TEST REPORT

CE MD REPORT

EN 60204-1-2018

Safety of machinery - Electrical equipment of machines - Part 1: General requirements

EN ISO 12100:2010

Safety of machinery - General principles for design - Risk assessment and risk reduction (ISO 12100:2010)

EN IEC 61400-1-2019

Wind energy generation systems - Part 1: Design requirements

EN 61400-2-2014COR.1:2019

Wind turbines - Part 2: Small wind turbines

Report Number.....:	**XDAQ447255698071047AR**
Date of issue.....:	Jul.10,2025
Total number of pages.....:	151 pages
Tested by (name, function, signature) .....:	Fade Zhan
Approved by (name, function, signature) .....:	Andy Yan
Name of Testing Laboratory preparing the Report.....:	BST Testing (Shenzhen)Co.,Ltd.
Address.....:	No.7, New Era Industrial Zone, Guantian, Bao'an District, Shenzhen, Guangdong, China
Applicant's name.....:	Yixing Naier wind power technology Co., Ltd
Address.....:	**No.288 Hubin North Road, Zhou Tie Town, Wuxi, Jiangsu, China**
Test specification:	
Standard.....:	EN 60204-1-2018 EN ISO 12100:2010 EN IEC 61400-1-2019 EN 61400-2-2014COR.1:2019
Test procedure.....:	MD test report
Non-standard test method.....:	N/A

BST TESTING (SHENZHEN) CO.,LTD. APPROVED

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Test Report Form No.....:	IEC 60204
Test Report Form(s) Originator.....:	EUROFINS Product Service
Test Item description .....:	Wind generator
Manufacturer(s).....:	Yixing Naier wind power technology Co., Ltd
Address.....:	No.288 Hubin North Road, Zhou Tie Town, Wuxi, Jiangsu, China
Test Date:.....:	Jul.02,2025to Jul.10,2025
Model/Type reference .....:	NE-50K
Additional model.....:	NE-100/NE-200、NE-300、NE-400、NE-500、NE-600、NE-800、NE-1000、NE-1500、NE-2000、NE-2500、NE-3000、NE-5000、NE-10K、NE-20K、NE-30K、NE-40K、NE-60K、NE-70K、NE-75K、NE-80K、NE-90K、NE-100K、NE-200K、NE-250K、NE-300K、NE-400K、NE-500K、NE-1000K
Ratings .....:	AC 380V
Tradmark .....:	/

22lQJn XYJDo4

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List of Attachments (including a total number of pages in each attachment):

1. Appendix 1 (10 pages): European group difference and national differences against IEC Standards:EN 60204-1-2018,EN ISO 12100:2010 ,Appendix 2 (1 pages): Product photo

Summary of testing:

The sample(s) tested complies with the requirements of EN 60204-1-2018,EN ISO 12100:2010,Max. ambient temperature is considered as 40°C.

Tests performed (name of test and test clause):	**Testing location:**
Refer to appended clause table for details	BST Testing (Shenzhen)Co., Ltd. No.7,New Era Industrial Zone, Guantian, Bao'an District, Shenzhen, Guangdong, China

Summary of compliance with National Differences (List of countries addressed):

☒ **The product fulfils the requirements of EN 60204-1-2018,EN ISO 12100:2010， EN IEC 61400-1-2019， EN 61400-2-2014COR.1:2019**

Copy of marking plate:

Wind generator
Model: NE-50K
Rating(s): AC 380V

CE

Yixing Naier wind power technology Co., Ltd

Note:

- The above markings are the minimum requirements required by the safety standard. For the final production samples, the additional markings which do not give rise to misunderstanding may be added.

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POSSIBLE TEST CASE VERDICTS:	
- test case does not apply to the test object..... :	N/A
- test object does meet the requirement..... :	P (Pass)
- test object does not meet the requirement..... :	F (Fail)
TESTING:	
Date of receipt of test item..... :	Jul.02,2025
Date (s) of performance of tests..... :	Jul.02,2025 to Jul.10,2025

GENERAL REMARKS:

"(See Enclosure #)" refers to additional information appended to the report.
"(See appended table)" refers to a table appended to the report.

Throughout this report a comma / ☒ point is used as the decimal separator.

