

# Maintenance, dependability and condition monitoring standards

## Standards related to maintenance

*Standards are available through the National Standards Authority of Ireland. Their web site: is [www.nsai.ie](http://www.nsai.ie)*

### Maintenance process during the Design /Development /Manufacturing /Installation Phase

#### Maintenance activities during design phase

- Reliability, Availability, Maintainability and Safety management during design
- Integrated Logistic Support
- Service concept
- Design out maintenance

Standard reference	Title
IEC 60300-3-12	Integrated logistic support
IEC 60300-3-10	Application Guide : Maintainability
IEC 60706-2	Maintainability of equipment – Maintainability requirements and studies during the design phase
IEC 60706-3	Maintainability of equipment –Verification of maintainability and collection, analysis and presentation of maintainability data
IEC 60706-5	Guide on maintainability of equipment - Diagnostic testing
CEN/TS 15331	Criteria for design, management and control of maintenance services for buildings
VDI 2891	Maintenance relevant criteria for purchase of machines. (Instandhaltungskriterien bei der Beschaffung von Investitionsgütern)
UNI 10224:2007	Maintenance - Process, sub-processes and main activities - Fundamental principles

## Maintenance process during Operating Phase

### Maintenance planning

- Criticality analyses (RCM, ...)
- Maintenance and risk management (RBI, ...)
- Value Based Maintenance
- Plant Maintenance Optimisation
- Lean Maintenance
- Decision making in maintenance
- Replacement investments

Standard reference	Title
IEC 60300-3-11	Application guide – Reliability Centred Maintenance
SAE JA1011	Evaluation Criteria for Reliability-Centred Maintenance (RCM) Processes
SAE JA1012	A guide to RCM standard
UNI 10366:2007	Maintenance - Design criteria of maintenance
UNI 10992:2002	Maintenance budget for manufacturers and suppliers of products and services - Guidelines for the definition, approval, management and check
UNI 11282:2008	Maintenance of the group transportation vehicles - Appraisal and evaluation of the condition of the vehicles in service on road
CEN/TS 15331	Criteria for design, management and control of maintenance services for buildings
UNI 11257:2007	Maintenance of buildings - Criteria for the drafting of plan and programme of maintenance of buildings – Guidelines
UNI 10604:1997	Maintenance. Criteria for design, management and control of the maintenance services of building
NEN 2767-1	Condition Assessment of Building and Installation Components – Part 1: Methodology
NEN 2767-2	Condition Assessment of Building and Installation Components – Part 2: List of Faults
NEN 2767-3	Condition Assessment of Building and Installation Components – Part 3: Aggregation of Condition Scores

## Maintenance support

- Spare part management
- Obsolescence management
- Maintenance tools management
- Maintenance documents
- Instrumentation & Wireless techniques
- Maintenance Information Systems (CMMS, ERM, ...)
- Benchmarking systems
- Education & training in maintenance
- Certification of maintenance personnel
- Traceability
- Qualification of equipment
- Maintenance standards

Standard reference	Title
EN 13306	Maintenance Terminology
IEC 50(191)	International Electrotechnical Vocabulary - Dependability and quality of service
IEC 61703	Mathematical expressions for reliability, maintainability and maintenance support items
PSK 6201	Maintenance terms and definitions
UNI 10147:2003	Maintenance - Additional terms and definitions to EN 13306.
UNI 11063:2003	Maintenance - Definitions of ordinary and extraordinary maintenance
UNI 11082:2003	Maintenance - Specific terminology for the group transportation field
NF X 60-012	Vocabulary of components of items and their supply (Termes et définitions des éléments constitutifs et de leurs approvisionnements pour les biens durables)
NF ISO 13372	Condition monitoring and diagnostics of machines – Vocabulary
EN 15221-1	Facility Management - Part 1: Terms and definitions

