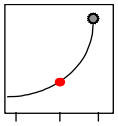
The Norwegian Petroleum Directorate

Maintenance baseline study

A method for self-assessment of maintenance management systems



Rev. 0 - May 1. 1998

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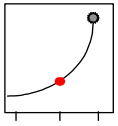
We would very much like to thank Amoco Norway Oil Company for kind assistance by their translation services.



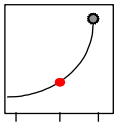
Description of the project

"The baseline maintenance study" was started as a project by the Norwegian Petroleum Directorate in the autumn of 1996. The objective of the project was to develop a **method for a systematic and comprehensive assessment of the company's own maintenance management system**. Through this project the NPD also wishes to contribute to a general improvement of the quality of the operator's system for managing safety-related maintenance and provide better predictability for the operators in terms of the NPD's expectations and requirements in this area.

Several considerations contributed to this project being initiated:

- Insufficient internal supervision in the companies of the maintenance function
- Insufficient capacity in the NPD to follow up every single field
- The need for stronger control of maintenance on installations nearing their final phase of operation
- New requirements related to a control system when introducing more advanced optimisation techniques

After having assessed their own maintenance management systems according to this method, the companies will have a documented basis for improving their management systems.



Description of the project (cont.)

Pilot studies

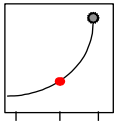
During 1997 and the winter of 1997/98 the self assessment concept "Maintenance management baseline-study" has been tested through so-called pilot studies with respectively Norske Shell, Elf Petroleum Norge and Norsk Hydro.

The experience from Shell, Elf and Hydro has provided valuable information for the further development of a management model for safety-related maintenance and for preparation of these guidelines. We are very grateful to these companies for their contribution and positive attitude!

Further plans

In 1998 Statoil will conduct a pilot study at one of their fields. Otherwise the companies are free to start their own baseline-studies. The NPD is prepared to provide the necessary guidance and support to the best of our capacity. Please contact Liv Nielsen, Svein Olav Drangeid or Sverre Øxnevad for an appointment.

The management model and guidelines will be attempted updated and improved on a continuous basis. It is our goal to raise the level of expectations in keeping with the technical and method-related development in the petroleum industry and in comparable industries. We also wish to give more room for presentation of examples of "good/best practices" in the field of maintenance management.



Purpose

The purpose of the study

For the **operators** the baseline-study is intended as a tool for continuous improvement of their own system for managing safety-related maintenance.

For the **authorities** the information gained from the baseline-studies shall be included in - and improve - the decision-making basis when selecting focus areas as regards maintenance, and in prioritising supervision of operators and fields.

For **operators and authorities** the study is intended to provide a common understanding of the management system's strength, weaknesses and improvement areas and form the basis for further communication and follow-up.

What is the study aimed at?

The study brings into focus the quality of the maintenance system as regards maintaining

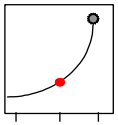
- **technical condition**
- **safe operation**

in the operating phase of installations. The questions in the guidelines concentrate on safety. Individual operators may include other matters, such as economy and production regularity.

The status of the baseline-study in the companies

The report which is to be prepared after the study is completed shall express the **management's** perception of

- the maintenance management system's **total quality** as of today
- **which improvements** need to be carried out where, how and when



Execution

Who shall evaluate the maintenance system?

The baseline-study is based on assessments of the maintenance management system performed by persons who are directly involved in various parts of the maintenance function. The concept behind this study is built on the principle of **those who work with maintenance on a daily basis knows best how to improve it.**

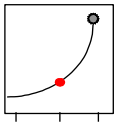
How often is the study to be conducted?

A regular evaluation of the management systems is an important condition for achieving continuous improvement in safety-related maintenance. It is therefore recommended to conduct the baseline-study regularly, for instance annually or every second year.

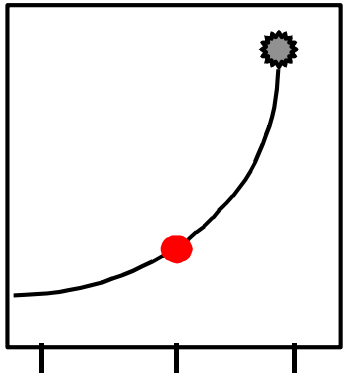
What should the study include?

The study shall be **focused on the entire safety-related maintenance process**, with associated resources, regardless of which organisational units have been delegated the responsibility for maintaining all or parts of it.

Maintenance related to drilling and well service on exploration rigs and fixed installations and on subsea facilities should also be included in the operator's baseline-study. Alternatively, it is possible to conduct separate studies of these functions, for example in collaboration with the drilling contractor.



Execution (cont.)



How to formulate the report - questions that need to be answered

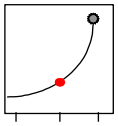
For **each element** in the management model, the following shall be summarised:

- **History and status** as regards choice, and change of objectives, strategies, methods, organisation, tools, etc., if relevant.
- **Problems and challenges** - strong and weak sides. (NB!) It is permitted to point out problems, even if nothing can be done about it for the time being.)
- **Objectives and improvement plans** (including improvement of processes)

The descriptions shall be on an overall level, in the range of 1 page per element.

List of measures

Initially in the report on the baseline-study there should **be an overview of all the improvement measures approved by the management**, both previous measures and measures that have been proposed by the baseline-study group. The planned measures ought to be arranged in prioritised sequence and with deadlines.

