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**Safety of machinery—Electro-sensitive
protective equipment—Part 1: General
requirements and tests**

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Health, Labour and Welfare and the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Japan Machinery Federation (JMF) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently JIS B 9704-1: 2000 is replaced with this Standard.

This Standard has been made based on IEC 61496-1: 2004 *Safety of machinery—Electro-sensitive protective equipment—Part 1: General requirements and tests* for the purpose of making it easier to compare this Standard with International Standard; to prepare Japanese Industrial Standard conforming with International Standard; and to propose a draft of an International Standard which is based on Japanese Industrial Standard.

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JIS B 9704 family consists of the following parts under the general title “*Safety of machinery—Electro-sensitive protective equipment*”:

- Part 1: General requirements and tests*
- Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)*
- Part 3: Particular requirements for Active Opto-electronic Protective Devices responsive to Diffuse Reflection (AOPDDR)*

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Safety of machinery—Electro-sensitive protective equipment—Part 1: General requirements and tests

Introduction This Japanese Industrial Standard has been prepared based on the second edition of IEC 61496-1 *Safety of machinery—Electro-sensitive protective equipment—Part 1: General requirements and tests* published in 2004 without any modifications of the technical contents.

The portions given sidelines or dotted underlines are the matters not included in the original International Standard, but added for the purpose of clarifying explanations or helping understanding.

This Standard has the status of the parent standard of the product family standards, and may be used as a normative reference in a dedicated product standard for the safety of machinery.

An electro-sensitive protective equipment (hereafter referred to as "ESPE") is applied to machinery presenting a risk of personal injury. It provides protection by causing the machine to revert to a safe condition before a person can be placed in a hazardous situation.

This part of JIS B 9704 provides general design and performance requirements of ESPE for use over a broad range of applications. Essential features of equipment meeting the requirements of this Standard are the appropriate level of safety-related performance provided and the built-in periodic functional checks/self-checks that are specified to ensure that this level of performance is maintained.

Each type of machine presents its own particular hazards and it is not the purpose of this part of JIS B 9704 to recommend the manner of application of the ESPE to any particular machine. The application of the ESPE should be a matter for agreement between the equipment supplier, the machine user and the enforcing authority, and in this context attention is drawn to the relevant guidance, for example JIS B 9700-1 and JIS B 9700-2.

This part of JIS B 9704 specifies technical requirements of the ESPE. The application of this Standard may require the use of substances and/or test procedures that could be injurious to health unless adequate precautions are taken. Conformance with this Standard in no way absolves either the supplier or the user from statutory obligations relating to the safety and health of persons during the use of the equipment covered by this Standard.

1 Scope This part of JIS B 9704 specifies general requirements for the design, construction and testing of non-contact ESPE designed specifically to detect persons as part of a safety related system for machinery. Special attention is directed to functional and design requirements that ensure an appropriate safety-related performance is achieved. An ESPE may include optional safety-related functions, the requirements for which are given in Annex A. The ESPE including such options shall also apply this Standard.

Requirements for specific types of sensing function shall be specified in other parts of JIS B 9704 (JIS B 9704-2 and JIS B 9704-3 are available at present).

This Standard does not specify the dimensions or configuration of the detection zone and its disposition in relation to hazards in any particular application, nor what constitutes a hazardous state of any machine. It is restricted to the functioning of the ESPE, testing method, marking, ESPE accompanying documents, and how it interfaces with the machine.

This Standard may be relevant to applications other than those for the protection of persons, for example for the protection of machinery or products from mechanical damage. In those applications, different requirements can be necessary, for example when the materials that have to be recognized by the sensing function have different properties from those of persons.

This Standard does not deal with electromagnetic compatibility (EMC) emission requirements.

NOTE: The International Standard corresponding to this Standard is as follows.

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and JIS are IDT (identical), MOD (modified), and NEQ (not equivalent) according to ISO/IEC Guide 21.

IEC 61496-1: 2004 *Safety of machinery—Electro-sensitive protective equipment—Part 1: General requirements and tests* (IDT)

2 Normative references The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. If the indication of the year is given to these referred standards, only the edition of the indicated year constitutes the provision of this Standard but the revision and amendment made thereafter do not apply. The normative references without the indication of the year apply only to the most recent editions (including amendments).

