NORSOK STANDARD

REGULARITY MANAGEMENT & RELIABILITY TECHNOLOGY

Z-016
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FOREWORD

NORSOK (The competitive standing of the Norwegian offshore sector) is the industry's initiative to add value, reduce cost and lead time and eliminate unnecessary activities in offshore field developments and operations.

The NORSOK standards are developed by the Norwegian petroleum industry as a part of the NORSOK initiative and supported by OLF (The Norwegian Oil Industry Association) and TBL (Federation of Norwegian Engineering Industries). NORSOK standards are administered and issued by NTS (Norwegian Technology Standards Institution).

The purpose of NORSOK standards is to contribute to meet the NORSOK goals, e.g. by replacing individual oil company specifications and other industry guidelines and documents for use in existing and future petroleum industry developments.

The NORSOK standards make extensive references to international standards. Where relevant, the contents of a NORSOK standard will be used to provide input to the international standardisation process. Subject to implementation into international standards, this NORSOK standard will be withdrawn.

Annex A is normative. Annex B,C,D,E and F are informative.

INTRODUCTION

The purpose of this standard is to establish requirements and guidelines for systematic and effective planning, execution and use of reliability technology to achieve cost-effective solutions. It is also an objective of the standard to arrive at a common understanding with respect to use of reliability technology in the various life cycle phases.

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1 SCOPE

This NORSOK standard covers analysis of reliability and maintenance of the components, systems and operations associated with exploration drilling, exploitation, processing and transport of petroleum resources. The standard focuses on regularity of oil and gas production and associated activities, but also covers system and equipment reliability and maintenance performance in general.

The standard presents requirements to planning, execution and use of reliability technology, structured around the following main elements:

- Regularity management for optimum economy of the facility through all of its life cycle phases, while also considering health, safety, environment, quality and human factors.
- Planning, execution and implementation of reliability technology.
- The application of reliability and maintenance data.
- Reliability based design and operation improvement.
- Establishment and use of reliability clauses in contracts.

2 NORMATIVE REFERENCES

The following standards include provisions which, through references in this text, constitute provisions of this NORSOK standard. The latest issue of the references shall be used unless otherwise agreed. Other recognised standards may be used provided it can be shown that they meet or exceed the requirements of the standards referred to below.

NORSOK O-001	LCC for systems and equipment
NORSOK O-002	LCC for production facility
NORSOK Z-008	Criticality classification method
ISO 14224	Collection and exchange of reliability and maintenance data for equipment (FDIS)
IEC 60300-3-4	Dependability management - Part 3: application guide - Section 4: Guide to the specification of dependability requirements

3 DEFINITIONS AND ABBREVIATIONS

3.1 Definitions

Active repair time	The part of the downtime during which a repair action is performed on an item, either automatically or manually, excluding logistic delays (e.g. manpower and spares), preparation for repair and preparation for production.
Availability	The ability of an item to be in a state to perform a required function under given conditions at a given instant of time or during a given time interval, assuming that the required external resources are provided. This ability is expressed as the proportion of time(s) the item is in the functioning state. <u>Note 1</u>: This ability depends on the combined aspects of the

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	reliability, the maintainability and the maintenance supportability. Note 2: Required external resources, other than maintenance resources do not affect the availability of the item.
Can	Verbal form used for statements of possibility and capability, whether material, physical or casual.
Common cause failure	Failures of different items resulting from the same direct cause where these failures are not consequences of another.
Corrective maintenance	Maintenance which is carried out after a fault recognition and intended to put an item into a state in which it can perform a required function.
Deliverability	The ratio of deliveries to planned deliveries over a specified period of time, when the effect of compensating elements such as substitution from other producers and downstream buffer storage is included.
Design life	Planned usage time for the total system. Note: Design life should not be confused with MTTF. The system comprises several items. Items may be allowed to fail within the design life of the system as long as repair or replacement is feasible.
Downtime	The time interval during which an item is in the down state which is characterised either by a fault, or by a possible inability to perform a required function, e.g. during preventive maintenance.
Failure	Termination of the ability of an item to perform a required function. Note 1: After failure the item has a fault. Note 2: “Failure” is an event, as distinguished from “fault”, which is a state.
Failure mechanism	The physical, chemical or other processes which lead or have led to a failure.
Failure mode	The effect by which a failure is observed on the failed item.
Failure rate	Number of failures relative to the corresponding operational time. Note 1: In some cases time can be replaced by units of use. In most cases 1/MTTF can be used as the predictor for the failure rate, i.e. the average number of failures per unit of time in the long run if the units are replaced by an identical unit at failure. Note 2: Failure rate can be based on operational time or calendar time.
Fault	State of an item characterised by inability to perform a required function, excluding the inability during preventive maintenance or