According to the EU directives which have been aligned with EU NLF (new legislative framework), both of manufacturer and importer's name and address shall be affixed on the product or, where that is not possible, on its packaging or in a document accompanying the product before the product is placed on the EU market.

Manufacturer's Declaration per sub-clause 4.2.5 of IECEE 02:

The application for obtaining a CB Test Certificate includes more than one factory location and a declaration from the Manufacturer stating that the sample(s) submitted for evaluation is (are) representative of the products from each factory has been provided..... :	**Yes** ☒ **Not applicable**

When differences exist; they shall be identified in the General product information section.

Name and address of factory (ies)..... :	Same as manufacturer

GENERAL PRODUCT INFORMATION:

Product Description

- This product is LED Display, indoor use only.
- The maximum ambient temperature is 40° C.

Model Differences –

N/A

Additional application considerations – (Considerations used to test a component or sub-assembly)

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EN 60204-1:2018			
Cl.	Requirement – Test	Result	Verdict
4.	GENERAL REQUIREMENTS		—
4.1	General considerations		P
	Hazard and risk assessment		P
4.2	Electrical components/devices suitable for their intended use		P
	and conform to the relevant IEC orEN standards		P
4.3	Power supply and related conditions:		—
4.3.1	Electrical equipment to be designed for correct operation with conditions of mains power supply		P
4.3.2	Supply Voltage		P
	Frequency		P
	Harmonics		N
	Voltage unbalance		N
	Voltage interruption		N
	Voltage dips :		N
4.3.3	DC Supplies Voltage :		N
	Voltage interruption		N
	Ripple (peak-peak) :		N
4.3.4	Special power systems		N
	Onboard power supply acc. to cl.4.3.2 and 4.3.3 may be exceed		N
4.4	Physical environment and operating conditions		P
4.4.1	Electrical equipment to be suitable for use in physical environment and operating conditions		P
4.4.2	Electromagnetic compatibility (EMC)		P
	Equipment not to generate electromagnetic disturbances above harmful levels: (applicable EMC-standard: EN50081-2)		P
	Equipment has adequate level of immunity to EMC: (applicable EMC- standards: EN 61000)		P
4.4.3	Electrical equipment to be capable for correct operation at intended ambient air temperature	-5°C - +40°C	P
4.4.4	Electrical equipment to be capable for correct operation at specified relative humidity:	25% - 95%	P
4.4.5	Electrical equipment capable of operating correctly at altitudes up to1000 m above m.s.l.		P
4.4.6	Electrical equipment shall be adequately protected against ingress of solid properties and liquids see clause 11.3		P
4.4.7	Ionizing and non-ionizing radiation Electrical equipment subject to radiation, additional measures		N

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	to be taken to avoid equipment malfunction		
4.4.8	Undesirable effects of vibration, shock and bump avoided		P
4.5	Electrical equipment designed to withstand the effects of transportation and storage within a temperature range of -25 to +55 °C	-25 to +55 °C	P
4.6	Heavy or bulky electrical equipment of the machine provided with suitable means for handling		P
4.7	Electrical equipment installed and operated in accordance with the supplier's instruction	Skilled person for installing and See instruction	P
5.	INCOMINGSUPPLYCONDUCTORTERMINATIONSAN DDEVICES FOR DISCONNECTING AND SWITCHING OFF	—	
5.1	Incoming supply conductor terminal		P
	electrical equipment of a machine connected to a single power supply	Single power supply	P
	power supply conductors terminated to main disconnecting device of electrical equipment		P
	neutral conductor "N" clearly indicated in technical documentation.	N indicated	P
	no connection between neutral conductor and bonding circuit nor combined PEN-terminals.	protective	P
	All terminals of incoming supply clearly marked (symbols acc. to EN60445) and clause16.1		P
5.2	Terminal for connection to external protective earthing system	—	
	Terminal for connection of external protective conductor provided and marked with "PE"	Grounding symbol used for PE	P
	Cross section of incoming PEconductor acc. to cl. 5.2, table 1	S<16, PE cross is S	P
	Terminals allow connection of external protective earth conductors PE		P
	other protective earth identified either by graphic symbol,letters "PE", or bicolour combinationgreen / yellow		P
5.3	Supply disconnecting device	—	
5.3.1	Power supply disconnecting device provided for electrical equipment		P
5.3.2	The power supply disconnecting device shall be one of the following type:	—	
	a) Switch-disconnector, acc. to EN60947-3 for appliance category AC-23 B or DC-23 B		N
	b) Disconnector with or without fuses, with aux. contact (acc. to EN60947-3)		N
	c) Power Circut Breaker suitable for isolation(acc. to EN 60947-2)	Circut Breaker comply with EN 60947-2	P

