IECEE OPERATIONAL DOCUMENT

IEC System of Conformity Assessment Schemes for Electrotechnical Equipment and Components (IECEE System)

IECEE Scheme for Certification of Personnel Competence for Machinery Safety

Specification for Units of Competence Assessment Outcomes
FOREWORD

Document Owner
IECEE CMC WG34 “Certification of Personnel Competence”

History of changes

<table>
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<tr>
<th>Revision Date</th>
<th>Brief summary of changes</th>
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<tr>
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<table>
<thead>
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IECEE Scheme for Certification of Personnel Competence for Machinery Safety
Specification for Units of Competence Assessment Outcomes

1 Scope

This Operation Document specifies the competence of personnel concerning the safety of machines specified in ISO 12100 which are used in the industrial field. It categorizes the competence required for implementation of risk assessment and protective measures based on its risk assessment results, and specifies the knowledge and skills required for each unit. It does not apply to knowledge or skills related to general mechanical design or manufacturing, excluding the field of machinery safety, or knowledge or skills in specific technical fields, or the ethics of engineers who engage in technical work using such knowledge or skills as a foundation.

Note 1 Although this Operation Document describes tasks that can be carried out by persons who have competence specified in each unit of competence, it does not limit each person’s work or duties to these tasks in actual operations.

Note 2 This Operation Document shows the categorization of competence based on the knowledge and skills required generally in the field of machinery safety, and is not intended to apply only to specific duty positions such as a designer. The users of this Operation Document are recommended to determine the required competence on the basis of work specified for each unit of competence.

Note 3 The “machinery used in the industrial field” in this Operation Document means machinery used in workplaces, and does not include machinery used in public environments or households. “Competence” means the same as what is defined in ISO/IEC 17024 as the ability to apply knowledge and skills to achieve intended results.

2 Normative references

The following standards constitute part of the provisions of this standard by quotation. For these normative references, their latest editions (including any amendments) apply.

ISO 12100, Safety of machinery-General principles for design- Risk assessment and risk reduction
ISO 13849-1, Safety of machinery—Safety-related parts of control systems-Part 1: General principles for design
IEC 60204-1, Safety of machinery—Electrical equipment of machines—Part 1: General requirements
ISO/IEC Guide 51, Safety aspects — Guidelines for their inclusion in standards

3 Terms and definitions

The main terms and definitions used in this standard are as in ISO 12100, ISO 13849-1, IEC 60204-1 and ISO/IEC Guide 51, and the following:

3.1 Knowledge

Facts, information, truths, principles or understanding acquired through experience or education (see ISO/IEC TS 17027:2014, 2.56)

3.2 Skill

Ability to perform a task or activity with a specific intended outcome acquired through education, training, experience or other means (see ISO/IEC TS 17027:2014, 2.74)
4 Competence required for personnel concerning machinery safety

4.1 Provisions and categorization of competence

The competence of personnel in machinery safety is specified by the ability to apply knowledge and skills related to the field of machinery safety.

The categories of competence specified in this Operation Document to properly implement risk assessment and protective measures based on ISO 12100 are as in Table 1. And the knowledge and skills required for each unit of competence are listed in Annex A.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>M10</td>
<td>Basics of machinery safety</td>
</tr>
<tr>
<td>M20</td>
<td>Risk assessment of machinery</td>
</tr>
<tr>
<td>M30</td>
<td>Planning of protective measures for machinery</td>
</tr>
<tr>
<td>M41</td>
<td>Design of protective measures for machinery–Mechanical design field</td>
</tr>
<tr>
<td>M42</td>
<td>Design of protective measures for machinery–Electrical design field</td>
</tr>
<tr>
<td>M43</td>
<td>Design of protective measures for machinery–Control design field</td>
</tr>
</tbody>
</table>

4.2 M10–Basics of machinery safety

4.2.1 General

M10 specifies the competence to safely operate machine(s). Personnel who have this competence can safely carry out routine and non-routine work on machinery for which adequate risk reduction has been implemented.

4.2.2 Work that can be carried out

The work that can be carried out by personnel capable of M10 is as in Table 2.

<table>
<thead>
<tr>
<th>Item</th>
<th>Work description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe operation of machines</td>
<td>Understand the basic knowledge of the field of machinery safety to operate machine(s).</td>
</tr>
<tr>
<td>Checking of protective measures against hazards</td>
<td>Understand the hazards in machine(s) to be used, and make sure that protective measures are maintained.</td>
</tr>
</tbody>
</table>

4.2.3 Required knowledge

Personnel capable of M10 shall have the following knowledge.

a) The following basic knowledge of machinery safety:

1) Basics of machinery safety (see 5.1)
2) Concept of safety in machinery safety standards (see 5.2)

b) Skills required to carry out duties are not specified.

