SLOVENSKI STANDARD
**oSIST prEN 16991:2016**

**01-julij-2016**

---

**Območje nadzora na podlagi ocene tveganja**

Risk based inspection framework (RBIF)

Risikobasierte Inspektion (RBIF)

Cadre d’inspection basée sur les risques (RBIF)



**Ta slovenski standard je istoveten z:** **prEN 16991**



---

**ICS:**

| | | |
|---|---|---|
| 03.100.01 | Organizacija in vodenje podjetja na splošno | Company organization and management in general |

**oSIST prEN 16991:2016** **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

**DRAFT**
**prEN 16991**

April 2016

ICS 03.100.01

English Version

# Risk based inspection framework (RBIF)

Cadre d'inspection basée sur les risques (RBIF)

Risikobasierte Inspektion (RBIF)

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 319.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.



CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.



**Warning** : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

**CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels**



Ref. No. prEN 16991:2016 E

# Contents

Page

# European foreword

This document (prEN 16991:2016) has been prepared by Technical Committee CEN/TC 319 “Maintenance”, the secretariat of which is held by UNI.

This document is currently submitted to the CEN Enquiry.

# Introduction

Since the late 1990s, the inspection and maintenance approaches in industry have been globally moving from prescriptive, time-based towards risk-based ones. This trend has been clearly driven by the wish to increase the on-stream production time, to reduce unscheduled downtime due to corrective maintenance and/or reduce equipment condition which could ultimately cause a shut down or have an undesirable impact on process safety.

This European Standard provides the essential elements of risk-based assessment of industrial assets according to the approach which has been developed and demonstrated in and by the European pre-standardization document CWA 15740:2008 (validity prolonged in 2011) and the corresponding RIMAP Network: "Risk-Based Inspection and Maintenance Procedures for European Industry"[2], [3]. One of the main goals of the project, as well as of this standard, has been to make inspection and maintenance programs in the industrial plants more cost-efficient while, at the same time, safety, health, and environmental performance is maintained or improved.

The document is intended for the managers and engineers establishing the RBIM (Risk-based Inspection and Maintenance) policies in the companies in power, process, steel and other relevant industries. It is supposed to be used in conjunction with relevant internationally accepted practices, national regulations and/or company policies. The document is supposed to provide a common reference for formulating the above policies and developing the corresponding inspection and maintenance programs within different industrial sectors.

In the context of other "framework" like documents (e.g. API 580 [4]), this document differs in two main aspects:



— the scope (other, non-process plant, types of equipment are included); and

— the compatibility with the EU regulations and leading ISO standards (9000, 14000, 31000, 55000).



The positive impact and transfer of industry practices resulting from the use of this document and from the approach promoted are expected to be of benefit for the European industry and strengthening of its competitiveness through better inspection and maintenance practices. The background of the RBIM methodology described here is explained more in detailed in the project RIMAP (Risk-based Inspection and Maintenance Procedures for European Industry), [5]. In the project, the industry independent methodology, has been validated for chemical, petrochemical, power and steel industries based on the Application Workbooks [6], [7], [8].

# 1 Scope

The objective of this European Standard is to provide the RBI Framework (RBIF) and basic guideline for Risk-Based Inspection and Maintenance (RBIM) in hydrocarbon and chemical process industries, power generation and other industries.

Although RBIF encompasses both inspection and maintenance, this document focuses primarily on RBI and its applicability within the context of RBIM. The RBIF thereby supports optimization of operations and maintenance as well as asset integrity management.

The main goal of this European Standard is to facilitate the establishment of risk based inspection and maintenance programs in the industrial plants in a documented and efficient way, while, at the same time, legal regulations are complied with and safety, health, and environmental performance is maintained or improved.

The RBIF addresses primarily the static containment equipment (e.g. tanks, piping), dynamic/rotating containment equipment (e.g. pumps, turbines, valves) and pressure relief devices, but can be extended to other types of equipment if appropriate. It addresses primary the equipment and/or systems in the in-service phase of the operation, but can be applied also in the, e.g. design-phase for analysis and determination of maintenance/inspection strategies or life extension phases.

The RBIF approach can also be used to ensure that targets pertinent to health, safety and environment are achieved, providing that legislative requirements are implemented and the required actions are taken.

# 2 Normative references



The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Not applicable.



# 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**3.1**
**risk**
combination of the probability of occurrence of harm and the severity of that harm [1,2]

[SOURCE: ISO/IEC Guide 51:2014]

**3.2**
**risk management**
coordinated activities to direct and control an organization with regard to risk[3]

[SOURCE: ISO Guide 73:2009, ISO 31000:2009]

[1] The probability of occurrence includes the exposure to a hazardous situation, the occurrence of a hazardous event, and the possibility to limit the harm.