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	other planned actions, or due to lack of external resources. Note: A fault is often a result of a failure of the item itself, but may exist without a failure.
Idle time	The part of the uptime which an item is not operating.
Maintainability	The ability of an item under given conditions of use, to be retained in, or restored to, a state in which it can perform a required function, when maintenance is performed under given conditions and using stated procedures and resources. Note: The term maintainability is also used as a measure of maintainability performance.
Maintenance supportability	The ability to provide the resources, services and management necessary to carry out maintenance Note: Mobilisation times of resources are used to quantify this ability in a regularity analysis.
May	Verbal form used to indicate a course of action permissible within the limits of the standard.
Mean time between failures	MTBF=MTTF+MDT. If the downtime equals the repair time; MTBF=MTTF+MTTR.
Mean time to failure	The mean time to failure is a predictor of the time to failure. Note: The MTTF of an item could be longer or shorter than the design life of the system.
Mean time to repair	The mean time to repair is a predictor of the active repair time.
Observation period	The time period during which regularity and reliability data is recorded.
Operating time	The time interval during which the item is performing its required function.
Predictive maintenance	Condition based maintenance carried out following a forecast derived from the analysis and evaluation of significant parameters of the degradation of the item.
Preventive maintenance	Maintenance carried out at predetermined intervals or according to prescribed criteria and intended to reduce the probability of failure or the degradation of the functioning of an item.
Production availability	The ratio of production to planned production, or any other reference level, over a specified period of time. Note 1: This measure is used in connection with analysis of delimited systems without compensating elements such as substitution from other producers and downstream buffer storage.

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	Battery limits need to be defined in each case. Note 2: The term injection availability may be used meaning the ratio of injection volume to planned injection volume.
Regularity	A term used to describe how a system is capable of meeting demand for deliveries or performance. Production availability, deliverability or other appropriate measures can be used to express regularity. Note: The use of regularity terms must specify whether it represents a predicted or historic regularity performance.
Regularity analysis	Systematic evaluations and calculations carried out to assess the regularity of a system. Note: The term should be used primarily for analysis of total systems, but may also be used for analysis of production unavailability of a part of the total system.
Regularity expenditures	The total cost of lost or deferred production due to downtime.
Regularity management	Activities implemented to achieve and maintain a regularity which is at its optimum in terms of the overall economy and at the same time consistent with applicable framework conditions.
Regularity objectives	An indicative level for the reliability/regularity one wishes to achieve. Objectives are expressed in qualitative or quantitative terms. Objectives are not absolute requirements and may be deviated based on cost or technical constraints.
Regularity programme	A description of the organisation, responsibilities and planned activities in one or several project phases with the aim of contributing to cost-effective regularity management of the project.
Regularity requirements	A required minimum level for the reliability/regularity of a system or in a field development project. Requirements are normally quantitative but may be qualitative.
Reliability	The ability of an item to perform a required function under given conditions for a given time interval.
Reliability data	Reliability data is meant to include data for reliability, maintainability and maintenance supportability.
Shall	Verbal form used to indicate requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted, unless accepted by all involved parties.
Should	Verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required.

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Uncertainty	Lack of knowledge about an unknown quantity. The uncertainty is expressed by probabilities.
Uptime	The time interval during which an item is in the up state which is characterised by the fact that it can perform a required function, assuming that the external resources, if required, are provided.
Variability	Variations in performance measures for different time periods under defined framework conditions. Note: The variations could be a result of the downtime pattern for equipment and systems, operating factors such as wind, waves and access to certain repair resources.

Figure 3.1 illustrates the relationship between some important reliability and regularity terms. Figure 3.2 illustrates the various contributors to downtime.