4.3 M20–Risk assessment of machinery

4.3.1 General

M20 specifies the knowledge and skills for the understanding of an overview of risk assessment that aimed to persons that participate in risk assessment team to carry out a risk analysis used to conduct a risk assessment according to ISO 12100.

protective measures.
4.3.2 Work that can be carried out

The work that can be carried out by personnel capable of M20 is as in Table 3.

<table>
<thead>
<tr>
<th>Item</th>
<th>Work description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification of hazards</td>
<td>Understand the following information and list hazards:</td>
</tr>
<tr>
<td></td>
<td>- Tasks in all phases of the machine life cycle</td>
</tr>
<tr>
<td></td>
<td>- Machine behaviors at normal and failure time</td>
</tr>
<tr>
<td></td>
<td>- Unintended behavior by operators and/or reasonably foreseeable misuse</td>
</tr>
<tr>
<td>Risk estimation</td>
<td>Evaluate the risk elements of each hazard according to the given estimation tools.</td>
</tr>
</tbody>
</table>

4.3.3 Required knowledge and skills

M20 shall have the following knowledge and skills.

a) The following knowledge of machinery safety:

1) Basics of machinery safety (see 5.1)
2) Concept of safety in machinery safety standards (see 5.2)
3) Process of risk assessment (see 5.3)
4) Inherently safe design measures (see 5.4)
5) Basic knowledge of safeguarding (see 5.8.1)
6) Basic knowledge of complementary protective measure (see 5.9.1)
7) Information for use (see 5.10)

b) The following skills required for implementation of practical tasks:

The skills to carry out the following in the process of risk assessment based on 5.3:

1) Identification of hazards (see 5.3.2)
2) Risk estimation (see 5.3.3)

4.4 M30–Planning of protective measures for machinery

4.4.1 General

M30 specifies the competence to plan protective measures on the basis of the results of risk assessment. This unit can carry out risk assessment as a team leader. And they can plan protective measures according to the results of risk assessment, understanding their relationships with related group safety standards and/or product safety standards. If there is a design change or the like related to machinery safety during setting up or operation of machinery, they can carry out risk reassessment on the change and can plan additional protective measures on the basis of its results.

Note The classification of group safety standards and product safety standards is as in ISO/IEC Guide 51.

4.4.2 Work that can be carried out

The work that can be carried out by personnel capable of M30 is as in Table 4.

<table>
<thead>
<tr>
<th>Item</th>
<th>Work description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation of risk assessment</td>
<td>Carry out risk assessment as a team leader.</td>
</tr>
<tr>
<td>Planning of protective measures</td>
<td>Plan protective measures based on the three-step method according to the results of risk assessments.</td>
</tr>
<tr>
<td>Documentation of risk assessment and risk reduction</td>
<td>Document results of risk assessment as well as procedures and results of risk reduction.</td>
</tr>
</tbody>
</table>
4.4.3 Required knowledge and skills

M30 shall have the following knowledge and skills:

a) The following knowledge of machinery safety:
   1) Basics of machinery safety (see 5.1)
   2) Concept of safety in machinery safety standards (see 5.2)
   3) Process of risk assessment (see 5.3)
   4) Inherently safe design measures (see 5.4)
   5) Design considering prevention of unexpected start-up (see 5.5)
   6) Basic knowledge of design of control systems with appropriate safety functions (see 5.6.1)
   7) Basic knowledge of appropriate design of electrical equipment of machine(s) (see 5.7.1)
   8) Safeguarding (see 5.8)
   9) Basic knowledge of complementary protective measure (see 5.9.1)
   10) Emergency stop functions (see 5.9.2)
   11) Information for use (see 5.10)
   12) Documentation of risk assessment and risk reduction (see 5.11)

b) The following skills required for implementation of practical tasks:
   1) The skills to carry out the following in the process of risk assessment based on 5.3:
      1.1) Determination of limits of machinery (see 5.3.1)
      1.2) Identification of hazards (see 5.3.2)
      1.3) Risk estimation (see 5.3.3)
      1.4) Risk evaluation (see 5.3.4)
   2) Planning of protective measures based on 5.4, 5.5, 5.6.1, 5.7.1, 5.8.1, 5.9.1, and 5.10
   3) Documentation of risk assessment and risk reduction based on 5.11

4.5 M41–Design of protective measures for machinery–Mechanical design field

4.5.1 General

M41 specifies the competence to design mechanical protective measures, in addition to the knowledge and skills in M30. This unit can design protective measures that meet requirements in mechanical design-related standards, on the basis of the results of risk assessment. They can also achieve adequate risk reduction for electrical and control elements related to mechanical elements, in cooperation with other personnel in charge of work for these elements.