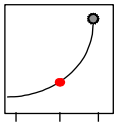


Maintenance management model

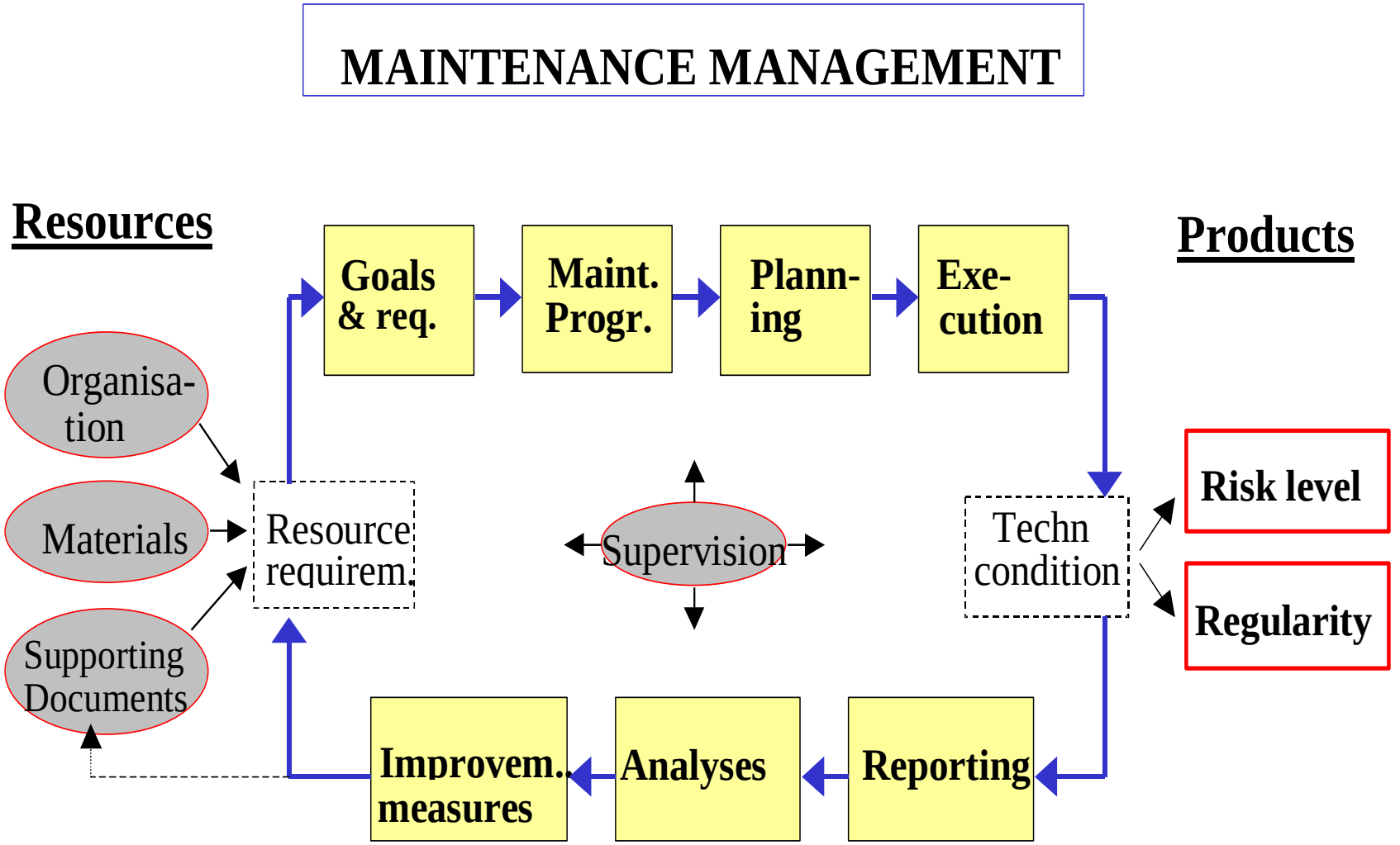
Management principles

When designing the model and questions in these guidelines, we have attempted to base it on the structure of a quality system. This means that:

- management systems shall contribute to a **continuous improvement** of the organisation's activities, products and services.
- management systems shall ensure that problems are continuously identified and solved and that good solutions are standardised. Problem-solving ought to be
  - aimed at improving work processes
  - integrated across organisational demarcation lines
  - proactive
- the different processes of the maintenance functions ought to be handled by a specific set of work **processes** (documents in procedures, flow charts, etc.)
- the work processes ought to be designed as complete **quality loops** and contain all phases in a problem-solving process.



Maintenance management model (cont.)



Maintenance management model (cont.)

Explanation of the model

In the model, **management of safety-related maintenance** is presented as an overall process (management loop) which, by means of necessary mobilisation of resources, produces safety (low risk) and (high) availability/regularity. Each of the elements in the management loop could consist of a number of work processes, with associated products. Supervision and resources are also included in the model.

Explanation of the text in the different chapters

Each element in the management loop has been allocated its own chapter. The contents are explained at the beginning of each chapter. To some extent examples of typical work processes and the products of these have also been provided. The questions in each chapter do not express specific regulatory requirements, but are aimed at aspects of maintenance, which in the NPD's opinion are important to safety. We have attempted to focus on **safety aspects** in each and every step of all the processes.

The questions are intended **to help create ideas**, and it is up to individual company to focus on questions and issues that, in the company's opinion, are important for improvement purposes. The work-group should use the guidelines, not as a checklist but as **basis for a constructive improvement discussion** that should be focusing on all possibilities for further development within the different areas. It is for instance very important to check practice against the objectives and requirements that are found in the company's own governing maintenance documents.

Comments are tied to some of the topics. These are based on observations from i.a. the NPD's supervisory activity and refers to areas that are particularly problematic and/or where the potential for improvement is significant. In this context we also refer to the NPD's report "Maintenance management. Experiences and Challenges" (NPD - 96 - 81). The report maybe obtained from the NPD. (See also list of references at the back of these guidelines.)

The NPD will not be allocating "marks" to the companies. Consequently it is not necessary to reply to each single question. Use those that are relevant and make your own!

Objectives and requirements

This chapter focuses on work processes for converting the company's own safety objectives and overall regulatory requirements to maintenance-related objectives and requirements, and on development of associated performance parameters/indicators for maintenance management.

Examples of products:

Requirements related to and measuring parameters for:

- backlog/outstanding maintenance
- availability/technical condition for systems and equipment critical to safety
- maintenance execution

Overall, safety-related objectives and management parameters

<u>Comments:</u> It is the NPD's experience that the companies' overall objectives and requirements relating to safety are only to a limited degree broken down to an operational level which makes it possible to use these to develop measuring and management parameters related to the maintenance function.

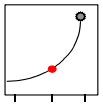
Has the company a set of clear, safety-related, maintenance objectives (long term, annual)?

- Which?

Which management parameters/indicators have been developed to follow up these objectives?

Are results measured against the overall objectives?

How do you handle deviations between objectives and actually achieved results?



Objectives and requirements, cont.

Requirements relating to outstanding maintenance

<u>Comments:</u> Corrective work orders are designed on the basis of occurred equipment failures. An occurred, failure mode which is critical to safety on an equipment unit can contribute to increased risk to the installation and must therefore be visualised as soon as it is uncovered. (In many companies, the failure modes are not visible in reports, etc. until the planning of the associated, corrective work order is finished).

Are upper acceptable limits established for the number of outstanding CM's with high priority (for occurred, safety-critical failure modes?)

Have similar limits been set for backlog of PM's?

Have limits been set at system/function level? - For which systems/ functions?

Which requirements exist for the frequency of monitoring, reporting and analysis of outstanding CM's (weekly, monthly, over time (trends)?

Objectives and requirements, cont.

Requirements relating to outstanding maintenance (cont.)

Which guidelines have been established in terms of measures if the acceptable limits are exceeded? (Example of measures: Reduced activity level, extra manning, start-up of maintenance campaign, etc.)?

Are these guidelines/procedures being complied with?

- Are there non-conformance treatment requirements?

Are overviews prepared that indicate development in the number of CM's for selected safety-critical systems and equipment?

- Are these overviews/reports used to manage maintenance? - How?

Objectives and requirements, cont.

Technical and operational requirements based on risk analyses

Comments: **In the quantitative total risk analyses that are prepared for installations in the operating phase (type QRA, etc.) a number of assumptions are made regarding the safety systems and safety critical production systems' availability, capacity, performance, etc. These assumptions are not always in line with the operator's requirements related to the same system (or the other way around: the operator's requirements are not reflected in the assumptions of the risk analyses).**

Are assumptions and results used to conduct risk analyses as basis for formulating requirements related to function/condition of

- Safety systems and
- Other systems critical to safety and equipment?

(How? - For which systems and equipment?)

Are these requirements communicated to, and visible for, the operating personnel?

Do conditions relating to manning levels, number of hours worked with hot work, shut-down of safety systems form the basis (as requirements) for carrying out the maintenance?

Are the requirements, and the motives behind them, defined and communicated to the maintenance personnel onshore and offshore?

Objectives and requirements, cont.

Follow-up of parameters in quantitative risk analyses

<u>Comments:</u> It is the NPD's experience that changes in assumptions/parameters in quantitative risk analyses are only to a limited extent followed up/monitored by the operating organisation. Phillips and Statoil have, in collaboration with the NPD, conducted a pilot project called the "Indicator Project", with the objective of developing indicators for measuring changes in risks, based on follow-up of changes in some important parameters. In our opinion there is a large potential for further development in this area (in parallel with a general improvement of the quality of the analyses). The "Indicator Project" is now expanded to comprise all the operators.

Are there routines /requirements for monitoring /reporting /analysing individuals or groups of initiating events that are included in the quantitative risk analyses? - Which?

- How can these be monitored? (Example: Indirect by the number of "real" activation of the safety system)

Are changes in the use of hot work, maintenance manning, maintenance programme, etc. checked against the assumptions in the risk analyses?

Objectives and requirements, cont.

Objectives related to events

<u>Comments:</u> Many accidents are triggered as a result of human error while carrying out maintenance. It is therefore very important for safety that causal relations are revealed, in order to prevent a recurrence.

Does the company have reports that show which/how many (initiating) evens and accidents are triggered during maintenance?

Which are the most frequently occurring causal relations of these events?

Are there certain types that are especially exposed/problematic in this connection? - Which?

- Is it possible (has it been considered) to connect the event log to the tag number in the maintenance administration system?

Has the company found it necessary to implement such measures to reduce human errors in connection with conducting maintenance? - Which?