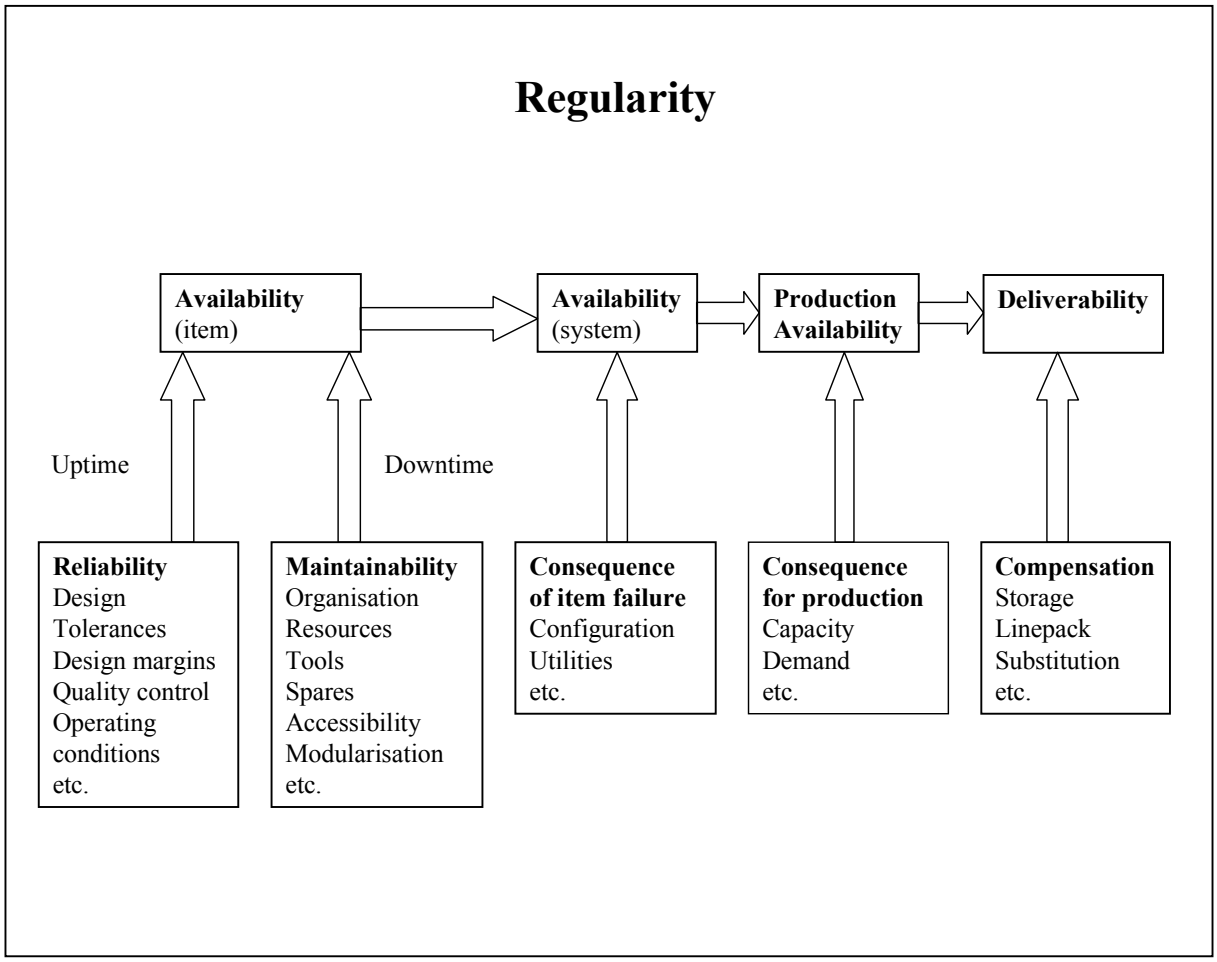

Figure 3.1 - Illustration of relationship between some regularity terms.