4.5.2 Requirements

The applicant shall have the level of technical education (or equivalent) attained, relevant to the application, through documents such as College Certificates and Vocational qualifications etc.
4.5.3 Work that can be carried out

The work that can be carried out by personnel capable of M41 is as in Table 5.

**Note** Although this competence is effective in any of planning, implementation, and verification of protective measures, it does not prescribe that all these tasks be carried out by the same personnel.

<table>
<thead>
<tr>
<th>Item</th>
<th>Work description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determination of requirement specifications for safety</td>
<td>Determine and document mechanical design requirement specifications for safety.</td>
</tr>
</tbody>
</table>
| Design of inherently safe design measures | **At least the following shall be taken into consideration for design:**  
- Visibility  
- Securing of space for prevention from crushing  
- Protection from sharp edges or projections  
- Protection from high-temperature parts  
- Limitation of the propulsive force and velocity of moving elements  
- Limitation of emissions  
- Prevention of hazards of pneumatic and hydraulic equipment |
| Design of safeguarding and complementary protective measures | **At least the following shall be taken into consideration for design:**  
- Appropriate strength of guards  
- Appropriate installation of sensitive protective equipment  
- Design of adequate openings that prevent the intrusion of a human body  
- Design of means for the escape of trapped persons |
| Creation of information for use | **At least the following shall be taken into consideration for creation:**  
- Attention to hazards such as drawing-in, trapping, and caught-in hazards in mechanical parts of machine(s)  
- Provision of information on safe means of access for cleaning, maintenance, and troubleshooting of machine(s) |
| Verification of requirement specifications | Make sure that the designed mechanical protective measures satisfy the requirement specifications for safety. |

4.5.4 Required knowledge and skills

M41 shall have the following knowledge and skills.

a) The following knowledge of machinery safety:
   1) Basics of machinery safety (see 5.1)
   2) Concept of safety in machinery safety standards (see 5.2)
   3) Process of risk assessment (see 5.3)
   4) Inherently safe design measures (see 5.4)
   5) Design considering prevention of unexpected start-up (see 5.5)
   6) Basic knowledge of design of control systems with appropriate safety functions (see 5.6.1)
   7) Basic knowledge of appropriate design of electrical equipment of machine(s) (see 5.7.1)
   8) Safeguarding (see 5.8)
   9) Complementary protective measure (see 5.9)
   10) Information for use (see 5.10)
   11) Documentation of risk assessment and risk reduction (see 5.11)

b) The following skills required for implementation of practical tasks:
   1) Skills required for M30. Details are as in 4.4.3 b).
   2) Skills of design and verification concerning electrical elements of protective measures based on 5.4, 5.5, 5.6.1, 5.7.1, 5.8, 5.9, and 5.10
4.6  M42–Design of protective measures for machinery–Electrical design field

4.6.1  General

M42 specifies the competence to design electrical protective measures, in addition to the knowledge and skills in M30. This unit can design protective measures that meet requirements in electrical design-related standards, on the basis of the results of risk assessment. They can also achieve adequate risk reduction for mechanical and control elements related to electrical elements, in cooperation with other personnel in charge of work for these elements.

4.6.2  Requirements

The applicant shall have the level of technical education (or equivalent) attained, relevant to the application, through documents such as College Certificates and Vocational qualifications etc.

4.6.3  Work that can be carried out

The work that can be carried out by personnel capable of M42 is as in Table 6.

Note

Although this competence is effective in any of planning, implementation, and verification of protective measures, it does not prescribe that all these tasks be carried out by the same personnel.

Table 6–Work that can be carried out by personnel capable of M42

<table>
<thead>
<tr>
<th>Item</th>
<th>Work description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determination of requirement specifications for safety</td>
<td>Determine and document electrical design requirement specifications for safety.</td>
</tr>
</tbody>
</table>
| Design of inherently safe design measures | At least the following shall be taken into consideration for design:  
- Selection of electrical parts and design of circuits that are appropriate for the characteristics of usage environments (ambient temperatures, humidity, altitude, contaminants, vibration, shock, etc.)  
- Appropriate input power supply switching functions  
- Protection from electric shock due to direct and indirect contact  
- Ergonomics-based operator interfaces |
| Design of safeguarding and complementary protective measures | At least the following shall be taken into consideration for design:  
- Safety during isolation from power supplies and electrical energy dissipation  
- Protective structures for preventing contact with hazardous voltage |
| Creation of information for use | At least the following shall be taken into consideration for creation:  
- Markings and warning signs indicating the risk of electric shock and high temperature  
- Warning functions that use light, sound, etc. |
| Verification of requirement specifications | Make sure that the designed electrical protective measures satisfy the requirement specifications for safety. |

