

# SVENSK STANDARD

## SS-EN 16991:2018

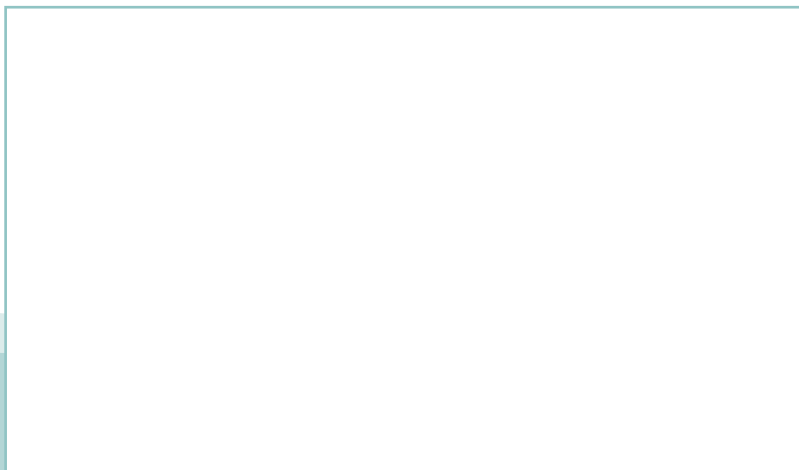


Fastställt/Approved: 2018-05-02  
Publicerad/Published: 2018-05-03  
Utgåva/Edition: 1  
Språk/Language: engelska/English  
ICS: 03.100.01

---

### **Riktlinjer för riskbaserad inspektion (RBI)**

### **Risk-based inspection framework**



# Standarder får världen att fungera

*SIS (Swedish Standards Institute) är en fristående ideell förening med medlemmar från både privat och offentlig sektor. Vi är en del av det europeiska och globala nätverk som utarbetar internationella standarder. Standarder är dokumenterad kunskap utvecklad av framstående aktörer inom industri, näringsliv och samhälle och befrämjar handel över gränser, bidrar till att processer och produkter blir säkrare samt effektiviserar din verksamhet.*

## Delta och påverka

Som medlem i SIS har du möjlighet att påverka framtida standarder inom ditt område på nationell, europeisk och global nivå. Du får samtidigt tillgång till tidig information om utvecklingen inom din bransch.

## Ta del av det färdiga arbetet

Vi erbjuder våra kunder allt som rör standarder och deras tillämpning. Hos oss kan du köpa alla publikationer du behöver – allt från enskilda standarder, tekniska rapporter och standardpaket till handböcker och onlinetjänster. Genom vår webbtjänst e-nav får du tillgång till ett lättnavigerat bibliotek där alla standarder som är aktuella för ditt företag finns tillgängliga. Standarder och handböcker är källor till kunskap. Vi säljer dem.

## Utveckla din kompetens och lyckas bättre i ditt arbete

Hos SIS kan du gå öppna eller företagsinterna utbildningar kring innehåll och tillämpning av standarder. Genom vår närhet till den internationella utvecklingen och ISO får du rätt kunskap i rätt tid, direkt från källan. Med vår kunskap om standarders möjligheter hjälper vi våra kunder att skapa verklig nytta och lönsamhet i sina verksamheter.

**Vill du veta mer om SIS eller hur standarder kan effektivisera din verksamhet är du välkommen in på [www.sis.se](http://www.sis.se) eller ta kontakt med oss på tel 08-555 523 00.**



# Standards make the world go round

*SIS (Swedish Standards Institute) is an independent non-profit organisation with members from both the private and public sectors. We are part of the European and global network that draws up international standards. Standards consist of documented knowledge developed by prominent actors within the industry, business world and society. They promote cross-border trade, they help to make processes and products safer and they streamline your organisation.*

## Take part and have influence

As a member of SIS you will have the possibility to participate in standardization activities on national, European and global level. The membership in SIS will give you the opportunity to influence future standards and gain access to early stage information about developments within your field.