Which objectives have been established in this area?

Are these followed up by means of measuring parameters?

Programme

The chapter focuses on work processes for development, updating and improvement of preventive maintenance programmes, inspection programmes, programme for condition assessment and testing, etc. In the following text, preventive maintenance is often used as a designation for these programmes combined.

Pro-
gramme

<u>Comments:</u> The NPD has registered large differences between the companies, both as regards the size of the total resources that are made available for development and updating of maintenance programmes, and the methods, standards, etc. that are used for this purpose.

Strategies and methods- reliability-based maintenance - (RCM), risk-based inspection (RBI)

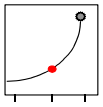
Are the company's strategies and methods for preparation of a programme for preventive maintenance, inspection, testing, etc. clearly expressed and communicated to the relevant units?

Are the strategies based on recognised standards or tested methods from other companies/ other industry?

To what extent are sufficient resources made available (skills, time, tools) to apply these strategies and methods in practice?

Are the existing <u>empirical data</u> (equipment failure frequencies, causes of failures, etc.) sufficiently reliable in relation to the applied methods?

- Are requirements relating to registering of failure data (type, equipment, level of detail, etc.) adjusted in accordance with the identified requirements when classifying criticality and preparing preventive maintenance programmes?
- Are personnel with operative experience used to qualify empirical data, etc.?



Programme, cont.

Methods for simplification of the RCM process

Comments: **A number of companies have experienced that application of so-called "full RCM" on all systems and equipment is very time consuming, and that the gains in the form of results do not correspond with the expended resources. The most important systems from a safety point of view with associated equipment ought, to, in the NPDs opinion, be given a full RCM review. We do not wish to recommend that streamlining /saving be effected in the form of simplification of method etc. (so-called "RCM-light"-versions) - as this could have negative safety-related consequences.**

For which systems are RCM-analyses appropriate, compared with the more "traditional" methods for developing maintenance programmes?

Have methods/guidelines been prepared to identify the systems that are to be given the full RCM review?

- Is the method tested, or verified by for example independent consultants?

Criticality classification

Which requirements does the company have as regards conducting analyses (functional analyses, FMEA/FMECA, etc.) for establishing criticality of systems and equipment?

Is there a requirement for criticality classification at failure mode level for the most critical systems in terms of safety?

Does the applied method and criticality model correspond to nationally or internationally recognised standards?

- Does it differentiate between criticality for safety and criticality in terms of production/economy?
- Are failure modes identified down to an equipment/component level which makes it possible to find the critical component(s) (maintainable items) and associated causes?
- Does the method give a satisfactory distribution of failure modes on the different classes of criticality?

Are sufficient resources in the form of time and competent personnel made available to perform the analyses?

Use of risk analyses for maintenance purposes

Comments: **The quantitative total risk analyses that are being prepared for the operating phase of the installation must, in the NPD's opinion, be changed and improved if they are to give a satisfactory input to the optimising of maintenance. In this connection it is important that the maintenance units impose requirements as regards the objective and results of the analysis.**

Is experienced maintenance personnel used for preparation and/or verification of maintenance-related assumptions in risk analyses?

Do the maintenance units impose requirements when conducting risk analyses, for instance requirements relating to manifestation of assumptions and results that concern maintenance?

Which routines/guidelines exist for communicating assumptions and results to the maintenance personnel?

When designing quantitative risk analyses, are arrangements being made for them to be used as basis for coarse separation in connection with criticality-classification of equipment (see the previous item)?

Preventive maintenance programme

How does it appear from the basic material for preparation of preventive maintenance programme:

- which safety-critical failure modes the programme is intended to prevent?
- which degradation mechanisms are to be prevented/observed?
- when reduced performance/availability brings a system/equipment into a failure modus?
- which assumptions are made in the total risk analysis in terms of :
  - the reliability/testing frequency etc. of the safety systems
  - the technical conditions of equipment, which in the event of failure could trigger an accident (leaks, etc.)?

Condition monitoring

Comments: **To measure the technical conditions means condition monitoring and control: vibration analysis off-line and on-line, borescoping of gas turbines, thermodynamic on-line, lubrication oil analysis, capacity, yield, flow-through/leak, thermography. The technical condition of an object is a relative value that expresses its degradation degree in relation to the design condition.**

Does the company have a clear philosophy for which safety-critical functions are going to be condition monitored?

Is relevant equipment available for planned monitoring?

- Is the reliability of the measuring equipment satisfactory in relation to the task(s)?

Which measures have the company initiated to map the degradation mechanisms and measure actual degradation of equipment with has passed its design lifetime?

Programme, cont.

Equipment which is out of service, etc.

Which requirements have been established relating to the maintenance/preservation programme for:

- equipment which is completely, or temporarily, out or service and
- leased equipment?

Which requirements apply for terminating equipment which is out of service?

Which requirements are imposed on re-qualification of equipment or components that will be brought into use again?

Which requirements/routines regulate "cannibalisation" of equipment?

Evaluation and updating of programme

Which procedure describes the process for continuous updating and improvement of existing inspection and maintenance programmes?

- Who is responsible for implementing and improving these processes?

Which requirements have been established for evaluating/updating programme (method, interval, etc.) in the event of, for example:

- modifications to equipment and when acquiring new equipment?
- changed operational conditions (for instance changes in pressures, gas/fluid composition, etc.)?
- "abnormal" degradation of equipment components that are critical to safety?

Programme, cont.

Quality assurance in case of changes in the programme

Have competent personnel been allocated for continuous updating/quality assurance of maintenance programme?

- Is offshore personnel used in these processes?

How is communication between the disciplines of maintenance, inspection/condition monitoring and production in the context of changes /revision of maintenance and inspection programmes?

- Is this communication satisfactory?

Which requirements/criteria must as a minimum be met in order to change a programme?

- Is non-conformance treatment necessary if it has not been documented in the basis for the decision that the change is defensible or necessary?

Who in the organisation is responsible for changes that are implemented?

- Who, if any, have been delegated the authority to make changes?

Are there clear guidelines for information/ communication of performed changes in the executing personnel? Do these function in practice?

Planning

The chapter focuses on work processes for long term planning of maintenance activities (for example 2 years, 5 years, etc.), and short term (monthly and weekly plans), individual work tasks (work orders) and day-to-day co-ordination.

Risk management

Comments: The petroleum industry in the Norwegian sector is facing major challenges in terms of maintaining an acceptable risk level in all phases of the lifetime of a field. For some fields the activity description on which the total risk analysis is based does not correspond to the factual activity level, since modifications, tie-ins with new fields, etc. is conducted more or less continuously, in parallel with operational and drilling activities.

Requirements relating to good risk management will therefore be a central factor in the planning and implementation phases of activities, including maintenance.

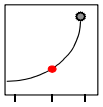
Long term resource planning

<u>Comments:</u> The NPD has registered that estimated required resources for maintenance purposes in connection with planned, simultaneous operational and project activities have been too low and in part unrealistic in some companies. The consequences have been a shortage of competent personnel to carry out the necessary maintenance and to participate in modification projects and/or projects for new fields.

Are there clear guidelines/ procedures for long time planning of maintenance activities?

- Who is responsible for follow up and improvement of the planning processes?

Are sufficient resources allocated for the planning task? (Experiences?)



Long term resource planning (cont.)

Are the maintenance unit's own plans sufficiently defined, co-ordinated and communicated to the company management?

- Whose main responsibility is this?

How and to what extent are the maintenance units involved in the company's overall long term planning?

- Are overall plans communicated to the maintenance units sufficiently detailed and within acceptable time limits?

Does a life cycle perspective form the basis for planning and budgeting of future maintenance activities?

- How is this perspective reflected when allocating funds for annual budgets?

Preparation of work orders - use of risk information

Does the company have available reports/statistics from its own installation that indicate how implementation of maintenance work and/or lack of or poor quality maintenance could increase risks?

- How large a share of registered events (near misses/accidents) are connected with maintenance activities? (Check this!)