Information: When there are JISs which are identical with the edition of the standard which the original International Standard IEC 61496-1:2004 refers to or JISs to which the standard of the part to refer to is equivalent in content, such JISs are referred to. When there are not these JISs, standards which the original International Standard refers to are referred to as they are.

JIS B 3502:2004 *Programmable controllers—Equipment requirements and tests*

NOTE: IEC 61131-2:1992 *Programmable controllers—Part 2: Equipment requirements and tests* is equivalent to the said standard.

JIS B 9700-1:2004 *Safety of machinery—Basic concepts, general principles for design—Part 1: Basic terminology, methodology*

NOTE: ISO/TR 12100-1:1992 *Safety of machinery—Basic concepts, general principles for design—Part 1: Basic terminology, methodology* is equivalent to the said standard.

Information: ISO 12100-1:2003 is identical with JIS B 9700-1:2004.

JIS B 9700-2:2004 *Safety of machinery—Basic concepts, general principles for design—Part 2: Technical principles*

NOTE: ISO/TR 12100-2:1992 *Safety of machinery—Basic concepts, general principles for design—Part 2: Technical principles* is equivalent to the said standard.

Information: ISO 12100-2:2003 is identical with JIS B 9700-2:2004.

JIS B 9705-1:2000 *Safety of machinery—Safety-related parts of control systems—Part 1: General principles for design*

NOTE: ISO 13849-1:1999 *Safety of machinery—Safety-related parts of control systems—Part 1: General principles for design* is identical with the said standard.

JIS B 9960-1:1999 *Safety of machinery—Electrical equipment of machines—Part 1: General requirements*

NOTE: IEC 60204-1:1997 *Safety of machinery—Electrical equipment of machines—Part 1: General requirements* is equivalent to the said standard.

JIS C 0447:1997 *Man-machine interface (MMI)—Actuating principles*

NOTE: IEC 60447:1993 *Man-machine interface (MMI)—Actuating principles* is identical with the said standard.

JIS C 0664:2003 *Insulation coordination for low-voltage equipment Part 1: Principles, requirements and tests*

NOTE: IEC 60664-1:1992 *Insulation coordination for equipment within low-voltage systems—Part 1: Principles, requirements and tests* is equivalent to the said standard.

JIS C 0920:2003 *Degrees of protection provided by enclosures (IP Code)*

NOTE: IEC 60529:2001 *Degrees of protection provided by enclosures (IP code)* is identical with the said standard.

JIS C 60068-2-6:1999 *Environmental testing Part 2: Tests — Test Fc: Vibration (sinusoidal)* (previous number: JIS C 0040:1999)

NOTE: IEC 60068-2-6:1995 *Environmental testing—Part 2: Tests—Test Fc : Vibration (sinusoidal)* is identical with the said standard.

JIS C 60068-2-29:1995 *Basic environmental testing procedures Part 2: Tests Test Eb and guidance: Bump* (previous number: JIS C 0042:1995)

NOTE: IEC 60068-2-29:1987 *Basic environmental testing procedures—Part 2: Tests—Test Eb and guidance: Bump* is identical with the said standard.

JIS C 61000-4-2:1999 *Electromagnetic compatibility (EMC)—Part 4: Testing and measurement techniques—Section 2: Electrostatic discharge immunity test* (previous number: JIS C 1000-4-2:1999)

NOTE: IEC 61000-4-2:1995 *Electromagnetic compatibility (EMC)—Part 4: Testing and measurement techniques—Section 2: Electrostatic discharge immunity test—Basic EMC publication* is identical with the said standard.

JIS C 61000-4-4:1999 *Electromagnetic compatibility (EMC)—Part 4: Testing and measurement techniques—Section 4: Electrical fast transient/burst immunity test* (previous number: JIS C 1000-4-4: 1999)

NOTE: IEC 61000-4-4:1995 *Electromagnetic compatibility (EMC)—Part 4: Testing and measurement techniques—Section 4: Electrical fast transient/burst immunity test—Basic EMC publication* is equivalent to the said standard.