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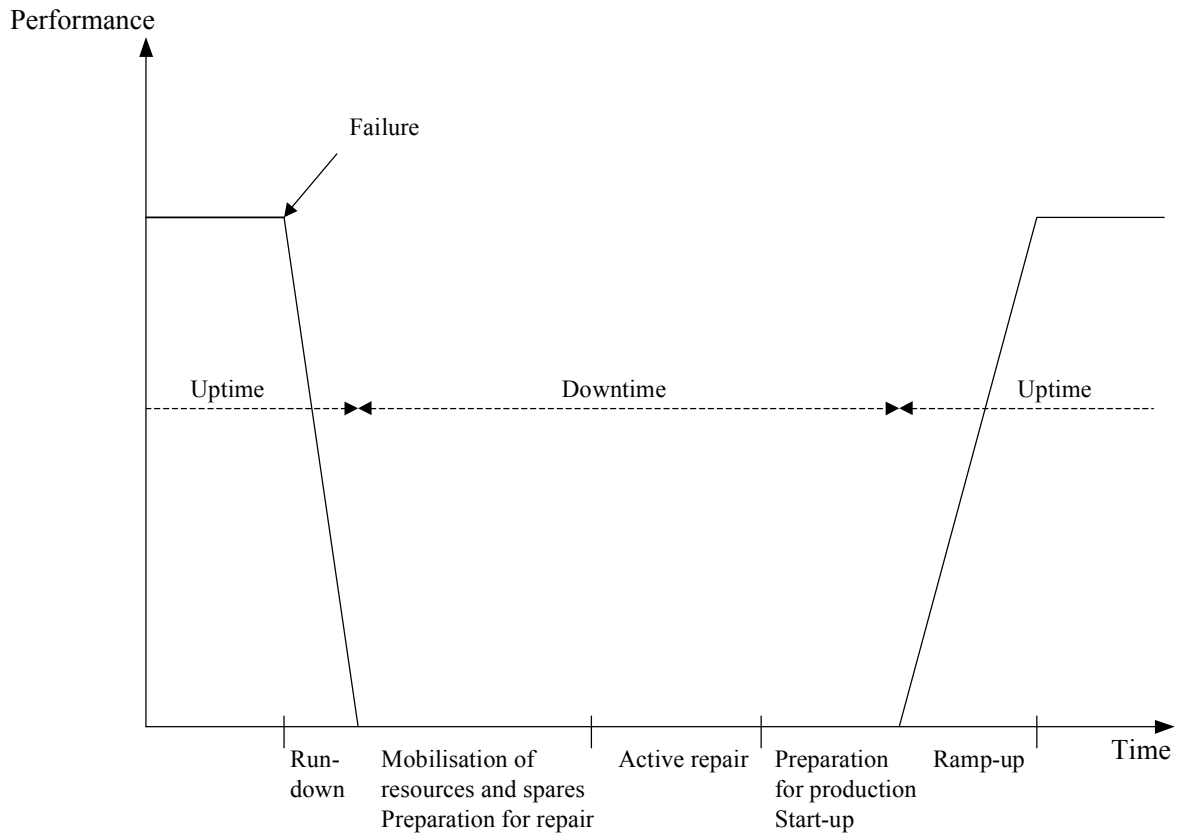

Figure 3.2 - Illustration of downtime associated with a failure event.

3.2 Abbreviations

CAPEX	Capital expenditures
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects and Criticality Analysis
FTA	Fault Tree Analysis
HSE	Health, Safety and Environment
IEC	International Electro-technical Commission.
ISO	International Organisation for Standardisation.
LCC	Life Cycle Cost
MDT	Mean downtime
MFDT	Mean fractional deadtime
MTBF	Mean time between failures
MTTF	Mean time to failure
MTTR	Mean time to repair
OPEX	Operational expenditures
OREDA	Joint industry project on collection and maintaining reliability data from exploration & production operations
RBD	Reliability Block Diagram
RBI	Risk Based Inspection
RCM	Reliability Centred Maintenance
REGEX	Regularity expenditures

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REGOP Regularity and operability review
RMP Regularity Management Programme

4 REGULARITY MANAGEMENT AND DECISION SUPPORT

4.1 Framework conditions

The objectives associated with systematic regularity management is to contribute to the alignment of design and operational decisions with corporate and business objectives.

In order to fulfil these objectives, technical and operational means as indicated in figure 4.1 may be used during design or operation to change the regularity level. Regularity management must include surveillance of project activities and decisions which may have an undesired effect on regularity.