## Get to know the finished work

We offer our customers everything in connection with standards and their application. You can purchase all the publications you need from us - everything from individual standards, technical reports and standard packages through to manuals and online services. Our web service e-nav gives you access to an easy-to-navigate library where all standards that are relevant to your company are available. Standards and manuals are sources of knowledge. We sell them.

## Increase understanding and improve perception

With SIS you can undergo either shared or in-house training in the content and application of standards. Thanks to our proximity to international development and ISO you receive the right knowledge at the right time, direct from the source. With our knowledge about the potential of standards, we assist our customers in creating tangible benefit and profitability in their organisations.

**If you want to know more about SIS, or how standards can streamline your organisation, please visit [www.sis.se](http://www.sis.se) or contact us on phone +46 (0)8-555 523 00**



Europastandarden EN 16991:2018 gäller som svensk standard. Detta dokument innehåller den officiella engelska versionen av EN 16991:2018.

The European Standard EN 16991:2018 has the status of a Swedish Standard. This document contains the official version of EN 16991:2018.

© Copyright/Upphovsrätten till denna produkt tillhör SIS, Swedish Standards Institute, Stockholm, Sverige. Användningen av denna produkt regleras av slutanvändarlicensen som återfinns i denna produkt, se standardens sista sidor.

© Copyright SIS, Swedish Standards Institute, Stockholm, Sweden. All rights reserved. The use of this product is governed by the end-user licence for this product. You will find the licence in the end of this document.

*Upplysningar om sakinnehållet i standarden lämnas av SIS, Swedish Standards Institute, telefon 08-555 520 00. Standarder kan beställas hos SIS som även lämnar allmänna upplysningar om svensk och utländsk standard.*

*Information about the content of the standard is available from the Swedish Standards Institute (SIS), telephone +46 8 555 520 00. Standards may be ordered from SIS, who can also provide general information about Swedish and foreign standards.*

Denna standard är framtagen av kommittén för Underhåll, SIS/TK 113.

Har du synpunkter på innehållet i den här standarden, vill du delta i ett kommande revideringsarbete eller vara med och ta fram andra standarder inom området? Gå in på [www.sis.se](http://www.sis.se) - där hittar du mer information.



EUROPEAN STANDARD

EN 16991

NORME EUROPÉENNE

EUROPÄISCHE NORM

April 2018

ICS 03.100.01

English Version

## Risk-based inspection framework

Cadre d'inspection basée sur les risques

Risikobasierte Inspektion (RBIF)

This European Standard was approved by CEN on 22 October 2017.

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. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists 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, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