[2] Other definitions, e.g. the one from ISO 31000 are recognized, but not used practically in the document.

[3] Systematic application of management policies, procedures, and practices to the tasks of analysing, evaluating and controlling risk

**3.3**
**inspection**
part of maintenance that can be followed by an active maintenance task in order to restore or to retain the availability of an item

**3.4**
**maintenance**
combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function [4]

[SOURCE: EN 13306:2010]

**3.5**
**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 [5]

[SOURCE: EN 13306:2010]

**3.6**
**corrective maintenance**
maintenance carried out after fault recognition and intended to put an item into a state in which it can perform required function



[SOURCE: EN 13306:2010]

**3.7**
**risk based inspection**
**RBI**
risk assessment and management process to plan, implement and evaluate inspections in a structured and documented way



**3.9**
**reliability centred maintenance**
method to identify and select failure management policies to efficiently and effectively achieve the required safety, availability and economy operation [9]

**3.10**
**probability of failure**
extent to which an event is likely to occur within the time frame under consideration [10]

**3.11**
**consequence of failure**
outcome of a failure that may be expressed, for example, in terms of safety to personnel, economic loss, and damage to the environment [11]

---

[4] Maintenance of an asset before the degradation reaches a point that leads to asset failure. It might be divided into time based (a certain interval of time) or condition based (according to the state of the object). Both types of preventive maintenance might be based on prescriptive, legislative or risk based requirements.

[5] Used to mitigate an unwanted condition e.g. leak or coating break down. For low consequence equipment run-to-failure followed by repair might be an acceptable corrective maintenance strategy.

**3.12**
**evergreening**
dynamic process of keeping records and analysis updated and relevant for the current situation

## 4 Abbreviated terms

**Table 1 — Abbreviations**

| Acronym | Definition |
|---|---|
| ALARP | As Low As Reasonably Practicable |
| API | American Petroleum Institute |
| ASME | American Society of Mechanical Engineers |
| CAD | Computer Aided Design |
| CAM | Computer Aided Manufacturing |
| CMMS | Computerized Maintenance Management System |
| CML | Condition Monitoring Location |
| CoF | Consequence of Failure |
| CUI | Corrosion Under Insulation |
| FME(C)A | Failure Mode, Effects (Criticality) and Analysis |
| HAZOP | HAZard and OPerability (study/analysis) |
| HCF / LCF | High Cycle Fatigue / Low Cycle Fatigue |
| HFF / LFF | High Fluid Flow / Low Fluid Flow |
| HS(S)E | Health, Safety (Security) and Environment |
| HSE | Health, Safety and Environment |
| H&S | Health and Safety |
| HT | High Temperature |
| IOW | Integrity Operating Window |
| IPF | Instrument Protective Function |
| KKS | Kraftwerk-Kennzeichensystem, Power Plant Classification System |
| KPI | Key Performance Indicators |
| LoF | Likelihood of Failure<br>NOTE: also referred to Probability of Failure (PoF) in some cases |
| LoPC | Loss of Primary Containment |
| MEI | Maintenance Execution Inspection |
| MOC | Management Of Change |
| MTBF | Mean Time Between Failure |
| NCR | Non Conformity Report |
| NDT | Non-Destructive Testing/inspection |

| Acronym | Definition |
|---|---|
| NII | Non-Intrusive Inspection |
| P&ID | Process and Instrumentation Diagram |
| PHA | Process Hazard Analysis |
| POD | Probability Of Detection |
| PoF | Probability of Failure.<br>NOTE: also referred to Likelihood of Failure (LoF) in some cases |
| PRV | Pressure Relief Valve |
| QA | Quality Assurance |
| QRA | Quantitative Risk Assessment |
| RBI | Risk Based Inspection |
| RBIF | Risk Based Inspection Framework |
| RBIM | Risk Based Inspection and Maintenance |
| RBM, RBLM | Risk-Based Maintenance, Risk-Based Life Management |
| RBWS | Risk Based Work Selection |
| RC(F)A | Root Cause (Failure) Analysis |
| RCM | Reliability Centered Maintenance |
| RIMAP | Risk based Inspection and Maintenance Procedures |
| VIB | Vibration |



# 5 RBI framework

## 5.1 RBIF principles

The risk-based approach shall apply a multi-discipline engineering analysis to ensure that targets related to health, safety, business and environment are met. These targets shall be met by implementing optimized inspection, monitoring and maintenance programs based on an appropriate risk-based methodology covering the following items:

— Planning of the primary work products of RBI assessments and management approach in such a way that risks at system and/or equipment level are managed, considering risks from both health/safety/environment (HSE) perspective and/or from the economic/business standpoints;

— Defining the RBI methodology in a framework which meets requirements of good engineering practices and industrial reference standards in handling hazardous materials and containment;

— Defining the minimum requirements in order to comply with legal or normative regulations and guidelines.