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EN 60204-1			
Clause	Requirement – Test	Result - Remark	Verdict
	d) any other switching device in accordance with an IEC product standard for that device and which meets the isolation requirements of IEC 60947-1 as well as a utilization category defined in the product standard as appropriate for on-load switching of motors or other inductive loads;		N
	e) a plug/socket combination for a flexible cable supply.		N
5.3.3	When supply disconnecting device is a switch-disconnector or a circuit- breaker		—
	Isolate electrical equipment from supply(acc. to EN 60947-2)	circuit- breaker	N
	One OFF (isolated) and one ON position only		N
	Clearly marked with ”0” and ”I”		N
	CB’s with additional reset position between ”0” and ”I”		N
	visible isolating distance or		N
	Position indication which cannot indicate the OFF-position until all contacts are actually open		N
	External operating device provided(except power operated CB’s)		P
	Colour black or grey preferred.		N
	If used as an emergency stop, red/yellow combination selected		N
	Locking means provided to lock inOFF-position		N
	In locked position an unintended closing for local or remote operation mode possible		N
	Disconnection of all live conductors (Exception: TN-supply systems, neutral conductor)	Disconnection of all live conductors	P
	Sufficient breaking capacity		P
	- a) to f) of cluase 13.4.5Plug/socket combinations		N
5.3.4	Handle of disconnecting device to be easily accessible		N
	Handle located between 0.6m and1.9m above service level		N
5.3.5	Following circuits not disconnect by supply disconnecting device:		—
	Lighting circuits during maintenance or repair	All power isolated	N
	Plug/socket outlets exclusively used for maintenance or repair		N

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EN 60204-1			
Clause	Requirement – Test	Result - Remark	Verdict
	Undervoltage protection circuits used for automatic tripping only at power supply failures		N
	Circuits of equipment to remain normally energised for satisfactory operation		N
	Control circuits for interlocking purposes		N
	Circuits which are not disconnected by supply disconnecting device:		—
	Permanent warning labels placed in proximity of supply disconnectors		N
	Appropriate remark in maintenance manual		N
	Warning label in proximity of circuit concerned		N
	or wiring separated from other wiring		N
	Wiring of safety interlocking circuits installed with different colour of insulation.		N
5.4	Devices for switching off for prevention of unexpected start-up:		—
	Means shall be provided to prevent inadvertent and / or mistaken closure of the disconnecting device		N
	Such devices appropriate and convenient for intended use		N
	Suitable placed		N
	Readily identifiable		N
	The following devices that fulfil the isolation function may be provided for this purpose:		—
	– devices described in 5.3.2,		N
	– disconnectors, withdrawable fuse links and withdrawable links only if located in an enclosed electrical operating area (see 3.19).		N
	Devices that do not fulfil the isolation function (for example a contactor switched off by a control circuit) may only be provided where intended to be used for situations that include:		N
	– inspections;		N
	– adjustments;		N
	– work on the electrical equipment where: - there is no hazard arising from electric shock (see Clause 6) and burn; - the switching off means remains effective throughout the work; - the work is of a minor nature (for example replacement of plug-in devices without disturbing existing wiring).		N
	NOTE 1 This part of IEC 60204 does not address all provisions for prevention of unexpected start up. See ISO 14118 (EN 1037).		—
5.5	Devices provided for disconnecting electrical equipment	Isolating switch	P