NF X 50-501	Maintenance - Reference conditions for items : Vocabulary of renovation and reconstruction activities (Durée de vie et durabilité des biens - Vocabulaire des activités de rénovation et de reconstruction - États de référence des biens de réemploi)
IEC 62550	Spare parts provisioning
VDI 2892	Management of maintenance spare parts. (Ersatzteilwesen der Instandhaltung)
UNI 10749-1:2003	Maintenance - Guidelines for management of maintenance materials - General aspects and organizational problems
UNI 10749-2:2003	Maintenance - Guidelines for management of maintenance materials - Criteria for classification, codification, standardization and support
UNI 10749-3:2003	Maintenance - Guidelines for management of maintenance materials - Criteria for the choice of materials to be managed
UNI 10749-4:2003	Maintenance - Guidelines for management of maintenance materials - Criteria for operational management
UNI 10749-5:2003	Maintenance - Guidelines for management of maintenance materials - Criteria for purchasing, tests and final check
UNI 10749-6:2003	Maintenance - Guidelines for management of maintenance materials - Administration criteria
UNI 10831-1:1999	Maintenance of buildings - Documentation and basic information for maintenance services of projects approved and executed - Structure, contents and levels of documentation
UNI 10831-2:2001	Maintenance of buildings - Documentation and basic information for maintenance services of projects approved and executed - Details of content of technical documentation and lay-out models
UNI 10874:2000	Maintenance of buildings - Criteria in order to write maintenance and use manuals
IEC 62402	Application guide – Obsolescence management
EN 13460	Maintenance - Documents for maintenance

NF X60-200	Technical documentations associated with an item throughout its life cycle
NF X60-212	Maintenance - Handbook of instructions maintenance -Definitions and general principles for the wording and layout
UNI 10584:1997	Maintenance. Systems of information of maintenance
UNI 10951:2001	Systems of information for the maintenance management of buildings - Guidelines
UNI 11414:2011	Maintenance - Guidelines for qualification of maintenance system
CEN/TR 15628	Maintenance - Qualification of Maintenance personnel
UNI 11420:2011	Maintenance - Qualification of maintenance personnel

### **Maintenance implementation**

- Contracting & outsourcing & insourcing
- Total Productive Maintenance
- e-maintenance
- Operator Based Maintenance
- Remote maintenance
- Relations Operational / Maintenance staff

<b>Standard reference</b>	<b>Title</b>
EN 13269	Maintenance - Guideline on preparation of maintenance contracts
IEC 60300-3-16	Application guide – Guidelines for specification of maintenance support services
EN 15221-2	Facility Management - Part 2: Guidance on how to prepare Facility Management agreements
UNI 10144:2006	Classification of maintenance services
UNI 10145:2007	Definition of evaluation factors of services maintenance firms

UNI 10146:2007	Criteria to prepare a contract for supplying maintenance finalized services
UNI 11126:2004	Telemaintenance - Criteria for the suitability of the items and for the definition of the related service
UNI 10148:2007	Maintenance - Management of a maintenance contract
UNI 10685:2007	Maintenance - Criteria to prepare a maintenance global service
UNI 11136:2004	Global service for maintenance of buildings - Guidelines
NF X60-008	Industrial maintenance - Maintenance outsourcing draft guide - Pre-contractual approach
NF X60-100	Maintenance – Preconditions to the maintenance contracts – Inventories and evaluation for the states of items
PSK ??	Maintenance in industry. Service agreement.

### **Maintenance techniques**

- Condition monitoring techniques
- Non Destructive Testing
- Diagnosis & Prognosis
- Maintenance and repair technology (mechanical and electrical methods for repairs)

<b>Standard reference</b>	<b>Title</b>
ISO 13381-1	Condition monitoring and diagnostics of machines - Prognostics - General guidelines
ISO 13379	Condition monitoring and diagnostics of machines - General guidelines on data interpretation and diagnostics techniques
VDI 2888	Maintenance condition monitoring. (Zustandsorientierte Instandhaltung)
VDI 2889	Methods and systems for condition and process monitoring in maintenance. (Einsatz wissensbasierter Diagnosemethoden und -systeme in der Instandhaltung)
PSK 5704	Condition monitoring. Vibration measurement. Acceptance test and vibration severity limits

UNI 10652:2009	Maintenance - Appraisal and evaluation of the goods condition
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### **Maintenance & Equipment history**

- Maintenance data collection
- Human error analysis
- Maintenance knowledge & best practices
- Tools for expert evaluation

<b>Standard reference</b>	<b>Title</b>
IEC 60300-3-2	Application guide – Collection of dependability data from the field
ISO 14224	Petroleum, petrochemical and natural gas industries - Collection and exchange of reliability and maintenance data for equipment
CEI/PAS 62508	Guidance on Human Factors Engineering for System Life Cycle - Applications
VDI 2885	Standardized data for maintenance planning and determination of maintenance costs - Data and data determination. (Einheitliche Daten für die Instandhaltungsplanung und Ermittlung von Instandhaltungskosten - Daten und Datenermittlung)

### **Assessment & improvement of equipment & maintenance**

#### **Equipment reliability**

- Root Cause Analysis
- Equipment health analysis
- Ageing and degradation mechanism modelling
- Remaining useful life assessment