JIS C 61000-6-2:2003 *Electromagnetic compatibility (EMC)—Part 6: Generic standards—Section 2: Immunity for industrial environments* (previous number: JIS C 1000-6-2:2003)

NOTE: IEC 61000-6-2:1999 *Electromagnetic compatibility (EMC)—Part 6: Generic standards—Section 2: Immunity for industrial environments* is equivalent to the said standard.

JIS C 8201-5-1:1999 *Low-voltage switchgear and controlgear—Part 5-1: Control circuit devices and switching elements—Electromechanical control circuit devices*

NOTE: IEC 60947-5-1:1997 *Low-voltage switchgear and controlgear—Part 5-1: Control circuit devices and switching elements—Electromechanical control circuit devices* is equivalent to the said standard.

JIS Q 9001:2000 *Quality management systems—Requirements*

NOTE: ISO 9001:2000 *Quality management systems—Requirements* is identical with the said standard.

IEC 60050-191:1990 *International Electrotechnical Vocabulary(IEV)—Chapter 191: Dependability and quality of service*

IEC 60249-2 *Base materials for printed circuits—Part 2: Specifications*

IEC 60439-1:1999 *Low-voltage switchgear and controlgear assemblies—Part 1: Type-tested and partially type-tested assemblies*

NOTE: JIS C 0704:1995 *Insulation test for control gear* is equivalent to IEC 60439-1:1985 or others (MOD).

IEC 60445:1999 *Basic and safety principles for man-machine interface, marking and identification—Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system*

NOTE: JIS C 0445:1999 *Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system* is identical with IEC 60445:1988 but not with IEC 60445:1999.

IEC 60950 (all parts) *Information technology equipment—Safety*

NOTE: JIS C 6950:2001 *Safety of information technology equipment* is equivalent to IEC 60950:1991-1996 (MOD). IEC 60950 was revised in 1999 and subsequently withdrawn in 2001, then IEC 60950-1:2001 has been published.

IEC 61000-4-3:2002 *Electromagnetic compatibility (EMC)—Part 4-3 : Testing and measurement techniques—Radiated, radio-frequency, electromagnetic field immunity test*

NOTE: JIS C 61000-4-3:2004 *Electromagnetic compatibility (EMC)—Part 4-3: Testing and measurement techniques—Radiated, radio-frequency, electromagnetic field immunity test* (previous number: JIS C 1000-4-3:2004) is identical with IEC 61000-4-3:1998 but not with IEC 61000-4-3:2002.

IEC 61000-4-5:2001 *Electromagnetic compatibility (EMC)—Part 4-5: Testing and measurement techniques—Surge immunity test*

NOTE: JIS C 61000-4-5:1999 *Electromagnetic compatibility (EMC)—Part 4: Testing and measurement techniques—Section 5: Surge immunity test* (previous number: JIS C 1000-4-5:1999) is equivalent to IEC 61000-4-5:1995 (MOD) but not to IEC 61000-4-5:2001.

IEC 61000-4-6:2001 *Electromagnetic compatibility (EMC)—Part 4-6: Testing and measurement techniques—Immunity to conducted disturbances, induced by radio-frequency fields*

NOTE: JIS C 61000-4-6:1999 *Electromagnetic compatibility (EMC)—Part 4: Testing and measurement techniques—Section 6: Immunity to conducted disturbances, induced by radio-frequency fields* (previous number: JIS C 1000-4-6:1999) is equivalent to IEC 61000-4-6:1996 (MOD) but not to IEC 61000-4-6:2001.

IEC 61508 (all parts) *Functional safety of electrical/electronic/programmable electronic safety-related systems*

NOTE: JIS C 0508-1 to JIS C 0508-7 *Functional safety of electrical/electronic/programmable electronic safety-related systems—Part 1 to Part 7* are identical with CDV or FDIS of IEC 61508-1 to IEC 61508-7 but not with parts of IS of IEC 61508.