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

**CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels**

# Contents

Page

European foreword .....	5
Introduction.....	6
<b>1 Scope .....</b>	<b>7</b>
<b>2 Normative references .....</b>	<b>7</b>
<b>3 Terms and definitions.....</b>	<b>7</b>
<b>4 Abbreviated terms .....</b>	<b>10</b>
<b>5 The RBI framework principles.....</b>	<b>11</b>
<b>5.2 RBIF requirements.....</b>	<b>12</b>
<b>5.2.1 General requirements.....</b>	<b>12</b>
<b>5.2.2 Plant and process documentation.....</b>	<b>13</b>
<b>5.2.3 Personnel requirements .....</b>	<b>14</b>
<b>5.2.4 Requirements for performing CoF analysis .....</b>	<b>15</b>
<b>5.2.5 Requirements for performing PoF analysis.....</b>	<b>16</b>
<b>5.2.6 Requirements for risk assessment.....</b>	<b>18</b>
<b>5.3 RBIF within the overall management system.....</b>	<b>18</b>
<b>5.4 Compatibility with other known approaches.....</b>	<b>19</b>
<b>6 The RBIF process .....</b>	<b>19</b>
<b>7 Initial analysis and planning .....</b>	<b>21</b>
<b>7.1 General description and scope .....</b>	<b>21</b>
<b>7.1.1 General .....</b>	<b>21</b>
<b>7.1.2 Planning and the preliminary analysis.....</b>	<b>21</b>
<b>7.1.3 Definition of objectives.....</b>	<b>21</b>
<b>7.1.4 Definition of systems, sub-systems (loops) and equipment to be considered.....</b>	<b>22</b>
<b>7.1.5 Definition of the scope of analysis.....</b>	<b>22</b>
<b>7.1.6 Definition of data sources available .....</b>	<b>22</b>
<b>7.1.7 Definition of regulations to be considered.....</b>	<b>23</b>
<b>7.1.8 Team specifications .....</b>	<b>23</b>
<b>7.1.9 Tools to be used.....</b>	<b>24</b>
<b>7.1.10 Accuracy of the acceptance of the methodology.....</b>	<b>24</b>
<b>7.2 Requirements.....</b>	<b>24</b>
<b>7.3 Inputs .....</b>	<b>24</b>
<b>7.4 Procedure .....</b>	<b>25</b>
<b>7.5 Output .....</b>	<b>25</b>
<b>7.6 Warnings and applicability limits .....</b>	<b>25</b>
<b>8 Data collection and validation .....</b>	<b>26</b>
<b>8.1 General description and scope .....</b>	<b>26</b>
<b>8.2 Requirements.....</b>	<b>26</b>
<b>8.3 Input.....</b>	<b>27</b>
<b>8.3.1 General .....</b>	<b>27</b>
<b>8.3.2 Collect and validate documented data.....</b>	<b>27</b>
<b>8.3.3 Collect relevant non-documented data .....</b>	<b>28</b>
<b>8.4 Procedure .....</b>	<b>28</b>

8.5	Output .....	29
8.6	Warnings and applicability limits.....	29
9	Multilevel risk analysis (ranging from screening to detailed) .....	30
9.1	General description and scope.....	30
9.2	Risk analysis - screening level.....	30
9.2.1	General.....	30
9.2.2	Inputs .....	31
9.2.3	Procedure .....	31
9.2.4	Output .....	31
9.3	Risk analysis - detailed assessment .....	32
9.3.1	General.....	32
9.3.2	Requirements.....	33
9.3.3	Inputs .....	33
9.3.4	Procedure .....	34
9.3.5	Output .....	36
	<b>ng/action plan</b>	
10.1	General description and scope.....	38
10.2	Requirements.....	38
10.3	Inputs .....	39
10.4	Procedure .....	39
10.4.1	General.....	39
10.4.2	Define degradation groups and relevant susceptible areas.....	40
10.5	Output .....	41
10.6	Warnings and applicability limits.....	42
11	Execution and reporting.....	42
11.1	General description and scope.....	42
11.2	Input .....	43
11.3	Procedure .....	43
11.4	Output .....	46
11.5	Warning/ application limits .....	46
12	Performance review/Evergreening phase .....	46
12.1	General description and scope.....	46
12.2	Requirements.....	47
12.3	Inputs .....	47
12.4	Procedure .....	48
12.4.1	General.....	48
12.4.2	Work process efficiency benchmarking.....	48
Annex A	(informative) Assessments .....	50
A.1	Example of a multilevel RBI analysis in power industry.....	50
A.2	Example of screening and detailed risk assessment.....	54
A.3	Reliability of risk assessment results in the screening phase.....	58
A.4	Example of assessment of damage/failure probability .....	59
A.5	Example of probability and consequence factors for qualitative analysis on the screening and detailed levels .....	60
A.6	Examples of types of in-service damage and their specifications .....	61
A.7	Example of various types of damage and their specifications in relation to hierarchical structure of the plant.....	63

**SS-EN 16991:2018 (E)**

<b>A.8</b>	<b>Example of classification of type of damage vs. prioritized methods of inspection.....</b>	<b>65</b>
<b>A.9</b>	<b>Example for determination of PoF .....</b>	<b>68</b>
<b>A.10</b>	<b>Example for determination of CoF.....</b>	<b>70</b>
<b>A.11</b>	<b>Example of KPIs and objectives for selection.....</b>	<b>76</b>
<b>A.12</b>	<b>Example of a RBI management system evaluation questionnaire [34] .....</b>	<b>79</b>
<b>A.13</b>	<b>Example of formulation and degradation of components, structures and systems.....</b>	<b>81</b>
	<b>Bibliography .....</b>	<b>83</b>



## European foreword

This document (EN 16991:2018) 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 October 2018 and conflicting national standards shall be withdrawn at the latest by October 2018.