Do detailed causal analyses exist of incidents/accidents related to maintenance?

- Are these used to improve procedures (work orders) for implementing preventive or corrective maintenance?
- Are they easily available for personnel who prepare the work orders?
  - can they be tied to the administration system for maintenance e.g. via a tag no.?

Are results from risk analyses etc. used to reinforce requirements relating to a proper implementation of maintenance in risky areas and on equipment exposed to risk?

Planning, cont.

Priority of work orders

Comments: The NPD has noted that few operators have a satisfactory system in terms of safety for prioritisation of work orders. On most installations priorities are made on a subjective basis, with or without the help of procedures, and without relation to, for instance, conducted criticality analyses of systems and equipment.

Are there clear rules/criteria for stipulating priorities on corrective and preventive work orders? - Which?

Does the occurred failure modes or the equipment's - safety-related criticality form the basis for stipulating priority of a corrective work order?

Are work orders for execution selected on the basis of the work order's execution deadline or on the basis of priority?

Are work orders with high priority as regards production /economy prioritised before work orders with the same priority due to safety? - What is practice?

Does a corrective work order keep its priority if it, due to scope of work/ complexity etc., is redefined to a modification project?

- how is this followed up, if relevant?
- who follows it up (ownership?)

Priority of work orders (cont.)

Does the work order contain sufficient information for determining priority of the work order?

- Which information is this?
- Which information is missing?
- What is the reason for possible deficiencies (no option regarding tools, unused option, etc.)?

To what extent does one depend on approximate assessments/experienced skilled people with determining priority of the work orders?

Planning, cont.

Deadlines for implementation

<u>Comments:</u> With most of the operating companies equipment failures are not manifested in reports etc. before the associated corrective work orders are planned (open). Often a deadline is also set for implementation on the basis of the date when the work order is presented.

Do all corrective work orders with high (safety-critical) priority receive a deadline?

- Is the deadline counted from the time the failure occurred or from the time when the planning of the work order is performed?

Is non-conformance treatment a requirement and/or should e.g. cause and consequence analyses be performed when a deadline for PM or CM is exceeded?

- Where these requirements/procedures complied with in practice?
- What kind of compensating measures were initiated?

Compensating measures - non-conformance treatment

Which requirements are established in terms of non-conformance treatment and/or execution of consequence analyses when initiating compensating measures (for instance if spares are lacking - or faulty)?

- Are these requirements respected?
- Who follows up/monitors?

Is the original work order maintained until the work is completed in accordance with specifications?

Planning, cont.

Risk-based frame conditions for planning

Comments: **The nuclear power industry in USA and France has gradually developed and partially brought into use data-based risk management tools for planning maintenance work. The tools, which obtain information from the quantitative total risk analyses, can give indications of changes of the risk level, for instance when carrying out maintenance activities that require safety systems to be shut-down, hot work to be performed, etc. This could be a solution also for the oil companies, even if the solution/degree of detail of the present risk analyses is unable to provide a sufficient answer as regards maintenance planning.**

Which requirements/guidelines does the company have for initiating compensating safety measures when carrying out maintenance that could increase the risk level (shut-down of safety systems, hot work, disconnection of redundant systems, etc.)?

Does the company have requirements relating to the maintenance of safety barriers for all systems and equipment components that are critical to safety?

How is the risk of placing safety systems out of operation assessed?

- Does maintenance personnel have sufficient knowledge of design assumptions, operational conditions etc. to be able to make such an assessment?

Has an upper limit been established for all the activities involving hot work and the total number of hours of hot work performed within a period?

Risk-based frame conditions for planning (cont.)

Has an upper limit been set for the continuous period individual safety systems can be set out of function?

- Are these limits observed in practice?
- Which requirements exist in terms of non-conformance treatment?

Does the company have guidelines that indicate the upper tolerance limits for how long it is permitted to carry out work that entails "significant" (see the following question) increase in the risk level on the installation, and/or that indicate how many hours/days this type of work can be carried out within a given period.

Which methods does the company have to indicate increases in the risk level during combinations of operational and modification activities, hot work, shut-down of safety systems, high number of occurred failure modes on safety-critical equipment (CM's), etc.?

Planning, cont.

Planning onshore and offshore

Is the distribution of roles and responsibilities clearly defined between onshore and offshore?

Is it clear to which degree plans originated onshore are guiding or binding?

- At which point can they be deviated from?
- Are there formal requirements relating to non-conformance treatment?

Do the plans originating onshore provide sufficient support for a systematic risk identification and co-ordination offshore?

Are the activity plans of the contractors subject to the same processing/assessment as the operator's own plans before they are presented to the platform management?

Planning, cont.

Planning tool

Does the planning tool provide sufficient overview for the platform management in terms of:

- who is where, own personnel and contractor personnel?
- workload in relation to available resources?
- interface/areas of risk?

Are communications between maintenance administration systems and planning tools satisfactory (if these are separated)?

Does the administration system provide sufficient overview of:

- Status of all work orders, also those in the planning phase?
- Which work orders are within the same geographical area, on the same system, etc.?

Planning of urgent jobs

Comments: Investigation of registered, undesired events indicate that urgent jobs - especially those that are not routine - are insufficiently planned. There may be faulty communication and information, for instance by JSA-meetings not being performed or being too superficial.

How are urgent jobs that are non-routine carried out?

Which requirements/means does the company employ to reduce the effect of pressure of time?

Which administrative barriers are intended to prevent undesired events as a result of pressure of time?

Execution

The chapter focuses on preparations, implementation, control and termination/supplementary work of preventive and corrective maintenance. Also included in this is registration of data/equipment history after completed maintenance on systems and equipment.

Execution

Job information

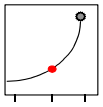
To what degree is the following information easily available for executing personnel:

- Detailed work order information (procedure for work execution)?
- Updated supporting documentation such as procedures, equipment data, drawings and equipment history?
- Information relating to risk-exposed areas and simultaneous operations, injuries to health, material safety data-sheets, special safety rules?

(See also the chapter on procedures for supporting documentation)

Is there any information on corrective work orders about the criticality of the occurred failure modes?

Does the work order specify what the equipment criticality is related to (safety/economy/ production)?



Execution (cont.)

Job Safety Analyses (JSA)

<u>Comments:</u> The NPD regards it as important that the workers who are performing the work <u>themselves</u> participate the Job Safety Analysis. Previously filled in JSA forms (from similar jobs) should only be used as checklists after the analysis is completed, in order to ensure that important danger elements or measures are not missed.

Does the company have clear requirements as regards when/how/by whom JSAs are to be conducted?

- Do the persons who are to conduct the maintenance participate in the Job Safety Analysis?
- Do they know the analysis method?
- Are there sufficient guidelines to carry out the analysis?

Are there examples of the JSA routines not having been complied with?

- What could be the reason for this?

Execution (cont.)

Work permits

Are there clear requirements relating to obtaining work permits?

- Are these complied with?
- Is the process efficient: To what degree does it "guarantee" a safe work place?

Who (position) approves the work permits?

- On what basis do the different job levels approve the work permits?
- Which conditions do the different positions assess in particular?

Are there routines for following up and control of work permits, during and after completion from:

- own supervisor?
- operating personnel?
- the safety staff?

Job preparation

Is responsibility for job preparation and preparation of the work place clearly defined?

- How is equipment prepared for maintenance and repairs?
- Who is responsible for control/verification?

Execution (cont.)

Marking of equipment

Which system is established to identify equipment which is cleared for maintenance and repair (in order to avoid starting work on the wrong equipment unit)?

Are there clear rules for marking and/or isolating equipment which is shut down and/or which is under repair?

- Both for brief periods and over long periods?
- Is the marking clearly visible/distinctive?
- How does the operating personnel keep informed of equipment which is out of operation?

Follow up, shift relief

Which requirements/procedures exist for continuous follow-up of work in progress?

- Is the actual work permit used to keep track of work in progress?
- Other means of tracking (blackboards, lists, screen-based systems)?