3 Terms and definitions For the purposes of this Standard, the following terms and definitions apply.

3.1 blanking optional function that permits an object of a size greater than the detection capability (detectable minimum size) of the ESPE (see 3.5) to be located within the detection zone without causing an OFF-state of the OSSD(s) (see 3.19)

NOTES 1 Fixed blanking is a technique wherein the locations of the blanked areas of the detection zone do not change during operation. The detection capability of the other parts of the detection zone remain unchanged.

2 Floating blanking is a technique wherein the blanked area of the detection zone follows the location of a moving object(s) during operation. The detection capability of the other areas remains unchanged.

3.2 controlling/monitoring device part of the ESPE having functions below

- receives and processes information from the sensing device and provides signals to the OSSD
- monitors the sensing device and the OSSD

3.3 detection capability sensing function (detection performance) parameter limit specified by the supplier that will cause actuation of the ESPE

Information The detectable minimum size of object is one of the parameters for the detection function of the ESPE.

3.4 detection zone zone within which a specified test piece will be detected by the ESPE

Information: It is synonymous with the zone within which a specified part of a person will be detected. Since it is verified by using the test piece that the specified part of a person is detected in the detection zone, it is defined in this way.

3.5 electro-sensitive protective equipment (ESPE) assembly of devices and/or components working together for protective tripping or presence-sensing purposes and comprising as a minimum (referred to as ESPE in this Standard)

- a sensing device
- controlling/monitoring devices
- OSSD (see 3.19)

NOTE: The safety-related control system associated with the ESPE, or the ESPE itself, may further include a secondary switching device (see 3.24), muting functions (see 3.16), stopping performance monitor (see 3.27), etc. (see Annex A).

Information 1 In this Standard, the ESPE is classified into Type 1 to Type 4, and the requirement of the ESPE of Type 2 to Type 4 is specified.

2 In this Standard, when the ESPE is simply written as "ESPE", it means all the types of EPSE. When the ESPE of a specific type is expressed, it is written as "Type N ESPE".

3.6 external device monitoring (EDM) means by which the monitors the state of control devices which are external to the ESPE (referred to as EDM in this Standard)

3.7 failure termination of the ability of an item to perform a required function (according to IEC 60050-191-04-01)

NOTES 1 After failure the item has a fault.

2 'Failure' is an event, as distinguished from 'fault', which is a state.

3 This concept, as defined, does not apply to items consisting of software only.

4 In practice, the terms fault and failure are often used synonymously.

Information: Although "failure" is distinguished from "fault" in the original International Standard, in this Standard the wording of "fault" may be changed to that of "failure".

3.8 failure to danger failure which prevents or delays all the OSSD going to, and/or remaining in the OFF-state in response to a condition which, in normal operation,

would result in their so doing

Information: The condition that the OSSD goes to or remains in the OFF-state shall be as follows (see 4.2.2).

- Loss of detection capability
- Increase in response time beyond the specified time
- Failure of OSSD itself (the OFF-state is impossible)
- Failure in fault detection

3.9 fault state of an item characterized by inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources (according to IEC 60050-191-05-01)

NOTES 1 A fault is often the result of a failure of the item itself, but may exist without prior failure.

- 2 The translations of "fault" into national languages are not always match the definition mentioned above. It is pointed out that the official translation into German and French also does not match the definition mentioned above.

Information: An item refers to a unit of hardware, software or a combination of these.

3.10 final switching device (FSD) component of the machine's safety-related control system that interrupts the circuit to the MPCE (see 3.14) when the OSSD goes to the OFF-state (referred to as FSD in this Standard)

3.11 integrated circuit—complex or programmable monolithic, hybrid or module circuit which satisfies one or more of the criteria below

- a) more than 1 000 gates are used in the digital mode
- b) more than 24 functionally different external electrical connections are available for use
- c) the functions can be programmed

NOTES 1 Examples include ASICs, ROMs, PROMs, EPROMs, PALs, CPUs, PLAs, and PLDs.

- 2 The circuits may function in the analogue mode, the digital mode, or a combination of the two modes.

3.12 integrated circuit—simple monolithic, hybrid or module circuit which satisfies none of the criteria in 3.11

NOTES 1 Examples are SSI or MSI logic ICs, comparators.