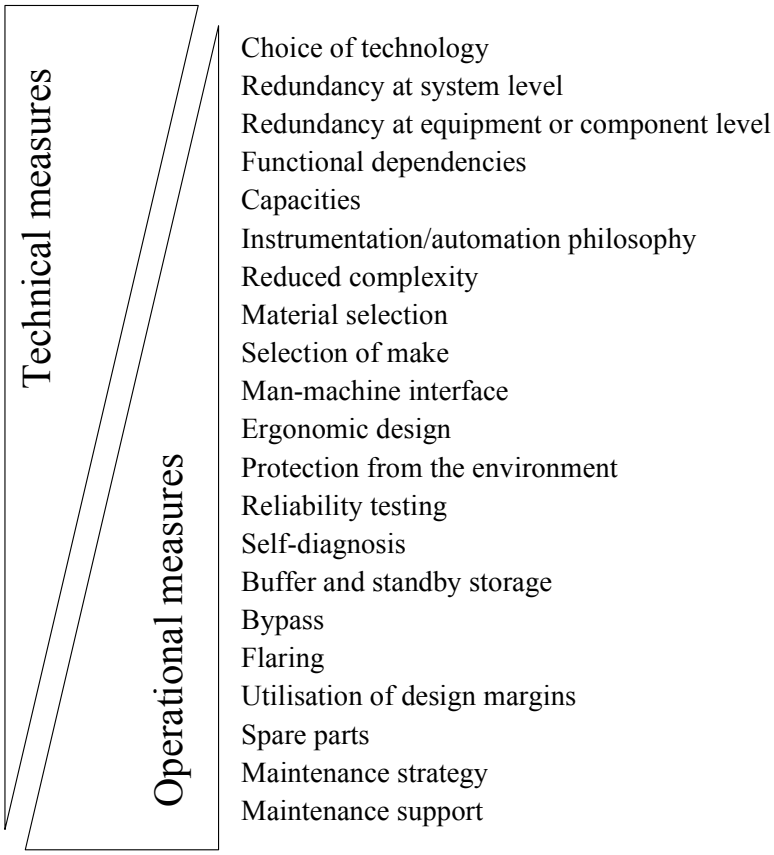

Figure 4.1: Important measures for control of regularity.

4.2 Optimisation process

The main principle for optimisation of design or selection between alternative solutions is economic optimisation within given constraints and framework conditions. As an economic criterion minimum life cycle cost should be used. The achievement of high regularity is of limited importance unless the associated costs are considered. This standard should therefore be considered together with the NORSOK standards O-001 “LCC for systems and equipment” and O-002 “LCC for production facility.

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Examples of constraints and framework conditions which will affect the optimisation process are:

- Requirements to design or operation given in authority regulations
- Requirements given in standards
- Requirements to health, safety and environment
- Requirements to safety equipment resulting from the risk analysis and the overall safety acceptance criteria
- Project constraints such as budget, realisation time, national and international agreements
- Conditions in the sales contracts
- Requirements to market performance

The optimisation process is illustrated in figure 4.2 below. The first step is to identify alternative solutions. Then these shall be checked with respect to the constraints and framework conditions that apply. The appropriate regularity parameters are predicted and the preferred solution is identified based on a LCC evaluation/analysis or another optimisation criterion. The process can be applied as an iteration process where the selected alternative is further refined and alternative solutions identified. Sensitivity analyses should be performed to take account of uncertainty in important input parameters. The execution of the optimisation process requires the regularity and reliability function to be addressed by qualified team members.