4.6.4  Required knowledge and skills

M42 shall have the following knowledge and skills.

   a) The following knowledge of machinery safety:
      1) Basics of machinery safety (see 5.1)
      2) Concept of safety in machinery safety standards (see 5.2)
      3) Process of risk assessment (see 5.3)
      4) Inherently safe design measures (see 5.4)
      5) Design considering prevention of unexpected start-up (see 5.5)
      6) Basic knowledge of design of control systems with appropriate safety functions (see 5.6.1)
      7) Appropriate design of electrical equipment of machine(s) (see 5.7)
      8) Safeguarding (see 5.8)
      9) Basic knowledge of complementary protective measure (see 5.9.1)
     10) Emergency stop functions (see 5.9.2)
11) Information for use (see 5.10)
12) Documentation of risk assessment and risk reduction (see 5.11)

b) The following skills required for implementation of practical tasks:
1) Skills required for M30. Details are as in 4.4.3 b).
2) Skills of design and verification concerning electrical elements of protective measures based on 5.4, 5.5, 5.6.1, 5.7, 5.8, 5.9.1, 5.9.2, and 5.10

4.7 M43–Design of protective measures for machinery–Control design field

4.7.1 General
M43 specifies the competence to design protective measures in control systems, in addition to the knowledge and skills in M30. This unit can design protective measures that meet requirements in safety design-related standards for control systems, on the basis of the results of risk assessment. They can also achieve adequate risk reduction for mechanical and electrical design elements related to control elements, in cooperation with other personnel in charge of work for these elements.

4.7.2 Requirements
The applicant shall have the level of technical education (or equivalent) attained, relevant to the application, through documents such as College Certificates and Vocational qualifications etc.

4.7.3 Work that can be carried out
The work that can be carried out by personnel capable of M43 is as in Table 7.

Note: Although this competence is effective in any of planning, implementation, verification, and validation of protective measures, it does not prescribe that all these tasks be carried out by the same personnel.

<table>
<thead>
<tr>
<th>Item</th>
<th>Work description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determination of requirement specifications for safety</td>
<td>Determine and document control design requirement specifications for safety.</td>
</tr>
<tr>
<td>Design of inherently safe design measures</td>
<td>At least the following shall be taken into consideration for design: - Avoidance of hazardous behavior of machine(s) - Safety and ease of control functions</td>
</tr>
<tr>
<td>Design of safeguarding and complementary protective measures</td>
<td>At least the following shall be taken into consideration for design: - PLr or the required SIL which is selected according to the results of risk assessment - Implementation of intended safety functions (including software)</td>
</tr>
<tr>
<td>Creation of information for use</td>
<td>At least the following shall be taken into consideration for creation: - Information on safety-related parts - Information on maintenance of performance of safety-related parts</td>
</tr>
<tr>
<td>Verification and validation of requirement specifications</td>
<td>Make sure that the designed control protective measures satisfy the requirement specifications for safety.</td>
</tr>
</tbody>
</table>

4.7.4 Required knowledge and skills
M43 shall have the following knowledge and skills.

a) The following knowledge of machinery safety:
1) Basics of machinery safety (see 5.1)
2) Concept of safety in machinery safety standards (see 5.2)
3) Process of risk assessment (see 5.3)
4) Inherently safe design measures (see 5.4)
5) Design considering prevention of unexpected start-up (see 5.5)
6) Design of control systems with appropriate safety functions (see 5.6)
7) Basic knowledge of appropriate design of electrical equipment of machine(s) (see 5.7.1)
8) Safeguarding (see 5.8)
9) Basic knowledge of complementary protective measure (see 5.9.1)
10) Emergency stop functions (see 5.9.2)
11) Information for use (see 5.10)
12) Documentation of risk assessment and risk reduction (see 5.11)
b) The following skills required for implementation of practical tasks:
1) Skills required for M30. Details are as in 4.4.3 b).
2) Skills of design and verification concerning electrical elements of protective measures based on 5.4, 5.5, 5.6, 5.7.1, 5.8, 5.9.1, 5.9.2, and 5.10