<b>Standard reference</b>	<b>Title</b>
IEC 60812	Analysis techniques for system reliability - Procedure for failure mode and effects analysis (FMEA)

IEC 62308	Reliability assessment methods
IEC 61649	Weibull analysis
SFS ??	Presentation of reliability, maintainability and availability predictions

### **Maintenance assessment**

- Benchmarking
- Performance Indicators & Dashboards
- Maintenance process diagnosis & audits
- Modelling and simulation of maintenance strategies
- Customer satisfaction surveys
- Best practices identification

<b>Standard reference</b>	<b>Title</b>
EN 15341	Maintenance — Maintenance Key Performance Indicators
VDI 2886	Benchmarking applied to maintenance. (Benchmarking in der Instandhaltung)
VDI 2893	Selection and formation of indicators for maintenance. (Auswahl und Bildung von Kennzahlen für die Instandhaltung)
PSK 7501	Key performance indicators of maintenance for use in process industry
PSK 7502	Key performance indicators of logistics. Material function
PSK ??	Condition audit in process industry
UNI 11134:2005	Maintenance - Maintenance ratios for the group transportation field
UNI 11178:2006	Maintenance - Maintenance ratios - Guidance for the application of UNI 10388 in the field of the infrastructures of the group transportation on railways
UNI 11069:2003	Maintenance - Maintenance ratios for the vehicles in service on road, with limited distances to be covered and frequent stops



## Life cycle management

### Asset Maintenance Management

- Maintenance process description – roles & responsibilities
- Maintenance excellence
- Life cycle management
- Life cycle extension
- Rebuilding & Reinvestment strategies
- Relations with auditing & safety organizations

Standard reference	Title
IEC 60300-3-14	Maintenance and maintenance support
NF X60-000	Maintenance function
DIN 31051	Fundamentals of maintenance. (Grundlagen der Instandhaltung)
PAS 55-1	Specification for thr optimized management of physical assets
PAS 55-2	Guidelines for the application of PASS 55-1
IEC 60300-3-3	Dependability management - Application guide - Life cycle costing
EN 1325-1	Value management, value analysis, functional analysis vocabulary – value analysis and functional analysis
EN 1325-2	Value management, value analysis, functional analysis vocabulary – value management

## Health and safety

### Health and safety in maintenance

- Occupational diseases and accidents
- Good practices in safety
- Good practices in environment preservation

<b>Standard reference</b>	<b>Title</b>
OSHAS 18001	Occupational Health and safety management systems - requirements
OSHAS 18002	Occupational Health and safety management systems - Guidelines for implementation of OSHA 18001
ILO-OSH-2001	Guidelines on occupational safety and health management systems
MASE	Guideline for improvement of health and safety at work
IEC 61508	Functional safety of electrical/electronic/ programmable electronic safety-related systems
IEC 61511	Functional safety – Safety instrumented systems for the process industry sector
UNI 10449:2008	Maintenance - Criteria to prepare and to manage the permit to work
CDM regulations	The Construction (Design & Management) Regulations
I.S. EN 60079-17	Explosive atmospheres. Electrical installations inspection and maintenance

## Standards related to Dependability

Standard reference	Title
IEC 50(191)	International Electrotechnical Vocabulary - Dependability and quality of service
IEC 61703	Mathematical expressions for reliability, maintainability and maintenance support items
IEC 60300-1	Dependability management, Part 1 – Dependability management systems
IEC 60300-2	Dependability management, Part 2 – Guidelines for dependability management
IEC 60300-3-1	Dependability management – Part 3: Application guide – Section 1: Analysis techniques for dependability, guide on methodology
IEC 60300-3-2	Dependability management – Part 3: Application guide – Section 2: Collection of dependability data from the field
IEC 60300-3-3	Dependability management – Part 3: Application guide – Section 3: Life cycle costing
IEC 60300-3-4	Dependability management – Part 3: Application guide – Section 4: Guide to the specification of dependability requirements
IEC 60300-3-5	Dependability management – Part 3-5: Application guide – Reliability test conditions and statistical test principles
IEC 60300-3-9	Dependability management – Part 3: Application guide – Section 9: Risk analysis of technological systems
IEC 60300-3-15	Dependability management - Part 3-15: Guidance to engineering of system dependability
IEC 62347	Guidance on system dependability specifications
IEC 61160	Formal design review
IEC 62198	Project risk management – Application guidelines
IEC 61882	Guide for hazard and operability studies