Which requirements exist for hand-over/information during shift relief (newly arrived personnel):

- Relating to operational personnel?
- Relating to maintenance personnel (who are doing the work)?

Are the requirements adequate - are they complied with?

Are there indications of problems from occurred near misses/accidents?

Execution (cont.)

Control of completed work

Is the technical work controlled/verified by:

- operational personnel
- line manager/third party?

Is this done on a spot check basis or after each job?

How is inexperienced personnel followed up?

Are checks being made to ensure the work place is cleared after the work is finished?

Are check-lists used to ensure quality of line maintenance and checks (service)?

- Have clear rules been established for the use of/handling/updating/storage of check-lists?

Execution (cont.)

Recording of data after completed maintenance

Have requirements been established to record data in in correlation with defined requirements in connection with review and updating to preventive maintenance programmes, preparation of risk and availability analyses, etc.?

Is the need for, and motivation for registration of maintenance data understood and accepted in the organisation?

- what are the benefits of this - are the results in line with the scope of the registration effort?

Is the registration medium user-friendly?

- can the skilled worker enter data himself, or are specialists required?
- can/must registrations be made in both free text and pre-defined categories for cause of failure, etc.
- Are categories for cause of failure etc. reasonable in terms of number and level of detail?
- Does the registration screen/registration form contain supplementary information in the form of lists of the most common failure modes, causes of failures, etc.?

Are requirement relating to recording of data after completed maintenance complied with and respected by performing personnel?

- How is it checked that registration takes place and that it is not faulty?
- Is this checked regularly?
- Is it possible to close a work order without meeting minimum requirements for registration

Who has the authority to close a work order?

Execution (cont.)

Verification of data

Is it verified that the entered data are correct?

- Whose responsibility is this?
- Whose responsibility is it to initiate measures to improve the recording of data in terms of quality and quantity?

Reporting

The chapter focuses on work processes for gathering and qualifying safety-related maintenance data, preparation and distribution of reports, statistics, etc. for maintenance units and management.

Comments: **In the NPD's opinion the companies' maintenance reports have insufficient focus on matters important to safety. Resource-related /financial measuring parameters dominate these reports. There is an apparent lack of clear guidelines for which measuring parameters have the highest priority and who are the target groups/customers of the reports. The reporting options in the different data bases are often not fully exploited. The companies' ambition level in terms of reporting within the area of safety-related maintenance appears to be generally low - and the improvement potential correspondingly high.**

What should be reported?

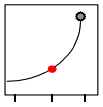
Does the company have clearly expressed requirements as regards which safety-related maintenance parameters/conditions that should be reported?

- Which are these - and what is the reason for requiring that these parameters be reported? - What will the reports be used for?

Are the safety-related company requirements (cf. the chapter on "Objectives and requirements") attended to through requirements relating to reporting, both in terms of scope and level of detail?

Are all available sources for safety-related maintenance data used when preparing reports, such as for instance:

- Event log, maintenance administration system, non-conformance register, etc.?
- Which relevant registers are not used, if relevant? - Why not?



Reporting (cont.)

Trends

Does the company's reports contain overviews/statistics/trends etc. for:

- Events (accidents/near misses, etc.) related to /relevant to maintenance?
- CM on safety-critical components and equipment for a period?
- Outstanding CM on safety-critical failures?
- CM on safety systems?
- Backlog on preventive maintenance on safety-critical equipment (equipment with safety-critical failure modes)?
- Backlog in test-programmes for safety system?
- Number of actuations of safety systems?
- Number of actuations of safety systems that are temporarily out of function due to maintenance?
- Non-conformance reports related to the maintenance function?

Reporting (cont.)

Qualification of data

Comments: **On some installations it appears numerous data are registered that are "never used". This could affect the maintenance personnel's motivation for recording data in the prescribed way - which will in turn affect the quality of these data registers.**

Do the empirical data that are recorded in the data registers meet the company's internal requirements related to format, quality, etc.

- This means: What do we expect to find - and what is, in fact, found?

Whose responsibility is it to qualify registered data?

Whose responsibility is it to ensure continuous improvement of the quality of registered data?

Content and format of reports

Is it clear to whom the different maintenance reports are issued (target group)?

- Which persons/units?
- Are the reports adapted to the target group's requirements in terms of content, degree of detail, readability, scope, etc.?

Reporting (cont.)

Distribution of reports

Does land-based and offshore personnel receive the reports they require, when they need them, and in an appropriate format?

- Give examples of when this is not the case? - What could be improved?

Does maintenance personnel know which reports are available?

Has it been assessed which reports the different players/management require?

Resources and improvement processes

Whose responsibility is it to initiate measures for (continuous) improvement of the content /quality/ utility value of the reports?

Are sufficient resources allocated to prepare reports with the desired scope and quality?

Analyses

This chapter addresses implementation of analyses of maintenance-related events and empirical data. For example analyses of: undesired events that have arisen during the maintenance work, analyses based on statistics and trends on failures in safety-critical equipment and safety systems, analyses of causal relations in the event of an increase in outstanding, corrective maintenance, etc.

Comments: Insufficient maintenance is often cited as the reason for undesired events. In the NPD's opinion, analyses are to an insufficient extent carried out on what has failed, why it failed, which parts of the system failed, etc. The analyses appear to be characterised by chance; by the lack of continuity, direction and systematic approach.

The consequences of insufficient analyses could be that initiated measures do not function, events repeat themselves, etc.

Requirements related to analyses

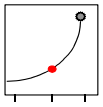
Which requirements have been established to initiate analyses when the control parameters indicate non-conformance with company objectives and requirements related to maintenance?

Which specific criteria/signals should "trigger" an analysis?

- Are requirements imposed on causal analyses when preventive maintenance programmes do not prevent safety-critical failure modes from occurring?

Which analyses are prepared on a routine basis? Examples:

- Analyses of trends of failures on safety-critical equipment and safety systems?
- Analyses of an increase in the amount of corrective maintenance?
- Other examples?



Analyses (cont.)

Causal analyses

Comments: **Analyses have a certain tradition in some disciplines. In most operating companies systematic analyses are carried out in connection with maintenance of heavy, rotating equipment.**

Does the company have a defined toolbox in the form of methods, analysis tools etc. to help make these analyses?

Does the company have methods for conducting root cause analyses?

Within which disciplines are such analyses performed?

Events/accidents

Are causal analyses conducted of all events that occur during maintenance work?

- Examples?

Are the causes of technical, organisational and human nature analysed?

Does maintenance personnel participate in these analyses?

Are event logs readily available - how are maintenance-related events defined?

Responsibility and resources

Does the maintenance function have available resources in the form of skills, time, methods, analysis tools, etc. to conduct analyses of the desired quality?

- Is the line manager's responsibility for conducting analyses clearly defined?

Improvement measures

This chapter focuses on work processes for initiating, implementing and following up of improvement measures, on the basis of completed analyses, experience transfer/best practice, etc.

Improvement measures

Areas for continuous improvement

<u>Comments:</u> It is the NPD's opinion that the potential for improvements within the area of safety-related maintenance is not sufficiently well exploited. The main problem appears to be the lack of an overall method /system in the application of these empirical data, implementation and use of analyses, implementation and follow-up of measures, standardisation of good solutions, etc.

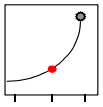
Does the company have a list of areas it wishes to prioritise through defined improvement processes?

- Which? (technical, human, organisational)

Which measurable, safety-related maintenance parameters should be improved?

- Examples?

Are implemented improvement measures followed up through measurement/ control, etc.?



Improvement measures (cont.)

Experience transfer systems

Which processes/procedures have been established for systematic transfer and follow-up of experience relevant to maintenance (see examples below)?

- From operation to new project
- From project to operation
- From other installations/fields?
- From other operating companies?
- From contractors?
- From other industry?
- From other shifts on the same installation?
- From other disciplines in the maintenance function?

Is the system of experience transfer used in practice? - Give examples.

Are there examples of valuable empirical information not in use? - What has prevented this?