5 Classification of knowledge and skills

5.1 Basics of machinery safety
The basic knowledge of machinery safety is as follows:

a) Knowledge of the following hazards (see ISO 12100 Annex B, Table B.1)
   1) Mechanical hazards
   2) Electrical hazards
   3) Thermal hazards
   4) Noise hazards
   5) Vibration hazards
   6) Radiation hazards
   7) Material and substance hazards
   8) Hazards arising from neglect of ergonomic principles
   9) Hazards associated with the environment in which the machine is used
  10) Combinations of hazards
b) Knowledge of methodology for risk assessment and risk reduction (see ISO 12100, Clause 4)

5.2 Concept of safety in machinery safety standards
The knowledge of the concept of safety in machinery safety standards is as follows:

a) The following knowledge of the concept of “safety” or “risk”:
   1) Terms and definitions related to machinery safety (see ISO/IEC Guide 51, Clause 3)
   2) Requirements for the use of the words “safety” and “safe” (see ISO/IEC Guide 51, Clause 4)
   3) Elements of risk (see ISO/IEC Guide 51, Clause 5)

b) Knowledge of basic terms and definitions related to machinery safety based on ISO 12100, Clause 3

c) Knowledge of the types and systems of the following standards for machinery safety (see ISO/IEC Guide 51, 7.1):
   1) Basic safety standards
   2) Group safety standards
   3) Product safety standards
   4) Standards that include safety aspects

5.3 Process of risk assessment

5.3.1 Determination of limits of machinery
The knowledge and skills of limits of machinery are as follows (see ISO 12100, 5.3):

a) Knowledge concerning types of limits of machinery
b) Skills of determining limits of machinery

5.3.2 Identification of hazards
The knowledge and skills of identification of hazards are as follows:

a) Knowledge of hazards shown in a) of 5.1 and their details
b) Knowledge of concrete examples of causes and results of hazards (see ISO 12100 Annex B, Table B.2)
c) Knowledge of hazardous situations (see ISO 12100 Annex B, Table B.3)
d) Knowledge of hazardous events (see ISO 12100 Annex B, Table B.3)
e) Knowledge of methods for identification of hazards (see ISO 12100, 5.4 and ISO/TR 14121-2, 5.3.2)
f) Skills of identifying hazards on the basis of a) to e) by taking the following into account:
   1) Human interaction during the whole life cycle of the machine
   2) Possible states of the machine
   3) Unintended behaviour of the operator or reasonably foreseeable misuse of the machine
5.3.3 Risk estimation
The knowledge and skills of risk estimation are as follows:

a) Knowledge of the idea of risk estimation taking the following into consideration (see ISO 12100, 5.5):
   1) Severity of harm
   2) Probability of occurrence of harm consisting of the following elements
      - Exposure of person(s) to the hazard
      - Occurrence of a hazardous event
      - Technical and human possibilities to avoid or limit the harm
b) Knowledge of risk estimation tools (see ISO/TR 14121-2, Clause 6)
c) Skills of implementing risk estimation on the basis of a) and b)

5.3.4 Risk evaluation
The knowledge and skills of risk evaluation are as follows:

a) Knowledge of the purpose and contents of risk evaluation (see ISO 12100, 5.6.1)
b) Knowledge of adequate risk reduction (see ISO 12100, 5.6.2)
c) Skills of determining the necessity and adequacy of protective measures

5.4 Inherently safe design measure
The knowledge and skills of inherently safe design measures are as follows:

a) Knowledge of types and an overview of inherently safe design measures taking the following into consideration (see ISO 12100, 6.2):
   1) Geometrical factors and physical aspects
   2) General technical knowledge of mechanical design
      Note: General technical knowledge of mechanical design can be acquired from technical specifications for mechanical adaptability, materials and their characteristics, and emission values. See ISO 12100, 6.2.3.
   3) Elimination of hazards or reduction of risks by the choice of appropriate technology
   4) Application of the principle of positive mechanical action
   5) Provisions for stability
   6) Provisions for maintainability
   7) Compliance with ergonomic principles
   8) Prevention of electrical hazards
   9) Prevention of hazards in pneumatic and hydraulic equipment
  10) Application of inherently safe design measures to control systems
  11) Minimization of the failure probability of safety functions
  12) Limitation of exposure to hazards by the reliability of equipment
  13) Limiting exposure to hazards through mechanization or automation of loading (feeding)/unloading (removal) operations
  14) Limiting exposure to hazards through location of setting and maintenance points outside hazard zones
b) Skills of designing inherently safe design measures on the basis of a)