- 2 The circuits may function in the analogue mode, in the digital mode, or in a combination of the two modes.

3.13 lock-out condition condition, initiated by a fault, preventing normal operation (3.30) of the ESPE

All OSSDs and, where applicable, all SSDs are signalled to go to the OFF-state.

3.14 machine primary control element (MPCE) electrically powered element that directly controls the normal operation (see 3.29) of a machine in such a way that it is the last element (in time) to function when machine operation is to be initiated or arrested (referred to as "MPCE" in this Standard)

NOTE: This element can be, for example, a power supply contactor, a magnetic clutch or an electrically operated hydraulic valve.

3.15 machine secondary control element (MSCE) machine control element, independent of the machine primary control element(s), that is capable of removing the source of power from the prime mover of the relevant hazardous parts (referred to as "MSCE" in this Standard)

NOTES 1 The MSCE is normally controlled by the SSD.

2 This element can be, for example, a mains contactor, a magnetic clutch or an electromagnetic valve.

3.16 muting temporary automatic suspension of a safety function(s) by safety-related parts of the control system

NOTE: For ESPE-muting, see A.7 in Annex A.

3.17 OFF-state state in which the output circuit does not permit the flow of current

3.18 ON-state state in which the output circuit permits the flow of current

3.19 output signal switching device (OSSD) component of the ESPE connected to the machine control system which, when the sensing device is actuated (detection) during normal operation, (3.29) responds by going to the OFF-state (referred to as "OSSD" in this Standard)

Information: OSSD not only goes to the OFF-state due to the actuation of the sensing device, but also goes to the OFF-state when the ESPE detects internal faults and goes to the lock-out condition.

3.20 overall system stopping performance time interval resulting from the sum of the ESPE response time and the time to the cessation of hazardous machine operation

3.21 response time maximum time between the occurrence of the event leading to the actuation of the sensing device and the OSSD achieving the OFF-state

3.22 restart interlock means of preventing automatic restarting of a machine after actuation of the sensing device during a hazardous part of the machine operating cycle, after a change in mode of operation of the machine, and after a change in the means of start control of the machine

NOTE: Modes of operation include inch, single stroke, automatic. Means of start control include foot switch, two-hand control, and single or double actuation of the ESPE sensing device.

3.23 safety-related part of a control system part or subpart(s) of a control system which respond(s) to input signals and generate(s) safety-related output signals

NOTES 1 This also includes monitoring systems.

2 The combined safety-related parts of a control system start at the points where the safety-related signals are initiated and end at the output of the power control elements (see Annex A of JIS B 9700-1)

3.24 secondary switching device (SSD) device which, in a lock-out condition of ESPE goes to the OFF-state.

It may be used to initiate an appropriate machine control action, for example de-energizing the MSCE (referred to as "SSD" in this Standard).

Information: Although SSD inevitably goes to the OFF-state when the ESPE is under the lock-out condition, it is not required that it goes to the OFF-state when the sensing device is actuated...

3.25 sensing device part of the ESPE which uses electro-sensitive means to determine the event or state that the ESPE is intended to detect

NOTE: For example, an opto-electronic sensing device would detect an opaque object entering the detection zone.

3.26 start interlock means which prevents an automatic machine start when the ESPE power supply is switched on, or is interrupted and restored

3.27 topping performance monitor (SPM) monitoring means to determine whether or not the overall system stopping performance is within the preset limit(s) (referred to as "SPM" in this Standard)

3.28 supplier entity (for example, manufacturer, contractor, installer, integrator) that provides equipment or services associated with the machine

NOTE: The user may act in the capacity of a supplier to himself.

Information: In order to facilitate the understanding of this Standard, the meanings of some terms which are not defined in the original International Standard shall be shown as follows.

