BS EN 15341:2019+A1:2022

BSI Standards Publication

Maintenance — Maintenance Key Performance Indicators

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National foreword

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The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by ▌A1⟩ ⟨A1▌.

The UK participation in its preparation was entrusted to Technical Committee DS/1, Dependability.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Maintenance - Indicateurs de performance clés pour la maintenance

Instandhaltung - Wesentliche Leistungskennzahlen für die Instandhaltung

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European foreword

This document (EN 15341:2019+A1:2022) has been prepared by Technical Committee CEN/TC 319 “Maintenance”, the secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2022, and conflicting national standards shall be withdrawn at the latest by December 2022.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document includes Amendment 1 approved by CEN on 20 April 2022.

This document supersedes [A1⟩ EN 15341:2019 ⟨A1].

The start and finish of text introduced or altered by amendment is indicated in the text by tags [A1⟩ ⟨A1].

The main technical changes compared to the previous EN 15341:2007 are the following:

— the standard was fully revised;

— the vision on all the Maintenance Components was enlarged, structuring the standard in a more complete way maintaining the economical, technical, organizational KPI of the previous edition.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

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Introduction

Maintenance Key Performance Indicators (KPI) of the Maintenance Function apply to all the physical assets either industrial, infrastructures or civil buildings or transportation systems, etc.

These indicators should be used to:

a) measure the status;

b) compare (internal and external benchmarks);

c) diagnose (analysis of strengths and weaknesses);

d) identify objectives and define targets to be reached;

e) plan improvement actions;

f) regular measurement of changes over time.

Maintenance of software alone is not covered in this document. However, maintenance of items and systems containing software is considered.

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1 Scope

This document lists Key Performance Indicators (KPIs) of the Maintenance Function and gives guidelines to define a set of suitable indicators, to appraise and to improve effectiveness, efficiency and sustainability in the maintenance of the existing physical assets either industrial, infrastructures, facilities, civil buildings or transportation systems, etc. in the framework of the external and internal influencing factors.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13306:2017, *Maintenance — Maintenance terminology*

EN 15628:2014, *Maintenance — Qualification of maintenance personnel*

IEC 60050-192:2015, *International Electrotechnical Vocabulary (IEV) — Part 192: Dependability*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13306:2017 and in IEC 60050-192:2015, and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at https://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1
asset
<physical> item that has potential or actual value for the organization

[SOURCE: EN 13306:2017, 3.2]

3.2
main area
fundamental part of a management discipline, which represents the more important knowledge and competence to achieve and maintain an excellent status within existing influencing factors

3.3
indicator
quantitative or qualitative measure of a characteristic or a set of characteristics of a phenomenon or performance of activities, according to defined criteria or a given formula or questionnaire

Note 1 to entry: The indicator is a tool for development and implementation of a strategy for monitoring progress towards the goals outlined in the strategy.

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3.4
item
part, component, device, subsystem, functional unit, equipment that can be individually described and considered

[SOURCE: EN 13306:2017, 3.1]

3.5
key performance indicator
KPI
indicator considered significant

3.6
time
generally used to describe time units related to the physical assets-equipment and its performance

3.7
man-hour
points the hours of labour spent in delivering maintenance activities

3.8
work order
document used by the maintenance function

Note 1 to entry: It specifies the deliverables, scope and cost of the approved work.

Note 2 to entry: It contains a pre-defined set of activities with specified materials, spare parts, tools and labour required to complete the job.

4 Maintenance function

The Maintenance Function is operating in various industrial plants, facilities, infrastructures, acting in different frameworks and contexts with different sizes, structures, objectives, specific constraints and influencing factors (see 5.2 and 5.3).

In this context, it is suitable to define an organizational Model of Maintenance Function, as standard reference to be implemented in relation with required objectives, available resources, and existing constraints.

This Model of Maintenance Function is reported in Figure 1.

The Model considers that for the Maintenance function to achieve the assigned objectives and excellence, it shall use an appropriate combination or parts of the various disciplines as HSE (Health Safety Environment), Administration, ICT (Information and Communication Technology), etc.