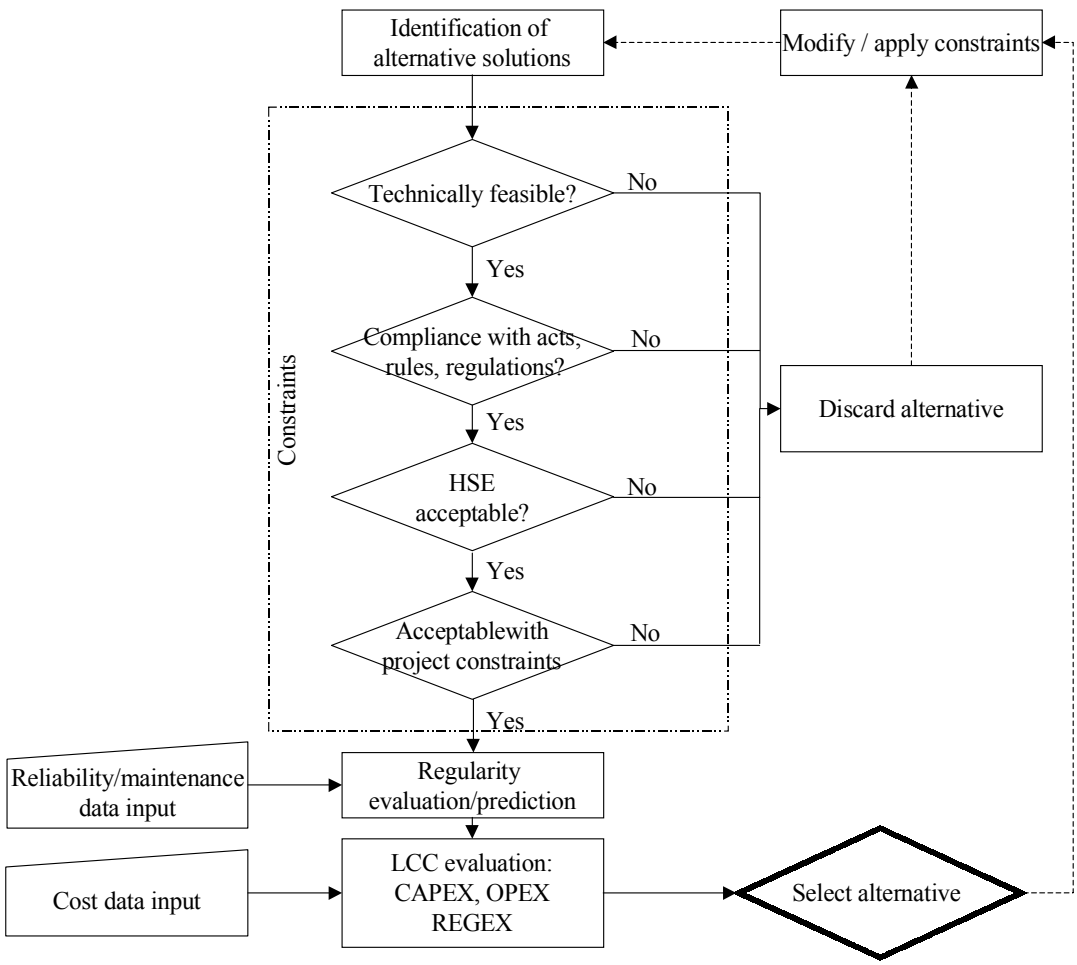

Figure 4.2 - Optimisation process

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4.3 Regularity objectives and requirements

Unnecessary limitations in the form of unfounded regularity requirements, shall be avoided to prevent that alternatives which could have been favourable in respect of overall economy are rejected during the optimisation process.

Regularity objectives and requirements should be used only if they are defined as a consequence of the framework conditions or constraints that apply.

The regularity objectives and requirements can be qualitative or quantitative. They can be formulated with respect to production availability, deliverability, reliability (time to failure of various failure modes), maintainability (mean or maximum duration of the shutdowns, intervention demand), redundancy (acceptable consequences of a failure), etc. Associated battery/boundary limits and important assumptions shall be clearly stated, especially to correctly interpret quantitative requirements.

4.4 Regularity Management Programme

4.4.1 Objectives

A Regularity Management Programme shall serve as a management tool in the process of achieving regularity objectives by cost-effective means and shall be a living document through the various life cycle phases. Regularity Management Programme shall be established for each field development project and updated at major milestones as required as well as being established for existing fields in operation. The Regularity Management Programme shall:

- Ensure systematic planning of regularity/reliability work within the scope of the programme.
- Define optimisation criterion.
- Define regularity objectives and requirements, if any.
- Describe the regularity activities necessary to fulfil the objectives, how they will be carried out, by whom and when. These shall be further outlined in separate regularity or reliability activity plans.
- Ensure that proper consideration is given to interfaces of regularity and reliability with other activities.

The regularity programme shall be at a level of detail which facilitates easy updating and overall co-ordination.

4.4.2 Programme activities

Regularity activities can be carried out in all phases of the life cycle of facilities to provide input to decisions regarding concept, design, manufacturing, construction, installation, operation and maintenance. Activities shall be initiated only if they are considered to contribute to added value in the project by improving quality of information to support decision making, or reduce economic or technological risk.

The regularity activities to be carried out shall be defined in view of the actual needs, available personnel resources, budget framework, interfaces, milestones and access to data and general information. This is necessary to reach a sound balance between the cost and benefit of the activity.

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