Improvement measures (cont.)

Methods and systematic

What kind of methods /processes has the company developed for implementation of systematic improvement in the maintenance function?

- Are the methods described in the guidelines/procedures?

Is the information from analyses, supervision, experience transfer, etc. to systematic follow-up and improvement in accordance with this method?

- Are analyses of basic causes of incidents (root cause analysis) used as basis for improvements of registered maintenance problems on different kinds of equipment?

Responsibility and resources

Who is responsible for initiating, implementing and following up improvement initiatives within the different areas?

Have resources been allocated in the form of time, competence etc. to ensure the continuity of the improvement work - or is it based on "campaigns if time allows"?

Supervisory activities

Super-vision

This chapter focuses on work processes for planning and implementation of supervision of own organisation and of contractors, drilling contractors/owners of floating units and suppliers. Control assignments that are part of the maintenance management's responsibility for day-to-day operation are not addressed here. Examples of supervision can be: audits, verifications, inspections, self assessments like "baseline-study of the maintenance management system", ISRS, etc.

Internal and external supervisory inspection

Comments: In the NPD's opinion the operator's supervision of the maintenance function is given lower priority than the safety-related significance/criticality would indicate. Scope and frequency of audits, etc. fluctuate greatly, both in terms of audits aimed at own organisation and for audits on contractors and suppliers. The operator's inspection and verification activities would benefit from becoming more systematic and in-depth. This applies in particular to drilling and well service and to chartered, floating installations. In the NPD's opinion there are also insufficient methods and improvement processes in terms of supervision.

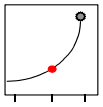
Objectives and requirements relating to supervision

Which objectives/requirements have been established for the company's supervision of the maintenance function offshore and onshore (in own company and of any contractors) as regards, for instance:

- How often should all of, or parts of the maintenance management system be audited?
- How often should technical verifications be conducted?
- Scope and depth of the audits/verifications?

Are the objectives/requirements made known to the maintenance personnel?

Do the supervisory activities meet the company's objectives/requirements in this area?



Supervisory activities (cont.)

Objectives and requirements relating to supervision (cont.)

Is there a reasonable balance between technically oriented and system oriented supervision? (which objectives/requirements apply?)

Criteria for selecting objects for supervision etc.

Has the company decided which problem areas should be given priority in the supervisory activity?

Do criteria exist for selection of objects for supervision?

- Are several criticality assessments used?

Is the supervision of the maintenance and drilling contractors sufficient considering the criticality of the activities for which these are responsible?

Supervisory activities plan

Have approved annual and long-term plans been established for internal an external supervisory activities aiming at the maintenance function.

- For whom are the plans committing?

How are deviations from the supervisory activity plans handled?

Supervisory activities (cont.)

Supervision

Resources and responsibility

Is the line management's responsibility in connection with initiation and implementation of the internal supervision and of the maintenance and drilling contractor clearly defined?

Have sufficient resources been allocated to conduct the supervisory activities in a satisfactory manner?

Comments: The NPD has, via its own supervision of the companies, registered a number of cases where supervisory teams have an inappropriate composition of people and insufficient competence.

Are requirements imposed in terms of competence for conducting supervision?

Is specific competence (own or contracted) utilised for audits and verifications in areas (maintenance systems, methods, equipment, etc.) of safety-related significance?

Follow-up

Comments: The NPD has at times found that line management sometimes neglect internal audit reports, i.a. with the consequence that the period from findings to correction is needlessly long. This applies especially to cases where the findings have no direct financial consequences.

Is there a systematic follow-up of findings from the supervisory activities?

Have sufficient resources been allocated for this?

Improvement process

Are the applied supervisory methods evaluated on a continuous basis?

Has the company started projects aimed at developing supervision methods?

Organisation

This chapter focuses on requirements and practice in connection with the design of work processes, manning, competence, training, prequalification and use of contractors, etc.

Organisation

Have responsibility, authority, reporting lines, communication lines, etc. been clearly defined and understood in all disciplines related to the maintenance function?

Are organisation charts, job descriptions, manuals, etc. in accordance with existing organisation?

Design of the organisation

Comments: The NPD has noted that several maintenance work processes are not described in documents or in any other way. Existing descriptions are inadequate (do not form complete quality loops).

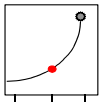
Has the company described/designed work processes for all central functions and supplementary functions in the maintenance system?

- Is this done in a systematic and documented manner?
- Are the processes described/designed as complete quality loops?

Are requirements relating to manning and skills for performing the work processes identified and described?

Are the processes continuously updated?

- is authority and responsibility for this clearly defined?
- have resources been allocated for this in the form of personnel and competence?



Organisation (cont.)

Manning basis

<u>Comments:</u> In some cases manning analyses appear to have been performed without sufficient basis in established maintenance programmes and defined maintenance work processes. In some cases the analyses appear to have been conducted after the manning level was decided (as a legitimisation of decisions already made). The NPD has also noted weaknesses in the actual analyses, such as insufficient highlighting of the risk potential in a tight manning situation. Follow-up of the analyses after changes in manning also seems inadequate. For instance, assumptions in the analyses are unknown in the organisation, they are not verified and the analyses are not updated when the assumptions change.

Is the safety-related criticality of the different work processes onshore and offshore assessed when the manning level is determined?

Are there any requirements in the company for manning analyses to be conducted in case of physical or operational changes?

Are analyses conducted in good time before the changes occur (allowing for discussions)?

Is sufficient account taken of the existing manning and competence in the land-based organisation with moving tasks from offshore to onshore?

- Are the safety-related issues arising from moving from offshore sufficiently highlighted?

Are assumptions and results from the manning analyses systematically checked in relation to practice?

Is there a defined work process for attending to this?

Have competent persons been appointed to attend to the process?

Are defined work processes regularly assessed and improved, if relevant? - By whom?

Organisation (cont.)

Organisation

Required competence

Has the operator defined all competence requirements in connection with existing and new technical challenges such as ageing installations, streamlining initiatives and the use of reliability-based maintenance methods?

- Are competence requirements specified for the functions/positions in question?
- Are these requirements updated systematically during reorganisations, changes in activities, etc.

Have objectives and requirements for future competence been prepared in connection with the long term plans for the maintenance function?

Have plans been agreed for competence development /training programme which are adapted to these objectives and requirements?

Are adequate financial and competence-related resources made available for these programmes?

Organisation (cont.)

Organisation

Relevant competence challenges

Comments: The NPD has noted that traditional maintenance organisations in some cases, for instance when conducting criticality analyses etc., rarely use competent personnel from other parts of the company.

Does the maintenance personnel have sufficient competence to assess all safety-related issues in connection with maintenance?

- Does this competence exist in other parts of the company?
- Is it being used?
- Is the problem of competence solved satisfactorily in other ways (contractors)?

Organisation (cont.)

Organisation

Multi-skilled groups

Comments: **A transition to autonomous, multi-skilled maintenance groups is gaining ground in most companies. It is the opinion of the NPD that the total effect of the changes has so far not been adequately measured, i.e. the financial savings have been documented, but not any safety-gains or any increased exposure to risk.**

Are achieved results measured against safety-related assumptions and objectives when changing to multi-skilled groups?

How is the effect of the organisational changes measured?

Has any wear and tear been noted on the knowledge-base/expert-environment in this connection?

- Has the wear had any effect on the quality of performed work?
- Has the management quality been affected by the changes?

Organisation (cont.)

Organisation

Personnel for projects and maintenance

<u>Comments:</u> For some companies it has in practice proved expensive, and also problematic from a safety point of view, to have insufficient maintenance personnel at one's disposal in periods with extraordinary tasks.

For instance, it is easy to end up with solutions that are inefficient in terms of costs and safety during modifications/ projects due to lack of participation by senior maintenance personnel.

Does the company have available maintenance personnel, for instance:

- When moving senior personnel to new fields/installations?
- When using offshore personnel for new projects?
- When using maintenance personnel for major modifications?
- On transition from contractor employees to own employees?