It is Management task:

a) to implement the appropriate resources, knowledge, rules, procedures activities;

b) to select how the maintenance needs to build and organize the various matters and disciplines in the following Sub Functions/Areas:

— HSE on Maintenance;

— Maintenance Management;

— Maintenance People Competence;

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— Maintenance Engineering;

— Organization and Support for Maintenance;

— Administration and Supply.

The maintenance function maintains the physical assets so that it can perform the required functions and consequently, the management shall act in a core framework that involves:

— The company

— The available resources

— The application of ICT and Enabling Technologies (e.g. Industry 4.0)

Acknowledging the fast development within maintenance, both from organizational and technological point, this document provides an overview of the content of sub-functions, activities, and tools to be considered when establishing activities and indicators to reach the targets.

It is suitable to use all the disciplines of Maintenance Function in the integrated framework to achieve the objectives assigned to the Maintenance of the Physical Assets with the support of ICT and Enabling Technologies (e.g. Industry 4.0).

The size and the depth of utilization depends on the maturity degree of each maintenance department and from its commitment to develop Maintenance activities towards the excellence.

During the life of each physical asset and its components, it is necessary to carry out maintenance activities to repair the failures, contain the degradation and wear with appropriate preventive actions, so as to lengthen the life of the unit and meet the required level of performance.

The Maintenance Function is an integration of 6 Sub-functions with the addition of methodology of Physical Asset Management and hardware and software of the Information and Communication Technology (see Figure 1).

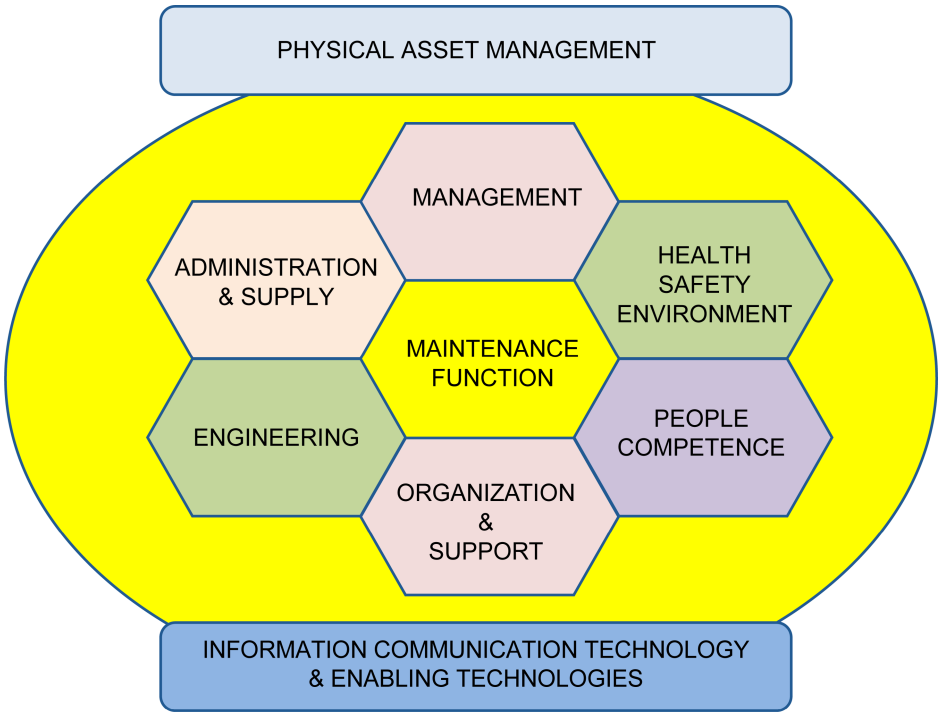

Figure 1 — Maintenance function and core framework

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In this integrated maintenance system each sub function shall be developed in order to achieve the objectives assigned to the Maintenance Function. These objectives can include e.g. H.S.E. issues, integrity and competitiveness of the physical assets, balancing productivity, costs and service.

In order to cover all the major aspects of physical assets management the key performance indicators are structured into eight groups, one for physical asset management, six dedicated to maintenance sub-functions, and the last one for the information communication technologies.