## 5.2 RBIF requirements

### 5.2.1 General requirements

The general requirements of RBIF are:

— the objectives and risk criteria shall be clearly defined;

— the assessment and the applied procedure shall comply with the locally applicable legal and regulatory requirements;

— the adequate level of input information shall be available for the assessment;

— the assessment shall be performed by a multidisciplinary team including personnel with the appropriate required competence and qualifications;

— the integrity and safety assessment and the applied procedures shall provide results, which are:

a) conservative; and

b) representable in a risk matrix, auditable and consistent with both the objectives and applied risk criteria supporting RBI planning and decision making on the target system or component;

— the assessment shall reflect the real conditions in the plant and be kept “evergreen”;

— change management shall be made according to an accepted and recognized standard - such as ISO 9000; and

— in the case that the computer models are used, these models shall be validated.



The RBI process is divided into a main level and an inspection and maintenance strategy level. The main level is shown in Figure 1 and takes into account the following factors:

— the opportunity to eliminate failure causes;



— the risk to personnel during execution of inspection and maintenance; and

— the risk of introducing new failure causes while trying to eliminate existing ones.

In cases where substituting the inspection and maintenance strategy is not possible, technical (e.g. robotics) or organizational (e.g. training) measures may be introduced to reduce risk and to avoid introducing new failures.

The decision-logic serves to three important purposes:

— to ensure a systematic evaluation of the need for inspective maintenance activities;

— to ensure consistency of the evaluation between different units, plant systems and similar units in different locations; and

— to simplify the documenting of the conclusions reached.

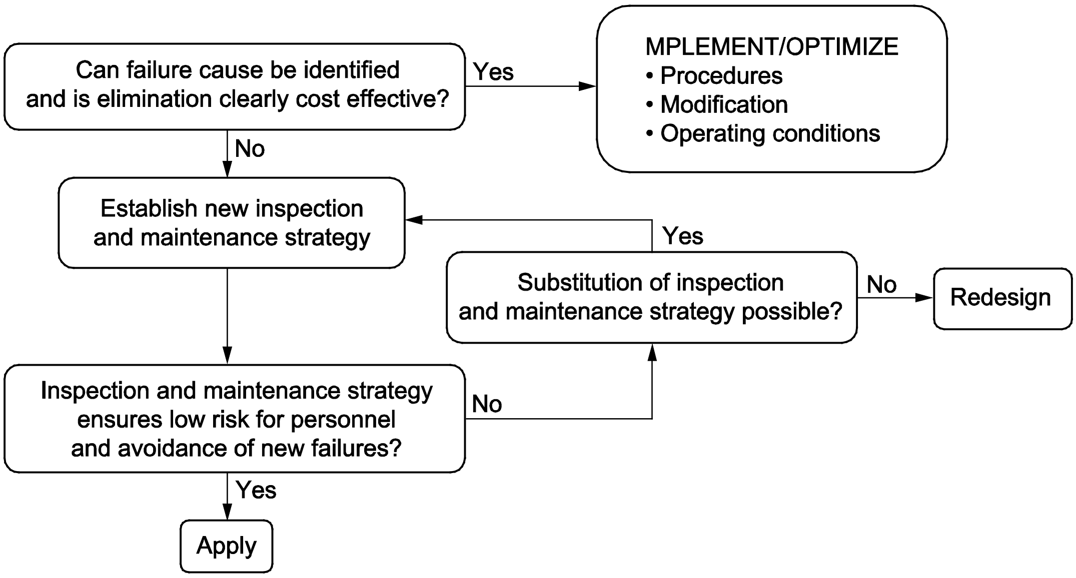


**Figure 1 — The main level of the decision making framework**

When the inspection and maintenance strategy has been determined, the method, intervals, and extent of inspection shall be determined so that risks remain acceptable and costs are optimized (ALARP). This is achieved by establishing risk reduction measures for the items that exceed the acceptance limits, and, where possible by mitigating measures like inspections and maintenance for items that remain below these limits for the period of assessment. The risk reduction effect of alternative measures as well as the costs of these measures shall be determined.

The approaches and methodologies used in RBIF should be compatible with the generic requirement resulting from basic ISO Standards such as ISO 9000-series, ISO 14000-series, ISO 55000 and, in particular, ISO 31000-series (IEC/ISO 31010, ISO/IEC Guide 51, ISO Guide 72, ISO Guide 73). Other standards with which RBIF should be also compatible are EN 13306, OHSAS 18001, ISO 22301 and ISO/IEC 17020.