IEC 62308	Reliability assessment methods
IEC 61165	Application of Markov techniques
IEC 61025	Fault tree analysis
IEC 61078	Reliability block diagram method
IEC 61882	Hazard and operability studies (HAZOP studies) - Application guide
IEC 60812	Analysis techniques for system reliability - Procedure for failure mode and effects analysis (FMEA)
IEC 61709	Electronic components reliability - Reference conditions for failure rates and stress models for conversion
IEC 60319	Presentation of reliability data on electronic components or parts
IEC 61650	Reliability data analysis techniques – Procedures for the comparison of two constant failure rates and two constant failure (event) intensities
IEC 60605-2	Design of test cycles
IEC 60605-4	Equipment reliability testing – Part 4: Statistical procedures for exponential distribution – Point estimates, confidence intervals, prediction intervals and tolerance intervals
IEC 60605-6	Test for the validity of the constant failure rate or constant failure intensity assumptions
IEC 61123	Reliability testing – Compliance test plans for success ratio
IEC 61124	Compliance tests for constant failure rate and constant failure intensity
IEC 61070	Compliance test procedures for steady-state availability
IEC 62309	Electrical engineering - Fitness for purpose and quality of products as new - Requirements and tests
IEC 61014	Programmes for reliability growth
IEC 61164	Reliability growth – Statistical test and estimation methods

IEC 62429	Reliability growth - Stress testing for early failures in unique complex systems
IEC 61163-1	Reliability stress screening, Part 1: Reparable items manufactured in lots
IEC 61163-2	Reliability stress screening, Part 2: Electronic component
IEC 61123	Reliability testing - Compliance test plans for success ratio
IEC 61710	Goodness-of-fit for the power law model
IEC 61649	Goodness-of-fit tests, confidence intervals and lower confidence limits for Weibull distributed data
IEC 61810-1	Electromechanical elementary relay - Part 1: General and safety requirements
IEC 61810-2	Electromechanical elementary relay - Part 2: Reliability
IEC 62059-31	Electricity metering equipment (a.c.) - Dependability - Part 31: Accelerated reliability testing
IEC 61508	Functional safety of electrical/electronic/ programmable electronic safety-related systems
IEC 61511	Functional safety – Safety instrumented systems for the process industry sector

## Standards related to Condition Monitoring

Standard reference	Title
ISO 10814	Mechanical vibration - Susceptibility and sensitivity of machines to unbalance
ISO 10816-1	Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 1: General guidelines
ISO 10816-2	Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 2: Land-based steam turbines and generators in excess of 50 MW with normal operating speeds of 1500 r/min, 1800 r/min, 3000 r/min and 3600 r/min
ISO 10816-3	Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in situ
ISO 10816-4	Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 4: Gas turbine driven sets excluding aircraft derivatives
ISO 10816-5	Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 5: Machine sets in hydraulic power generating and pumping plants
ISO 10816-6	Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 6: Reciprocating machines with power ratings above 100 kW
ISO 10816-7	Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 7: Rotodynamic pumps for industrial applications, including measurements on rotating shafts
ISO 10817-1	Rotating shaft vibration measuring systems - Part 1: Relative and absolute sensing of radial vibration
ISO 11342	Mechanical vibration - Methods and criteria for the mechanical balancing of flexible rotors
ISO 13372	Condition monitoring and diagnostics of machines - Vocabulary

ISO 13373-1	Condition monitoring and diagnostics of machines - Vibration condition monitoring - Part 1: General procedures
ISO 13373-2	Condition monitoring and diagnostics of machines - Vibration condition monitoring -- Part 2: Processing, analysis and presentation of vibration data
ISO 13374-1	Condition monitoring and diagnostics of machines - Data processing, communication and presentation - Part 1: General guidelines
ISO 13374-2	Condition monitoring and diagnostics of machines - Data processing, communication and presentation - Part 2: Data processing
ISO 13379	Condition monitoring and diagnostics of machines - General guidelines on data interpretation and diagnostics techniques
ISO 13380	Condition monitoring and diagnostics of machines - General guidelines on using performance parameters
ISO 13381-1	Condition monitoring and diagnostics of machines - Prognostics - Part 1: General guidelines
ISO 14694	Industrial fans - Specifications for balance quality and vibration levels
ISO 14695	Industrial fans - Method of measurement of fan vibration
ISO 1680	Acoustics - Test code for the measurement of airborne noise emitted by rotating electrical machines
ISO 17359	Condition monitoring and diagnostics of machines - General guidelines
ISO 18434-1	Condition monitoring and diagnostics of machines - Thermography - Part 1: General procedures
ISO 18436-1	Condition monitoring and diagnostics of machines - Requirements for training and certification of personnel - Part 1: Requirements for certifying bodies and the certification process
ISO 18436-2	Condition monitoring and diagnostics of machines - Requirements for training and certification of personnel - Part 2: Vibration condition monitoring and diagnostics
ISO 18436-3	Condition monitoring and diagnostics of machines - Requirements for qualification and assessment of personnel - Part 3: Requirements for training bodies and the training process
ISO 18436-4	Condition monitoring and diagnostics of machines - Requirements for qualification and assessment of personnel - Part 4: Field lubricant analysis