5.5 Design considering prevention of unexpected start-up
The knowledge and skills of prevention of unexpected activation are as follows (see ISO 14118):

a) Knowledge of means for isolation from power supplies and energy dissipation that consider the following:
   1) Devices for isolation from power supplies
   2) Locking (securing) devices
   3) Devices for stored-energy dissipation or restraint (containment)
   4) Verification
b) Knowledge of measures, other than isolation from power supplies and energy dissipation, to prevent unexpected start-up that consider the following:
   1) Measures to prevent accidental generation of start commands
   2) Measures to prevent accidental start commands resulting in unexpected start-up
   3) Automatic monitoring of the category 2 stopped condition
b) Skills of designing measures for preventing an unexpected start-up on the basis of a) and b)
5.6 Design of control systems with appropriate safety functions

5.6.1 Basic knowledge
Basic knowledge of design of control systems with appropriate safety functions are as follows (see ISO 13849-1):
   a) Knowledge of parameters for evaluating performance levels (PL) of safety-related parts of control systems (SRP/CS)
   b) Knowledge of specifications and details of safety functions that can be provided by SRP/CS
   c) Knowledge of safety evaluation process and PLr determination of SRP/CS
   d) Knowledge of software safety requirements
   e) Knowledge of fault consideration and fault exclusion

5.6.2 Design and evaluation of control systems
The knowledge and skills of design and evaluation of control systems with appropriate safety functions are as follows:
   a) The following knowledge of design and evaluation of safety-related parts of control systems (SRP/CS) or safety-related electrical control systems (SRECS) (see ISO 13849-1, IEC 60241-1, and ISO 13849-2):
      1) Knowledge of details of evaluation methods for SRP/CS or SRECS
      2) Knowledge of programming and change management of application software
         Note: The application software specified in this standard is created by the machine manufacturers for safety functions (e.g., user programs in programmable controllers), and does not include software embedded into systems by the control device manufacturers (see ISO 13849-1, 3.1.36 and 3.1.37).
   b) Skills of design and evaluation of SRP/CS or SRECS based on knowledge in a) and 5.6.1
   c) Knowledge and skills of validation of SRP/CS or SRECS
   d) Knowledge and skills of documentation of information related to SRP/CS or SRECS

5.7 Appropriate design of electrical equipment of machine(s)

5.7.1 Basic knowledge
The basic knowledge of appropriate design of electrical equipment of machine(s) is as follows (see IEC 6024-1):
   a) Knowledge of the causes of hazardous situations of electrical equipment, and of the protective measures needed for persons exposed to hazards
   b) Knowledge of connection of input power supply conductor, and devices for disconnecting and switching off
   c) Knowledge of design for protection against electric shock
   d) Knowledge of equipotential bonding
   e) Knowledge of control functions
      Note: The control functions include start-up functions, stop functions, operation mode, control functions in the event of failure.
   f) Knowledge of arrangement and installation of operator interface and machine-mounted control devices
      Note: The operator interfaces and machine-mounted control devices include push buttons, indicator lights and displays, start devices, enable control devices.

5.7.2 Design and verification of electrical equipment
The knowledge and skills of appropriate design and verification of electrical equipment of machine(s) are as follows (see IEC 60204-1):
   a) The following knowledge for design of electrical equipment:
      1) Electrical protection of equipment
         Note: The electrical protection of equipment includes overcurrent protection, abnormal temperature protection, and protection against supply interruption or voltage reduction and subsequent restoration.
      2) Power supply and voltage of control circuits
      3) Control gear: location, mounting, and enclosures
      4) Conductors, cables, and wiring
      5) Selection and design of electric motors and associated equipment
      6) Local lighting of accessories and equipment
7) Marking, warning signs and reference designations
   b) Skills of designing electrical equipment on the basis of the knowledge in a) and 5.7.1
   c) Knowledge and skills of technical documentation
   d) Knowledge and skills of verification
   Note: The verification of electrical equipment includes checking of its compliance with technical documents, verification of conditions for protection by automatic disconnection of supply, functional testing.

5.8 Safeguarding

5.8.1 Basic knowledge
The basic knowledge of safeguarding of machine(s) is as follows:
   a) Knowledge of the basic characteristics and use of the following guards:
      1) Fixed guard
      2) Movable guard
      3) Adjustable guard
      4) Interlocking guard
   b) Knowledge of the basic characteristics and use of the following protective devices:
      1) Sensitive protective equipment
      2) Two-hand control device