### 5.2.2 Plant and process documentation

The assignment of a risk-based inspection plan for pressure equipment item shall follow a well-defined, rigorous, and logical process to ensure that all pertinent information has been considered. Otherwise, critical factors may be overlooked.

The RBI process shall be clearly documented in a written procedure. This document procedure shall be referenced and controlled. The procedure shall define each step to be taken during the risk assessment process. The procedure shall explain in detail how hazards are defined for each system or item, how PoF and CoF are established, and how this is used to determine risk level and inspection plans.

It is essential that all RBI assessment shall be clearly documented with all factors contributing to the final risk assessment defined. A minimum documentation shall include:

— team members performing the assessment and their competence,

— re-assessment interval;

— factors used to determine risk;

— assumptions made during the assessment;

— risk assessment results (unmitigated risk levels);

— actions required to move to new mitigation risk levels; and

— optionally: risk assessment results (mitigated risks levels).

This documentation will allow risk assessments to be reviewed on a regular basis and to be revised based on changes to process, updated inspection information, and other new information.

### 5.2.3 Personnel requirements

RBIF requires competent personnel at all levels as well as appropriate routines for the execution of the assessment. The RBI program shall define the personnel who will participate during each stage of the risk assessment, including their required qualifications, training, plant specific knowledge and experience. Key RBI team members should include:

— a team leader(facilitator);

— a materials and damage mechanism specialist with sufficient qualification and experience to understand the process, predict failure mechanisms and identify limitations in inspection techniques;

— an inspection and maintenance specialist;

— a plant operation and process specialist;

— reliability and risk assessment personnel, environment, health and safety personnel and financial and business personnel; and

— an external specialist, e.g. a regulator.



The RBIF shall have a documented process in place for assessing the competency level of the personnel involved in the risk assessment to ensure that the team has the required knowledge and experience to make sound judgments.



The team shall have technical knowledge and RBI experience. All personnel participating in the RBI program shall understand the program and the implications of the decisions made.

Particular cases, depending on the type of industry, the personnel may require special competencies. In addition, local rules and legislation, may set requirements to competencies involved. Due consideration should be given to the width of background skills and expertise collated in the team. One or more of the skills may be possessed by one person, but it is emphasized that RBI planning is a team effort and usually needs a facilitator.

### 5.2.4 Requirements for performing PoF analysis

#### 5.2.4.1 General requirements

General RBIF requirements for PoF analysis are:

1) recognized models;

2) conservatism of simplified approaches;

3) auditability of results;

4) competences;

5) multi-level approaches (screening - detailed, in level of asset hierarchy); and

6) additional aspects to be considered.

These requirements are explained in detail below.

#### 5.2.4.2 Recognized models

PoF assessment method shall be verified/benchmarked against a recognized (established) degradation model, which is generally being used, accepted and referred to in the open literature (e.g. the standards like IEC/ISO 31010).

#### 5.2.4.3 Conservatism of simplified approaches

Available methods for determining Probability of Failure may vary in the level of detail. The results from the risk screening shall be conservative compared to the results from a detailed analysis; in other words it may yield higher or equal average score of probability of failure compared to a more detailed approach.

#### 5.2.4.4 Auditability of results

The results shall be auditable by similar experts (peer view); therefore the methodology, the input data, the decision criteria and the results shall be documented (the results may be recorded in an approved document).

#### 5.2.4.5 Competences

The RBI team shall include with written evidence the following areas of expertise: inspection, maintenance, materials and damage mechanism, process technology, RBI, operations and facilitation. For each area of expertise a certain requirement shall be defined related to competence and experience. Some of the expertise may be combined in one person.



#### 5.2.4.6 Multi-level approaches (screening - detailed, in level of asset hierarchy)

Qualitative, semiquantitative or quantitative approaches (ranging from screening to detailed) shall be used. The use of descriptive terms, such as “very high” to “very low” or similar can be used only if the meaning (explanation) of these terms is provided. The approach can be multi-level both in terms of “qualitative/quantitative” and in terms of level of asset hierarchy.

#### 5.2.4.7 Additional aspects to be considered

The PoF assessment shall be structured with well-defined boundary conditions. It should (in order to allow the use of other/similar approaches for global companies) be done in such a way that the following aspects are covered to screen the operation and identify the relevant degradation mechanism.

— identify susceptible degradation mechanism;

— establish realistic (“best estimate”) damage rates;

— assess the effect of the inspection and monitoring program in the past as well as the one planned for the future;

— determine the confidence level in the damage rate e.g. consider the following aspects:

   a) inspection history and validity;

   b) process parameters and available process data;

   c) degradation models, their applicability and shortcomings; and

   d) effect of mitigation such as effect of inhibitors and recoating;