5 KPIs and their objectives

5.1 General

When the actual or expected performance is not satisfactory, management shall define objectives and strategies to improve the resources utilization of involved sub-functions using the KPIs, allowing the organization to:

a) define the objectives;

b) measure the performance;

c) compare the performance versus the historical value of benchmarks;

d) identify strengths and weaknesses;

e) control progress and changes;

f) define plan and strategies of improvements;

g) make regular measurement of changes over time;

h) share the results.

These indicators can be used:

- on a periodic basis, for instance by preparing and following-up a budget, during performance assessment, comparing results in many ways: budgeted, expected, predicted, planned, actual, etc.;
- on a spot basis, for instance within the framework of specific audits, studies and/or benchmarking.

The period of time to be considered for measurement depends on the organization policy, aims and time constants of measured phenomena; it can be: day, week, month, quarter, semester, year, etc.

The KPIs can be often calculated as a ratio between factors (numerator and denominator) measuring the activities, resources or events, according to a given formula, but can also be the result of the quantitative or qualitative questionnaire.

The numerical values, the qualitative and the quantitative data to calculate each KPI shall be collected and elaborated based on available methods and procedures of general industrial accounting and specific management accounting rules, applied to the maintenance function.

These indicators are used to measure any qualitative or quantitative characteristics of an item or a process to create a homogeneous base to compare and set objectives to improve.

In some cases it is suitable to use specific pre-prepared questionnaire to give to the managers and experts the possibility to carry out qualitative assessments in a simple and efficient way.

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5.2 Influencing factors

The Influencing factors are variable conditions outside of Maintenance Function which have an impact on the measured indicator. They can be general or specific, internal or external, controllable or non-controllable.

Examples of external influencing factors are:

a) location,

b) society culture,

c) national labour policies and costs,

d) market and economy,

e) laws and regulations,

f) sector / branches,

g) stakeholders,

h) technology,

i) environmental conditions.

Examples of internal Influencing factors are:

j) organization culture,

k) organization scale,

l) organization objectives,

m) criticality of the physical asset,

n) severity and complexity of the process,

o) product mix,

p) physical assets scale and complexity,

q) utilization rate,

r) age of physical asset.

These factors shall be considered as reference conditions to understand the framework where maintenance is operating. It is necessary to consider the influence and the impact of factors, in order to achieve homogeneous and appropriate evaluations without misunderstandings and misleading.

5.3 Maintenance Resources

The maintenance resources are:

— competence of direct and indirect people;

— labour internal and external;

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— spare parts and materials;

— diagnostics and predictive technologies;

— maintenance tools and equipments;

— engineering knowledge;

— good maintenance practices to repair, restore, prevent and improve;

— information technology systems: hardware and software and enabling technologies (e.g Industry 4.0);

— supply and supporting services.

The role of management is to achieve the best maintenance performance, in line with the stated company objectives, using and dosing the appropriate resources, optimizing all the management, organizational and administrative aspects with an integrated information system.

5.4 Maintenance Processes

The maintenance processes are the various actions used by each sub-function to implement the activities to achieve the best competitiveness and suitable results according to the stated aim of the organization, see EN 17007.

6 Maintenance KPIs Matrix

Table 1 shows the KPIs of Maintenance within a Physical Asset Management, the 6 maintenance Sub-functions and the Information Communication Technology.

The KPIs reported in the matrix related to each subsystems/methodology are divided in areas, which represent the fundamental contents or characteristic to be measured, controlled and improved to achieve a quantitatively and qualitatively excellent assessment.

Most indicators can be used at different aggregation levels depending on whether they are used to measure the performance of physical assets, production lines, given equipment, item, etc.

The indicators can be split by professional levels in relation to the organizational structure established by each organization.