ISO 18436-6	Condition monitoring and diagnostics of machines - Requirements for qualification and assessment of personnel - Part 6: Acoustic emission
ISO 18436-7	Condition monitoring and diagnostics of machines - Requirements for qualification and assessment of personnel - Part 7: Thermography
ISO 1925	Mechanical vibration - Balancing - Vocabulary
ISO 1940-1	Mechanical vibration - Balance quality requirements of rigid rotors - Part 1: Specification and verification of balance tolerances
ISO 1940-2	Mechanical vibration - Balance quality requirements of rigid rotors - Part 2: Balance errors
ISO 1996-1	Acoustics - Description, measurement and assessment of environmental noise - Part 1: Basic quantities and assessment procedures
ISO 1996-2	Acoustics - Description, measurement and assessment of environmental noise - Part 2: Determination of environmental noise levels
ISO 2017-1	Mechanical vibration and shock - Resilient mounting systems - Part 1: Application of source and receiver isolation
ISO 2017-2	Mechanical vibration and shock - Resilient mounting systems - Part 2: Technical information to be exchanged for the application of vibration isolation associated with railway systems
ISO 2041	Vibration and shock - Vocabulary
ISO 22266-1	Mechanical vibration - Torsional vibration of rotating machinery - Part 1: Land-based steam and gas turbine generator sets in excess of 50 MW
ISO 2314	Gas turbines - Acceptance tests
ISO 2954	Mechanical vibration of rotating and reciprocating machinery - Requirements for instruments for measuring vibration severity
ISO 5348	Mechanical vibration and shock - Mechanical mounting of accelerometers
ISO 7626-1	Vibration and shock - Experimental determination of mechanical mobility - Part 1: Basic definitions and transducers
ISO 7626-2	Vibration and shock - Experimental determination of mechanical mobility - Part 2: Measurements using single-point translation excitation with an attached vibration exciter



ISO 7626-5	Vibration and shock - Experimental determination of mechanical mobility - Part 5: Measurements using impact excitation with an exciter which is not attached to the structure
ISO 7919-1	Mechanical vibration of non-reciprocating machines - Measurement on rotating shafts and evaluation criteria - Part 1: General guidelines
ISO 7919-2	Mechanical vibration - Evaluation of machine vibration by measurements on rotating shafts - Part 2: Land-based steam turbines and generators in excess of 50 MW with normal operating speeds of 1 500 r/min, 1 800 r/min, 3 000 r/min and 3 600 r/min
ISO 7919-3	Mechanical vibration of non-reciprocating machines - Measurements on rotating shafts and evaluation criteria - Part 3: Coupled industrial machines
ISO 7919-4	Mechanical vibration of non-reciprocating machines - Measurements on rotating shafts and evaluation criteria - Part 4: Gas turbine sets
ISO 7919-5	Mechanical vibration of non-reciprocating machines - Measurements on rotating shafts and evaluation criteria - Part 5: Machine sets in hydraulic power generating and pumping plants
ISO 8297	Acoustics. Determination of sound power levels of multi-source industrial plants for the evaluation of the sound pressure levels in the environment. Engineering method
ISO 8528-9	Reciprocating internal combustion engine driven alternating current generating sets - Part 9: Measurement and evaluation of mechanical vibrations
ISO 8569	Mechanical vibration and shock - Measurement and evaluation of shock and vibration effects on sensitive equipment in buildings
ISO 8626	Servo-hydraulic test equipment for generating vibration - Method of describing characteristics
ISO 8821	Mechanical vibration - Balancing - Shaft and fitment key convention
ISO 22096	Condition monitoring and diagnostics of machines - Acoustic emission
ISO 8579-2	Acceptance code for gears - Part 2: Determination of mechanical vibrations of gear units during acceptance testing