Organisation (cont.)

Use of contractors

Is it clear which parts of own documented requirements relating to maintenance (requirements relating to control system, competence, performance of analyses, etc.) which is to be imposed on contractors?

Does the incentive/compensation arrangements affect the willingness/motive for doing a high quality job?

Do agreements ensure that the integrity of the equipment is attended to throughout its entire lifetime?

- What is the experience in this area?

Has a process been defined for continuous reassessment to ensure the requirements relating to contractors are met?

- Have responsible units/persons been appointed for this task?
- Is the operator's maintenance personnel sufficiently involved in this?

Prequalification of contractors

Have requirements been established as to how the prequalification is to be carried out?

Are the above maintenance management requirements in practice based on safety consideration during pre-qualifications?

Is the maintenance personnel involved in the prequalification?

Is the prequalification process reassessed and improved on a continuous basis?

Materials

This chapter focuses on work processes for purchasing, goods inwards, storage, preservation/ maintenance, shipment, control, etc. of spare parts and material, as well as availability, maintenance of tools, etc.

SPARE PARTS AND MATERIALS

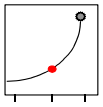
Availability

Does the safety-related criticality of equipment form the basis for formulating requirements relating to spare parts and available materials?

Is the availability satisfactory (in accordance with requirements) for materials that will be stored

- offshore?
- onshore?
- with the supplier?

How is non-conformance with required availability and actual availability handled?



Maintenance

Do preservation/maintenance programmes exist for spare parts and materials?

- Is equipment which is temporarily out of service a part of this programme?

Does a programme exist for testing/verification procedures in order to confirm that spares and materials have the specified quality, i.e. that the part/material is suited for the purpose?

Material management

Comments: The NPD has observed problems regarding a link between material management systems, equipment registers and maintenance administration systems.

Is the materials management system user-friendly?

- How is the response time?
- Is it simple to track orders?

Is it possible to order parts directly in the maintenance administration system?

Is there a satisfactory communication/link between the material management system and the equipment register?

- Is the spare parts store adjusted in case of replacement or modification of equipment, etc.?

Materials (cont.)

TOOLS

Tools comprise both hand tools and heavy, temporary equipment, including leased tools, tools rotated from other platforms and the contractor's tools.

Availability

Which requirements have been imposed in traceability of different types of tools?

Is there a satisfactory system in place for meeting these requirements?

- Does it function in practice?

Calibration and testing

Which requirements are imposed on maintenance/calibration/trials/testing of different types of tools?

Has a programme been developed to meet these requirements?

Are there requirements relating to registration of maintenance history on heavier types of tools which is rotated from other platforms (cf. drilling area)?

- How is this history made readily available?

Materials (cont.)

Leased tools and third party tools

Are the same requirements imposed for leased tools as for own tools?

- How is this tracked through control routines, etc.?
- Whose responsibility is it to follow this up?

When are leased tools regarded as permanent?

Supporting documentation

This chapter focuses on work processes intending to handle quality, availability, updating, etc., of different kinds of technical and administrative supporting documentation, in the form of an equipment register with maintenance history, drawings (P&IDs, mech. flowchart, loop drawings, etc.), and maintenance procedures. General issues related to computer-based information processing systems have also been addressed.

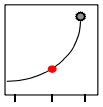
DRAWINGS, etc.

Comments: The lack of, quality of, or erroneous use of technical supporting documentation is often said to be contributory causes of major accidents in most industries. The NPD has noted that the technical documents in the companies quite frequently are not completely updated, and hence not completely valid. This seems to be the case especially at start-up of a new plant/system, and at start-up after major technical modifications. NPD has also noted deficiencies in the technical documentation in connection with transfer from manual to computer-based equipment files.

Requirements related to documentation

Do requirements exist for technical documentation in terms of upgrading /validity, as a condition for start-up/operation?

- Which requirements relating to validity/traceability of documentation apply before safety-related critical systems and equipment can be brought into use?
- What is the acceptable limit for time backlog in terms of updating documentation?
- Which deadlines for updating of documentation does the operations organisation apply to the modification projects?
- Have different disciplines varying updating requirements?



Suporting documentation (cont.)

Status mapping

Is the technical supporting documentation systematically mapped regarding status and possible need for updating?

- Who is responsible for monitoring status?
- How often is mapping /monitoring performed?
- What is the relevant status for different kinds of documentation?
- Does the relevant supplementary documentation vary between the different disciplines?

Have maintenance problems been noted in connection with incorrect/not updated documentation?

- Which consequences have been observed/registered?

Control, verification and evaluation

Which routines have been established for continuous control, verification and evaluation of the quality of updated documentation?

Do these processes function satisfactorily?

- Who is responsible for implementation?

Suporting documentation (cont.)

Availability/validity

Have the non-updated parts of the documentation been earmarked?

Are updated versions of documents easily available to the users?

- Is clear information given about where one may gain access to these (on the computer screen, offshore, onshore, etc.)?

Which processes apply for removal of documentation which is no longer valid?

User-friendliness

Is the supporting documentation "readable" for the users?

- do the users have sufficient competence to read the documentation?
- is there variation between disciplines?
- does this involve any risk potential?
- could this become a problem if experienced personnel were to leave?
- is sufficient training offered?

Suporting documentation (cont.)

Updating process for drawings, etc.

Which procedures have been established for updating/improvement of drawings, etc.?

- Have areas of responsibility been established?

Have resources (personnel/competence, etc.) been allocated for this process?

- Is the work handled in accordance with objectives/ requirements?

PROCEDURES

Comments: The lack of, quality of, or erroneous use of technical and administrative procedures is often said to be contributory causes of major accidents in most industries. But in spite of the significance of safety procedures, very few companies have a clear philosophy for how to use procedures. The procedure development discipline generally appears to be inadequately attended to in the petroleum activity. See for instance the Sintef-report "Procedure development. Method for analysis and description of work tasks". (Gunnhild Åm et al STF38 A97411). ref. 3. We also refer to associated "procedure project" in Phillips.

Procedure development

Has the company established requirements as regards design of procedures?

- are requirements imposed in terms of layout, readability, specification of additional tasks, etc.?

Are the procedures comprehensible to all maintenance personnel (cf. transfer to multi-trades/multi-skills)?

Suporting documentation (cont.)

Use of procedures

Does the company have a clear strategy for how to use procedures in a safety-related context?

- when/under which conditions can they be deviated from?
- who approves non-conformances?
- are requirements imposed on non-conformance treatment?

Resources/competence

Does the company have sufficient competence to design procedures with a satisfactory (safety-related) quality?

Are sufficient resources allocated for this?

Updating process for procedures

Have processes been established for continuous updating and improvement of maintenance procedures?

- Who is the owner of these processes?
- Have resources been allocated (personnel/skills, etc.) to handle this work?

Suporting documentation (cont.)

COMPUTER BASED SYSTEMS

Comments: **It is the NPD's impression that the companies' maintenance units have not been sufficiently diligent in defining their own requirements and communicating them to the rest of the company when introducing major, multi-functional, data-based administration systems.**

To what extent is maintenance personnel informed and involved during development and introduction of computer-based information processing systems?

- Are systematic analyses/assessments conducted on safety-related aspects (advantages/ disadvantages) prior to decisions being made on the introduction of new systems?
- Are requirement specifications developed based on the maintenance unit's requirements when introducing major, integrated data systems, such as SAP?

Definitions

Definition of concepts
(draft, not complete - The NPD must agree with the industry which standards to use).

Failure/failure modus/failure condition

British Standard BS 5760, part 5: "the effect by which a failure is observed on a failed item"

Function:

Vinje, safety analysis: For a system or a machine: The operations of processes which the machine or system is designed to carry out

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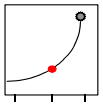
Criticality:

Product of probability and consequence of an event = risk. (NPD's own-produced - for the time being).



Definitions (cont.)

Procedures:

NS-ISO-8402:1994: "indicated method for performing an activity".