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.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus,

Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

**SS-EN 16991:2018 (E)****Introduction**

Since the late 1990s, inspection and maintenance approaches in industry have been globally moving from prescriptive, time-based towards risk-based ones. This trend has clearly been established by the wish to increase the on-stream production time, to reduce unscheduled downtime due to corrective maintenance, to avoid shutdown due to equipment failure and/or to reduce undesirable impacts on process safety.

This European Standard provides the essential elements of risk-based assessment of industrial assets according to the approach developed and demonstrated in the European pre-standardization document CWA 15740:2008 [1]. The CWA 15740 document was updated in 2011, and from 2014 its further development continued within this document and the corresponding EU Project RIMAP (Risk-Based Inspection and Maintenance Procedures for European Industry) [2] [3].

The document is intended for managers and engineers establishing the RBIM (Risk-based Inspection and Maintenance) policies in the process, power, steel and other relevant industries. This document is intended to be used in conjunction with the relevant internationally accepted practices, national regulations and RBI

developing the corresponding inspection and maintenance programs.

The background of the RBIM methodology is provided by the EU project RIMAP (Risk-based Inspection and Maintenance Procedures for European Industry) [4]. In this project, the industry independent methodology has been validated for chemical, petrochemical, power and steel industries and summarized in the respective RIMAP Application Workbooks [4].

The main goal of this European Standard and the former RIMAP project is to support the establishment and application of risk-based inspection and maintenance programs in industrial plants in a documented and efficient way, while at the same time maintaining or improving safety, health and environment performance.

The RBIF addresses primarily static pressure equipment (e.g. tanks, piping), but is also applicable to dynamic/rotating equipment (e.g. pumps, turbines, valves) and pressure relief devices, and it can be extended to other types of equipment, if appropriate. It addresses primarily the equipment and/or systems in the in-service phase of the operation, but can also be applied in the design-phase for analysis and/or determination of maintenance/inspection strategies or life extension phases. Application of this RBIF in industry will take into account also the general developments in the industry and maintenance practices (e.g. The Industry 4.0).

## 1 Scope

This European Standard specifies the Risk-Based Inspection Framework (RBIF) and gives guidelines for Risk-Based Inspection and Maintenance (RBIM) in hydrocarbon and chemical process industries, power generation and other industries where RBI is applicable.

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

## 2 Normative references

There are no normative references in this document.

## 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

Note 1 to entry: The probability of occurrence includes the exposure to a hazardous situation, the occurrence of a hazardous event, and the possibility to limit the harm.

Note 2 to entry: Other definitions, e.g. the one from ISO 31000 are recognized, but not used practically in the document.

[SOURCE: ISO/IEC Guide 51:2014, 3.9]

### 3.2 risk management

coordinated activities to direct and control an organization with regard to risk

Note 1 to entry: Systematic application of management policies, procedures, and practices to the tasks of analysing, evaluating and controlling risk.

[SOURCE: ISO Guide 73:2009, 2.1, ISO 31000:2009, 2.2]

### 3.3 equipment

individual item that is part of a system, equipment is comprised of an assemblage of components Examples include pressure vessels, pressure relief devices, piping, boilers and heaters.

[SOURCE: API RP 581:2016, 3.1.23]

### 3.4 inspection

examination for conformity by measuring, observing or testing the relevant characteristics of an item

[SOURCE: EN 13306:2010, 8.1]