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Table 1 — Maintenance KPIs matrix

SUB FUNCTIONS, TOOLS AND METHODOLOGIES	KPIs	MAIN AREAS			
Maintenance within physical asset management	PHA_i	Sustainability i = 1 to 3	Capacity Effectiveness Integrity i = 4 to 11	Service Level i = 12 to 13	Economics i = 14 to 20
Sub-function 1 Health - Safety Environment	HSE_i	Laws- Rules conformity i = 1 to 3	Statistical Records i = 4 to 12	Safe Practice i = 13 to 17	Prevention and Improvements i = 18 to 22
Sub-function 2 Maintenance Management	M_i	Strategy i = 1 to 3	Function i = 4 to 10	Technical Assessment i = 11 to 16	Continuous Improvement i = 17 to 22
Sub-function 3 People Competence	P_i	Maintenance Manager i = 1 to 3	Maintenance Supervisor/ Maintenance Engineer i = 4 to 9	Maintenance Technician Specialist i = 10 to 12	Education i = 13 to 21
Sub-function 4 Maintenance Engineering	E_i	Capability Criticality i = 1 to 3	Durability i = 4 to 9	Preventive Maintenance i = 10 to 16	Engineering Improvements i = 17 to 19
Sub-function 5 Organization and Support	$O\&S_i$	Structure and Support i = 1 to 8	Planning and Control i = 9 to 22	Productivity Effectiveness i = 23 to 28	Quality i = 29 to 30
Sub-function 6 Administration and Supply	$A\&S_i$	Economics i = 1 to 6	Budget &Control i = 7 to 19	Outsourcing services i = 20 to 25	Materials and spare parts i = 26 to 29
Information Communication Technology, Enabling technologies	ICT_i	Management i = 1 to 6	Administration and Supply i = 7 to 10	Organization and Support i = 11 to 13	Engineering i = 14 to 20 TEC 18.20

7 KPIs of "Maintenance within Physical Asset Management"

Maintenance within physical asset management allows the optimal life cycle management of physical assets to sustainably achieve the stated organization objectives.

The Maintenance activities play a significant role in the life cycle management of physical assets, because the maintenance function takes care of their integrity for the majority of the life.

Physical asset management indicates the appropriate importance of maintenance in the various life cycle stages and helps the maintenance management to define effective long term maintenance strategy.

The physical assets management provides the interrelations between the maintenance and the other physical asset processes, in order to measure the performances through the whole asset life, in line with vision, mission, values and organization objectives.

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The main KPIs, named PHA_i, shared by driven areas as reported in Table 2 are the following:

— Sustainability: PHA1, PHA2, PHA3;

— Capacity, Effectiveness, Integrity: PHA4, PHA5, PHA6, PHA7, PHA8, PHA9, PHA10, PHA11;

— Service Level: PHA12, PHA13;

— Economics: PHA14, PHA15, PHA16, PHA17, PHA18, PHA19, PHA20

Table 2 — KPI of maintenance within physical asset

KPI	FACTORS	DEFINITIONS AND NOTES
PHA1 Maintenance contribution to improve sustainability (%)	Annual maintenance cost to improve sustainability	The cost of maintenance resources spent yearly to improve the sustainability
	Physical assets turnover	Annual turnover generated by the physical asset
PHA2 Maintenance issues-projects included in the strategic life plan (%)	Maintenance issues/projects included in the strategic life plan	Maintenance issues/projects included in the strategic life plan of the physical assets
	Maintenance issues-projects proposed	Strategic issues/projects evaluated and proposed by maintenance in the budget
PHA3 Capital intensity required to generate turnover	Physical asset turnover	Annual turnover generated by the physical asset
	Physical asset replacement value	A1 Physical asset replacement value is the estimated amount of capital that can be required to build the existing physical asset A1
PHA4 Utilization rate of production capacity (%)	Actual production output	Total effective output
	Standard production capacity	Production capacity in term of output is pre-defined production standard capacity for a period of time according to manufacturing rules
PHA5 Rate of replacement (%)	Replacement costs	Annual expenditures to replace the existing physical assets
	Physical assets replacement value	A1 The estimated amount of capital that would be requested to build the existing physical asset A1