5.8.2 Selection and design of guards
The knowledge and skills of selection and design of guards are as follows:
   a) The following knowledge for design and manufacture of guards:
      1) Knowledge of important points in guard design For example, minimizing the access to the hazardous zone, and containment of emissions of components and hazardous substances (see ISO 14119 and ISO 14120)
      2) The installation positions of guards and the size of guards and their openings, taking into consideration the intrusion of a human body (see ISO 13855 and ISO 13857)
      3) Minimum gaps to avoid crushing (see ISO 13854)
      4) Principles and types of interlocks and technical measures against defeat of interlocks (see ISO 14119)
   b) Skills of designing guards on the basis of a)

5.8.3 Design of safeguarding measures that use sensitive protective equipment
The knowledge and skills of design of appropriate sensitive protective equipment is as follows (see IEC/TS 62046):
   a) The following knowledge for selection and design of electro-sensitive protective equipment (ESPE):
      1) Selection and design of electro-sensitive protective equipment (ESPE)
      2) Appropriate installation of electro-sensitive protective equipment (ESPE) taking into consideration the intrusion of a human body (see also ISO 13855)
   b) Skills of selection and design of sensitive protective equipment on the basis of a)

5.8.4 Design of other safeguarding measures
The knowledge and skills of other safeguarding measures are as follows:
   a) Knowledge for selection and design of safeguarding measures that consider the following:
      1) Selection and design of two-hand control devices (see ISO 13851)
      2) Selection and design of protective measures for stability
         Note: The protective measures for stability include anchor bolts, fixation devices, limiting devices.
   b) Skills of selection and design of other safeguarding measures on the basis of a)

5.9 Complementary protective measures

5.9.1 Basic knowledge
The basic knowledge for implementation of complementary protective measures of machinery is as follows:
   a) Basic knowledge of emergency stop functions
   b) Knowledge of escape and rescue of trapped persons
   c) Knowledge of isolation and energy dissipation
   d) Knowledge of easy and safe handling of machinery and heavy components
   e) Basic knowledge of safe access to machinery
5.9.2 Emergency stop functions
The knowledge and skills of design of emergency stop functions are as follows (see ISO 13850):
   a) The following knowledge of emergency stop functions:
      1) Types and selection of actuators
      2) Stop and reset by emergency stop functions
   b) Skills of designing emergency stop functions on the basis of a)

5.9.3 Safe means of access to machinery
The knowledge and skills of safe means of access to machinery is as follows:
   a) Knowledge of the design that considers the following, along with all routine tasks of operation, setting (setup, etc.) and maintenance:
      1) Means and routes for safe access to machinery
      2) Safe design of openings
   b) The following knowledge of design of permanent means of access to machinery:
      1) Selection of fixed lifting facilities (see ISO14122-1)
      2) Working platforms and walkways (see ISO 14122-2)
      3) Stairs, stepladders and guard-rails (see ISO 14122-3)
      4) Fixed ladders (see ISO 14122-4)
   c) Skills of designing means of access to machinery on the basis of a) and b)

5.10 Information for use
The knowledge and skills of information for use of machine(s) are as follows (see ISO 12100, 6.4):
   a) The following knowledge of creation of information for use:
      1) Arrangement and characteristics of information for use
      2) Signals and warning devices
      3) Markings, signs (pictograms) and written warnings
      4) Knowledge of accompanying documents
   b) Skills of creating information for use on the basis of a)