Comments: When a procedure is documented, the term "written procedure" is often used. A documented procedure normally indicates the purpose of and the scope of the activity, what should be done and by whom, when, where and how to do it; which materials, equipment and documentation is to be used, and who should manage and register it.

Process:

NS-ISO-8402:1994: "gathering of interactive resources and activities that convert supplies to results".

Comment: Resources can include personnel, finances, plant, equipment, techniques and methods.

Safety-critical failures

Failure modes that can initiate undesired, emerging events (and develop into accidents)

Safety system

Its function is to prevent initiating events from developing into accidents

Definitions (cont.)

System

NS 5801: Formalised collection of mutually co-ordinated procedures.

Maintenance:

Technical and administrative activities that are conducted in order to maintain or regain (possibly improve) a system's functional properties (for instance output). (Sintef.)

For instance: Daily care, testing, inspection, adjustment/straightening, removal/demolition, replacement, reinstallation, trouble shooting, calibration, determination of failure/condition, repair, overhaul and reclamation (Norsk Termbank - Statoil).

Combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain in it, or restore it to, a state in which it can perform the required function. (Draft: Maintenance Terminology - European Standard (CEN)).

Maintenance backlog

Is used for preventive maintenance activities that have not been carried out in accordance with the time limit.

Outstanding maintenance

Corrective maintenance for occurred failure/failure modi/ failure conditions (Counted from the day the failure mode occurred).

Definitions (cont.)

Abbreviations

PM = Preventive Maintenance

CM = Corrective Maintenance

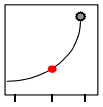
RBI = Risk Based Inspection

RCM = Reliability Centred Maintenance (in the text RCM is often used as a common denomination for RCM and RBI).

References

1. NPD Report: "Maintenance Management - experience and challenges" (NDP - 96 - 81)
2. NPD-letter: "Comments on Norsk Standard (Draft) "Criticality Classification Method" (95/1825-37) of 21.01.97)
3. Sintef report: G. Åm et al: "Procedure development. Method for analyse and description of work assignments" (STF38 A97411)

(INCOMPLETE REFERENCE LIST. TO BE CORRECTED IN THE NEXT ISSUE)



Guidelines for implementation

The chapter presents proposals for planning, organising and implementation of the basic study. It also gives a brief description of the different players' roles and responsibility, and advice on how to teach those participating in the process.

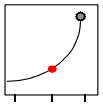
Establish objectives and mandate for the mapping process

It is decisive for the utility value of the study that the company's senior management at an early stage have thorough knowledge of the project and is able to give the baseline-study-group the necessary support and commitment. The management itself should define the goals for the work and participate in the design of the mandate of the baseline-study-group. By involving the company's senior management at an early stage in the project planning, the method and strategy of the project will be better understood.

Project planning and implementation period

Experience gained of the pilot projects has indicated that a realistic implementation period for the mapping process is from four to six weeks, depending on the size and complexity of the organisation, the scope of the study and the organisation of the mapping work. A typical schedule could be as follows:

- Week 1 - preparations and training programme
- Weeks 2-5 - working meetings, document studies, interviews and observations
- Weeks 5-6 - prepare report and prioritise measures



Quality plan

It has proven useful to prepare a quality plan before the mapping process starts. The purpose of such a quality plan is first and foremost to provide a brief and precise description of activities, organisation and the roles and areas of responsibility of those involved. The quality plan can, as an example, have the following main structure:

- Facts about the study
- A brief description of the background, purpose and scope
- Information and training activities
- How the maintenance management model is structured, with resources and phases in the maintenance process
- Activity descriptions, time-estimate and progress plan
- The participants in the mapping process and their roles
- How to organise the work meetings
- Construction and format of the final report
- Verification and approval process

The baseline-study group

A successful baseline-study depends on the composition of the baseline-study group. We therefore recommend that the group in addition to the team leader and facilitator be composed of the following categories:

- A representative from the management (preferably operations manager or similar) who can function as process owner
- A first line manager from the installation
- A planner or work foreman (senior skilled person) from the installation
- One (or more) maintenance engineer(s) or leader(s) from the maintenance environment onshore

In addition, the team should involve relevant expertise in some of the work meetings as required, for instance to obtain support for strategic planning, personnel and organisation, material management, health, environment and safety, quality and control systems, information systems, etc. These persons should as far as possible be identified before the work starts, to enable them to participate efficiently in the planned introductory and training activities.

The regular members of the baseline-study-team must realise that the work with the baseline-study will occupy almost 50% of their working hours for 3-5 weeks. The team leader will need to work almost full time in the same period. Therefore their supervisors will need to understand that the group members will have to be released from their normal duties and responsibilities in this period.

The team leader

It is the responsibility of the team leader to ensure the baseline-study is performed efficiently and in accordance with the plan. The duty of the team leader is to keep the baseline-study-group focused on the task and lead the discussions in the work meetings. He must have the trust of the baseline-study group and the ability to co-operate with the parts of the organisation that are involved in the baseline-study. The management is responsible for appointing the team leader. Since the decisions and initiatives will be made by the team leader, this person ought to have the ability to:

- establish constructive communication lines between the management and all others who could become involved in the mapping process
- develop and manage the progress of the mapping process as regards milestones and deadlines
- ensure that the mapping process is allocated the necessary resources (offices, equipment, support, personnel, etc.)
- organise responsibility and tasks in and between the work meetings in co-operation with the facilitator

The facilitator

The basic idea of the baseline-study is that the maintenance personnel accept responsibility for improving and further developing their own maintenance function. Experience has shown that improvement measures are far more successful when they spring from those who are personally responsible or directly involved, as opposed to improvement measures that are initiated as a result of, for instance, inspections by outsiders.

It has nonetheless proved useful, especially during the initial trials with self assessment models, such as the baseline-study, to have a qualified outside facilitator who can give advise and provide guidelines and support the baseline-study group through the mapping process. The facilitator can help the baseline-study group through difficult topics, ensure that important information is identified and registered, and support the team leader with planning, organising and resource management.

When the baseline-study-group has achieved a certain routine and experience through repeated baseline-studies, the role of the facilitator will become less important. It may, however, still be useful to have an outside facilitator who can look at complex issues across groups and areas of responsibility.

The workshop meetings

Between the workshop meetings the team leader, in co-operation with the facilitator, ought to make arrangements to ensure all necessary material and documents are available for the team which is to be assessed in the next meeting. The workshop meetings ought to be planned to last for about one half working day.

The questions relating to the different elements of the maintenance managing model shown in the guidelines are meant to form the basis for creativity and discussion. It is important that the questions are not just signed out by "yes" or "no" as on a check list. The baseline-study-group ought to use the guidelines as basis for a constructive improvement discussion which ought to focus on all possibilities for further development and improvement within the various areas. In this phase of the mapping process, which is a pure brainstorming phase, this ought to be made independent of costs and other limiting factors.

To the extent that the discussion in the work meeting reveals circumstances of which the baseline-study-group lacks knowledge, the period after the work meeting ought to be used for interviews, observations or further documentation studies in order to supplement the assessments of the group.

Not until all elements have been discussed, and all possible improvement measures have been presented in the form of a draft baseline-study report complete with objectives and proposed initiatives, should the team leader with management involvement prepare a prioritised and binding list of initiatives.

Training and information

Most companies involved in the petroleum activities have already in one form or another focused on quality and improvement work and team-based work methods. Most have also undertaken training and introduction to improvement measures in all or parts of the organisation. We recommend that the company base the organisation of the baseline-study mainly on the foundation that already exists, and concentrate training on circumstances that are special to the baseline-study.

We recommend that the company develop three training/introduction packages:

- 1-2 hours introduction seminar for the company's top management
- 1-2 hours training team-building seminar for team leader, facilitator and the rest of the work group
- 1 hour introduction for personnel with specialist professional skills who participate in parts of the work meetings (and possibly as information to the other parts of the organisation).

To the extent it is possible everyone who needs training should be identified before the baseline-study process starts. The training activities should be scheduled and documented in the project quality plan.