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KPI	FACTORS	DEFINITIONS AND NOTES
PHA6 Total equipment effectiveness[1] R1 x R2 x R3 (%) (see Figure 2)	R1 Maintenance effectiveness (availability defined in IEC 60050-192:2015) (%)	Required time less down time due to maintenance reasons as: – stoppages due to failures, – anomalous situations as reduction of quality, quantity and speed, – preventive actions: predictive, on condition predetermined, – maintenance improvements
		Required time fulfilling the expected technical standard and product characteristics
	R2 Manufacturing effectiveness (%)	Required time less down time due to maintenance less lost time due to manufacturing causes as: – start up, – shutdown, – change over, – speed reduction, – less quantity and quality for operations reasons
		Required time less lost time due to maintenance reasons as: – failures stoppages, – anomalous situations as reduction of quality, quantity and speed, – preventive actions: predictive, on condition, predetermined, – maintenance improvements
	R3 Quality effectiveness (%)	Lost time due to non conformity of quality materials, and process yield with technical standard
		Manufacturing time less lost time due to manufacturing reasons as a start-up, shutdown, change over, speed reduction, quality defects of materials and poor quality for operation mistakes

1) T.E.E., time based, see Figure 2. Named also Overall Equipment Effectiveness =O.E.E.

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KPI	FACTORS	DEFINITIONS AND NOTES
PHA7 Integrity	-High -Medium -Sufficient -Insufficient -Poor	The appraisal values due to the compliance of existing physical asset to: a) laws, b) regulations, c) international standard, d) physical status measured by: 1) integrity tests 2) predictive analysis 3) non-destructive tests
PHA8 Operational availability due to maintenance (%)	Total Operating time	Time when the physical asset is performing as required
	Total Operating time + Downtime	Time when the physical asset is performing as required plus the time lost due to failures and preventive maintenance activities
PHA9 Age of physical asset (%)	Actual cumulative operational life	Total operating time See maintenance records
	Expected cumulative operational life	Expected operating time See management reports
PHA10 Economic life ratio (%)	Total actual cumulative Life	See maintenance records
	Depreciation Life	See economics reports book keeping rules
PHA11 Average unavailability Costs due to maintenance reasons (Euro/hour)	Total unavailability costs	Total costs direct and indirect related to the unavailability due to maintenance
	Total hours of unavailability	Total hours of unavailability due to maintenance reasons
PHA12 Maintenance service level (%)	Achieved performance/required performance	Mix of performance as safety, operational availability, total maintenance cost, quantity of preventive maintenance, etc. measured by predefined indicators to compare the achieved versus the required
PHA13 Average maintenance cost for operational available time (Euro/Hour)	Total maintenance cost	[A1⟩ See M17 ⟨A1]
	Hours of operational availability	See maintenance records
PHA14 Annual maintenance cost on annual total life cost (%)	Annual maintenance costs	[A1⟩ See M17 (annually) ⟨A1]
	Annual total industrial life cost	See total industrial annual cost to keep the physical asset running

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KPI	FACTORS	DEFINITIONS AND NOTES
PHA15 Impact of maintenance on standard technical output (Euro/output unit)	Annual maintenance cost	[A1⟩ See M17 (annually) ⟨A1]
	Annual standard technical output	Annual technical standard output of a physical asset is the quantitative output generated fulfilling the qualitative characteristics
PHA16 Return on improvements (%)	Saving generated by improvements	See accounting reports
	Cost of the implemented improvements	Total expenditures due to the implementation of the improvements
PHA17 Impact of maintenance cost on an annual turnover of physical asset (%)	Total maintenance cost	[A1⟩ See M17 ⟨A1]
	Annual turnover	Turnover generated by the sales of products/services developed by physical asset
PHA18 Direct and indirect cost impact of asset on annual turnover of the asset (%)	Total maintenance cost + unavailability costs + depreciation	See accounting and maintenance reports
	Annual turnover	Turnover generated by the sales of product/service developed by the physical assets
PHA19 Proportion of maintenance time on annual planned time (%)	Down time due to maintenance works	See records of maintenance
	Total annual planned time	See production plan records
PHA20 Contribution of capitalized spare parts on replacement value of physical asset (%)	Cost of capitalized critical spare parts	Value of the annual average inventory of capitalized critical spare parts. The critical spare parts are the spare parts having high unit value, long lead time, whose unavailability [A1⟩ can ⟨A1] create big production loss
	Physical Asset Replacement Value	[A1⟩ Physical asset replacement value is the estimated amount of capital that can be required to build the existing physical asset. ⟨A1]

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