5.11 Documentation of risk assessment and risk reduction
The knowledge and skills of documentation of risk assessment are as follows (see ISO 12100, Clause 7):
   a) Knowledge of the contents to be included in documents on risk assessments
   b) Knowledge and skills of documenting implemented procedure, achieved results, and residual risks
<table>
<thead>
<tr>
<th>No.</th>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ISO 13850</td>
<td>Safety of machinery-Emergency stop-Principles for design</td>
</tr>
<tr>
<td>2</td>
<td>ISO 14119</td>
<td>Safety of machinery-Interlocking devices associated with guards-Principles for design and selection</td>
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<tr>
<td>3</td>
<td>ISO 13854</td>
<td>Safety of machinery-Minimum gaps to avoid crushing of parts of the human body</td>
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<td>4</td>
<td>ISO 13851</td>
<td>Safety of machinery-Two-hand control devices-Functional aspects and design principles</td>
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<tr>
<td>5</td>
<td>ISO 14122-1</td>
<td>Safety of machinery-Permanent means of access to machinery-Part1:Choice of a fixed means of access between two levels</td>
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<td>6</td>
<td>ISO 14122-2</td>
<td>Safety of machinery-Permanent means of access to machinery-Part2:Working platforms and walkways</td>
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<td>7</td>
<td>ISO 14122-3</td>
<td>Safety of machinery-Permanent means of access to machinery-Part3:Stairs, stepladders and guard-rail</td>
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<td>8</td>
<td>ISO 14122-4</td>
<td>Safety of machinery-Permanent means of access to machinery-Part4:Fixed ladders</td>
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<td>9</td>
<td>ISO 14118</td>
<td>Safety of machinery-Prevention of unexpected start-up</td>
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<td>10</td>
<td>ISO 13855</td>
<td>Safety of machinery-Positioning of safeguards with respect to the approach speeds of parts of the human body</td>
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<tr>
<td>11</td>
<td>ISO 14120</td>
<td>Safety of machinery-Guards-General requirements for the design and construction of fixed and movable guards</td>
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<td>12</td>
<td>ISO 13857</td>
<td>Safety of machinery-Safety distances to prevent hazard zone being reached by upper and lower limbs</td>
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<td>13</td>
<td>IEC 62061</td>
<td>Safety of machinery-Functional safety of safety-related electrical, electronic and programmable electronic control systems</td>
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<td>14</td>
<td>ISO/IEC 17024</td>
<td>Conformity assessment -General requirements for bodies operating certification of persons</td>
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<td>15</td>
<td>ISO 13849-2</td>
<td>Safety of machinery-Safety related parts of control systems-Part 2: Validation</td>
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<td>16</td>
<td>ISO/TR 14121-2</td>
<td>Safety of machinery - Risk assessment - Part 2: Practical guidance and examples of methods</td>
</tr>
<tr>
<td>17</td>
<td>IEC/TS 62046</td>
<td>Safety of machinery - Application of protective equipment to detect the presence of persons</td>
</tr>
<tr>
<td>18</td>
<td>ISO/IEC TS 17027</td>
<td>Conformity assessment -Vocabulary related to competence of persons used for certification of persons</td>
</tr>
</tbody>
</table>
Annex A
(Normative)
Knowledge and skills required for each unit of competence

The correlation of the categories of competence with the knowledge and skills required for each unit are as in Table A.1.

Table A.1–Classification list of the knowledge and skills required for each unit of competence specified in this Operation Document

<table>
<thead>
<tr>
<th>Classification of the required knowledge and skills</th>
<th>Units of competence</th>
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<tbody>
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<td></td>
<td>M10 Basics of machinery safety</td>
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<tr>
<td>5.2 Concept of safety in machinery safety standards</td>
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<td>5.3 Process of risk assessment</td>
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<td>5.3.1 Determination of limits of machinery</td>
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<td>5.3.2 Identification of hazards</td>
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<td>5.3.3 Risk estimation</td>
<td>D</td>
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<tr>
<td>5.3.4 Risk evaluation</td>
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<tr>
<td>5.4 Inherently safe design measure</td>
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<td>5.5 Prevention of unexpected start-up</td>
<td>P</td>
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<tr>
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<tr>
<td>5.6.1 Basic knowledge</td>
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</tr>
<tr>
<td>5.6.2 Design and evaluation of control systems</td>
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<tr>
<td>5.7 Appropriate design of electrical equipment of machine(s)</td>
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<td>5.7.1 Basic knowledge</td>
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<td>5.7.2 Design and verification of electrical equipment</td>
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<td>5.8 Safeguarding</td>
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<tr>
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<tr>
<td>5.8.2 Selection and design of guards</td>
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<td>5.8.3 Design of safeguarding measures that use sensitive protective equipment</td>
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<td>5.8.4 Design of other safeguarding measures</td>
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<tr>
<td>5.9 Complementary protective measures</td>
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<tr>
<td>5.9.1 Basic knowledge</td>
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<tr>
<td>5.9.2 Emergency stop functions</td>
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<td>5.9.3 Safe means of access to machinery</td>
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<td>5.10 Information for use</td>
<td>K</td>
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<tr>
<td>5.11 Documentation of risk assessment and risk reduction</td>
<td>D</td>
</tr>
</tbody>
</table>

**Note** The symbols in the table denote the following:
- K = Knowledge is required
- P = Knowledge and skills for planning are required
- D = Knowledge and skills for design (implementation) are required

**Footnote**⁹⁰ These knowledge and skills for design (implementation) are required specifically for each specialized (mechanical, electrical, or control) field.
Annex B
(Informative)
Work that can be carried out in each unit of competence

For ease of understanding of this Operation Document, Figure B.1 shows the categories of competence, and lists work that can be carried out in each unit. This shows the main work that can be carried out in each unit of competence, and does not limit the work of personnel who have the relevant competence to the following tasks in actual operations. And the same personnel may carry out the work in each field in M41, M42, and M43 if they have the competence required for the relevant field.

Figure B.1–Work that can be carried out in each unit of competence