 Do Defect Reports require adequate information to properly specify repair requirements?</td>
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<tr>
<td>5.4 Are Defect Reports properly documented and managed?</td>
<td></td>
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<tr>
<td>5.5 Do Work Orders/Workpacks properly specify repair requirements?</td>
<td></td>
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<tr>
<td>5.6 Are mobilisation and safety measures prior to repair work properly managed?</td>
<td></td>
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<tr>
<td>5.7 Are repair tasks properly executed?</td>
<td></td>
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<tr>
<td>5.8 Are completion checks, tests and site restoration properly managed?</td>
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<tr>
<td>5.9 Is repair monitoring properly managed?</td>
<td></td>
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<tr>
<td>5.10 Are repair history and data properly recorded?</td>
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<tr>
<td>5.11 What analysis is applied to repair history and data?</td>
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<tr>
<td>5.12 Is the ICB involved in review/authorisation of SCE repair procedures?</td>
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## SECTION 7 : MAINTENANCE SOFTWARE PROGRAMMES

<table>
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<tbody>
<tr>
<td>7.1 Is the software custom written for an organisation, or is it a commercially available proprietary system?</td>
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<tr>
<td>7.2 Is the software modified specifically to suit an organisation’s requirements?</td>
<td></td>
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<tr>
<td>7.3 If software is a proprietary product is it provided as separate modules for particular business functions?</td>
<td>Proprietary software is often distributed as separate programme modules with seamless interactivity, each serving a particular business function</td>
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<tr>
<td>7.4 If software is a proprietary product with separate modules which modules are in use?</td>
<td>An organisation can pick and choose whichever suite of modules best serves its requirements</td>
</tr>
<tr>
<td>7.5 Was the development of the software primarily based on Maintenance System requirements, or on another business function?</td>
<td>The origins of a software programme can have major consequences on the complexity and transparency of its use in a Maintenance System. There are programmes which were first developed as maintenance management tools and subsequently evolved with other practical management modules and programmes which have been developed as modules to integrate with pre existing financial management packages.</td>
</tr>
<tr>
<td>7.6 Have all relevant issues been addressed in the choice of software?</td>
<td>Relevant issues may include: 1) Budget 2) Computer system specification and limitations 3) Pre-existing maintenance software databases 4) Interfaces with other software 5) Scope and complexity of Maintenance System 6) Range of intended users 7) Licence agreement limitations on concurrent users, no of databases etc. 8) Availability of other management modules with maintenance software 9) Scope of costing and resource usage data input required 10) Standard reporting formats available 11) Degree of customisation available 12) Security, access and user rights issues 13) Software developer support 14) Simplicity of user interfaces 15) Training and familiarisation required</td>
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| 7.7 Have all relevant consideration been addressed in setting up the software? | Once a software programme has been installed, considerations may include the following:  
1) Existing data migration  
2) Training and familiarisation  
3) Procedures  
4) Security, access and user rights  
5) Technical support  
6) Interfaces with other software programmes  
7) Integration of various software programmes into effective maintenance management |
| 7.8 Is the use of all software programmes essential to effective management of the Maintenance System properly integrated? | The use of planning and other software that are not integrated within a specific maintenance programme should be managed so as to eliminate inconsistencies and contradictory outputs |
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