3.29 normal operation operation of the ESPE performed in such a manner that the ESPE makes the most of safety function in order not to perform operation for the in-

specification and repair of the ESPE or machines but to perform operation for the protection of persons from risk sources during the actual operation of machines

3.30 normal operation operation of the ESPE performed in such a manner that all the functions required for the ESPE are correctly actuated (including operation under test)

3.31 actuation (of sensing device) sending out signals such that the sensing device makes OSSD go to the OFF-state when detecting an object

3.32 verification confirmation by provision of objective evidence that specified requirements have been fulfilled (in accordance with 3.8.4 of JIS Q 9000)

3.33 validation confirmation by provision of objective evidence that requirements for a specific intended use or application are fulfilled (in accordance with 3.8.5 of JIS Q 9000)

4 Functional, design and environmental requirements

4.1 Functional requirements

4.1.1 Normal operation (3.29) In normal operation (3.29), the ESPE shall respond by giving (an) appropriate output signal(s) when part of a person greater than or equal to the detection capability (the detectable minimum size as specified in the other part of JIS B9704) enters or is in the detection zone.

The ESPE response time shall not exceed that stated by the supplier. No means of adjustment of the response time shall be possible without the use of a key, key-word or tool.

4.1.2 Sensing function The detection capability shall be effective over the detection zone specified by the supplier. No adjustment of the detection zone, detection capability or blanking function (monitored, unmonitored) shall be possible without the use of a key, key-word or tool.

4.1.3 Types of ESPE In this Standard, general requirements shall be specified for three types of ESPEs. The types their performance in the presence of faults and under influences from environmental conditions. In this part, the effects of electrical and electromechanical faults are considered (listed in Annex B). Additional requirements are provided in the other parts of JIS B 9704 where faults generated by the particular sensing technology employed are considered. It is the responsibility of the machine manufacturer and/or the user to prescribe which type is required for a particular application.

NOTE: Requirements for a Type 1 ESPE are not being specified at this time.

A Type 2 ESPE shall fulfil the fault detection requirements of 4.2.2.3.

For a Type 2 ESPE, in normal operation (3.29) the output circuit of at least one OSSD shall go to the OFF-state when the sensing function is actuated, or when the ESPE power supply is switched off.

Information: This specification does not always require that a Type 2 ESPE shall have two or more OSSDs. That at least one OSSD shall go the OFF-state implicitly requires that the interface between the ESPE and machines ensures safety if at least one OSSD goes to the OFF-state. It is required that the ESPE which has only one OSSD shall have at least one SSD in addition to one OSSD (see 4.2.2.3).

A Type 2 ESPE shall have a means of periodic test.

A Type 3 ESPE shall fulfil the fault detection requirements of 4.2.2.4.

A Type 4 ESPE shall fulfil the fault detection requirements of 4.2.2.5.

For a Type 3 ESPE and for a Type 4 ESPE, in normal operation (3.29) the output circuit of at least two OSSDs shall go to the OFF-state when the sensing function is actuated, or when the ESPE power supply is switched off.

Information: This specification requires that a Type 3 and Type 4 ESPE shall have at least two OSSDs. Furthermore, it is not prohibited that they have three or more OSSDs.

4.2 Design requirements

4.2.1 Power supply The ESPE shall be designed to operate correctly with the conditions of the power supply as specified below, unless otherwise specified by the user.

a) AC supply

- Voltage: 0.85 to 1.1 of nominal voltage
- Frequency: 0.99 to 1.01 of nominal frequency (continuously)
0.98 to 1.02 of nominal frequency (short-time)
- Harmonics: Harmonic distortion not to exceed 10 % of the total r.m.s. voltage between live conductors for the sum of the 2nd through to the 5th harmonic

Harmonic distortion not to exceed additional 2 % of the total r.m.s. voltage between live conductors for the sum of the 6th through to the 30th harmonic

b) DC power supply

Battery supply

- Voltage: 0.85 to 1.15 of nominal voltage
0.7 to 1.2 of nominal voltage in the case of battery-operated vehicles

c) Converter supply

- Voltage: 0.9 to 1.1 of nominal voltage
- Ripple: Shall not exceed 5% of nominal voltage (peak-to-peak)

For protection against electric shock, see 4.2.3.2.

NOTE: For protection against electrical interference, the power supply of the ESPE should meet the requirements of IEC 61000-6-2.

4.2.2 Fault detection requirements

4.2.2.1 General The ESPE shall respond to the faults listed in Annex B, in accordance with 4.2.2.3 to 4.2.2.5 as appropriate.

It shall not be possible for the ESPE to achieve a reset from a lock-out condition by interruption and restoration of the mains power supply when the fault which initiated the lock-out condition is still present.

At power on and prior to OSSD(s) going to the ON-state, a test shall be performed to verify the absence of internal faults within the ESPE.

Information 1 The following 4.2.2.3 to 4.2.2.5 specify how the ESPE shall respond and operate when faults occur in the ESPE by type of ESPE. The condition of fault response by type is similar to, but not the same as the condition of fault response by category specified in JIS B 9705-1 (ISO 13849-1).

Fault tolerance of this equipment is referred to as N when the equipment does not lose the safety function even when N pieces of faults are accumulated, and when the equipment loses safety function when (N+1) pieces of faults are accumulated. The meaning of fault tolerance here does not mean that the safety device continues normal operation (3.30) even under the fault condition. When the shift of the machine to the safe condition can be controlled before the machine stopping even if the safety device operation stops due to faults, the equipment is regarded as having fault tolerance. That is, when the ESPE goes to the lock-out condition when detecting faults, although normal operation (3.29) of the machine becomes impossible, the safety function of the ESPE is regarded to be kept.

The type specified in this Standard and fault tolerance of the category specified in JIS B 9705-1 shall be as follows. Fault tolerance of Type 3 and Type 4 is different from that of category 3 and category 4.

Fault tolerance specified in this Standard		Fault tolerance specified in JIS B 9705-1	
Type	Fault tolerance	Category	Fault tolerance
1	—	1	0
2	0	2	0
3	2	3	1
4	3 or more (Whether verification of 4 or more is required or not depends on fault occurrence probability, fault independency, etc.)	4	2 or more (Whether verification of 3 or more is required or not depends on fault occurrence probability, technology to use, architecture, application, etc.)

- 2 In this Standard, although fault tolerance of the ESPE is required, the degree of fault occurrence probability is not required. The failure rate of Type 4 ESPE is not always lower than that of Type 2 ESPE. The Type 2 ESPE, no matter how low its failure rate may be, has a possibility of losing safety function in case of failure. The Type 4 ESPE, even if it may fail, does not lose safety function due to failure.
- 3 For the classification of types, the requirement for EMC (see 4.3) and the requirement for the number of OSSD (see 4.1.3) in addition to fault tolerance are taken into consideration.

4.2.2.2 Particular requirements for a Type 1 ESPE Particular requirements for a Type 1 ESPE are not under consideration at this time.

4.2.2.3 Particular requirements for a Type 2 ESPE A Type 2 ESPE shall have a means of periodic test to reveal a failure to danger (for example, loss of detection capability, response time exceeding that specified).

A single fault resulting in the loss of detection capability or the increase in response time beyond the specified time or preventing one or more of the OSSDs going to the OFF-state, shall result in a lock-out condition as a result of the next periodic test.

Where the periodic test is intended to be initiated by an external (for example machine) safety-related control system, the ESPE shall be provided with suitable input facilities (for example terminals).

The duration of the periodic test shall be such that the intended safety function is not impaired.

NOTE: If the Type 2 ESPE is intended for use as a trip device (for example when used as a perimeter guard), and the duration of the periodic test is greater than 150 ms, it is possible for a person to pass through the detection zone without being detected. In this case a restart interlock should be included.

Information: If the movement speed of a person is 2 m/s, and the test duration of the ESPE (including response time) is 150 ms, it is possible for a person to advance 30 cm without being detected into the detection zone during the test.

If the periodic test is automatically initiated, the correct functioning of the periodic test shall be monitored and a single fault in the parts implementing the monitoring function shall be detected. In the event of a fault, the OSSD(s) shall be signalled to go to the OFF-state.

If one or more OSSDs does not go to the OFF-state, a lock-out condition shall be initiated.

An ESPE with only one OSSD shall have a minimum of one SSD.

4.2.2.4 Particular requirements for a Type 3 ESPE A single fault resulting in a loss of detection capability or an increase in response time beyond the specified value or a single fault preventing one or more OSSD going to the OFF-state shall cause the ESPE