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EN 60204-1			
Clause	Requirement – Test	Result - Remark	Verdict
	Supply-disconnecting device used		N
	In addition to the supply disconnecting device, the following devices that fulfil the isolation function may be provided:		N
	– devices described in 5.3.2;		N
	-disconnectors, withdrawable fuse links and withdrawable links only if located in an enclosed electrical operating area and relevant information is provided with the electrical equipment (see Clause 17)		N
5.6	Provided with adequate means to prevent unauthorised, inadvertent and /or mistaken closing		P
	Devices acc. to cl. 5.4 and 5.5 provided with locking means		N
	Locking means provided with device		P
	Where a non-lockable disconnecting device (for example withdrawable fuse-links, withdrawable links) other means of protection against reconnection (for example warning labels in accordance with 16.1) may be provided.		N
	However, when a plug/socket combination according to 5.3.2 e) is so positioned that it can be kept under the immediate supervision of the person carrying out the work, means for securing in the disconnected state need not be provided.		N
6	PROTECTION AGAINST ELECTRIC SHOCK		—
6.2	Protection against direct contact:		—
6.2.1	- by means of protection by enclosure		P
	- by means of insulation of live parts		P
	- by means of protection against residual voltages		P
6.2.2	Protection by enclosure:		—
	Live parts located inside enclosures conform to relevant requirements of clauses 4, 12 and15 Protection against direct contact at least IP2X or IPXXB		N
	Where top surfaces of enclosures are readily accessible, degree of protection against direct contact is IP4X or IPXXD.		P
	Opening of enclosure possible only under one of the following conditions:		—
	a) use of a key or a tool. Special requirements for enclosed electrical operating areas may apply		N
	live parts inside of doors with protection degree of IP1X or IPXXA		N

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EN 60204-1			
Clause	Requirement – Test	Result - Remark	Verdict
	live parts likely to be touched during resetting or adjustment with protection degree IP2X or IPXXB		N
	b) disconnection of live parts inside enclosure prior to opening of enclosure	No such condition	N
	at door interlocking safety circuit, door will open only when main isolator is in open position		N
	For skilled persons a special device provided, to defeat interlocking circuit under following conditions:		—
	Special device or tool provided to permit skilled persons to defeat the interlock provided that:		—
	- opening of disconnector possible at all times while interlock is defeated		N
	- upon closing the door, interlock is automatically restored		N
	If more than one door allows access to live parts, care must be taken, at implementation of this subclause		N
	All parts remaining live after switching off mains supply to be protected against direct contact with at least IP2X or IPXXB	All parts not live after isolated switching off	N
	Such parts marked with warning symbol acc. to cl.17.2		N
	Excepted from this requirement for marking are:		—
	- Parts that can be live only due to connection to interlocking circuits, distinguished by colour as potentially live acc. to cl. 14.2.4		N
	- Terminals of supply disconnecting device when latter mounted alone in a separate enclosure		N
	c) opening of doors without use of key or tool and without disconnection of live parts possible only when all live parts are protected against direct contact by IP2X or IPXXB		N
	where protection is provided by barriers, tools required for their removal or		N
	all live parts automatically disconnected when barrier is removed		N
6.2.3	Protection by insulation of live parts:		—
	Live parts completely covered with insulation	Internal wire, components are coved with insulaiton	P
	insulation can be removed only by destruction		P
	insulation capable to withstand mechanical, chemical, electrical and thermal stress occurring under normal service conditions		P
	Paint, varnish lacquer etc. not used as insulation	Such material not used as insulation	P

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Clause	Requirement – Test	Result - Remark	Verdict
6.2.4	Protection of residual voltage:		—
	Live parts with residual voltage =60V after disconnection, to be discharged to = 60V within 5s after disconnection,Except are components with charges of = 60 µC	residual voltage <60V	P
	where pins of plugs or similar devices after withdrawal are exposed, discharge time = 1s		N
	such conductors protected against direct contact by at least IP2X or IPXXB		N
	if above requirements cannot be achieved, additional disconnecting devices or appropriate warning devices shall be applied. (see cl.13.8.4)		N
6.2.5	For protection by barriers, 412.2 ofIEC 60364-4-41 shall apply.	No barriers	N
6.2.6	For protection by placing out of reach, 412.4 of IEC 60364-4-41 shall apply. For protection by obstacles, 412.3 of IEC 60364-4-41 shall apply.		N
	For conductor wire systems or conductor bar systems with a degree of protection less than IP2X, see 12.7.1.		N
6.3	Protection against indirect contact:		—
6.3.2	Measures to prevent the occurrence of a hazardous touch voltage		—
6.3.2.2	use of class II electrical devices or apparatus (double insulation, reinforced insulation or by equivalent insulation acc. to EN60536)		N
	use of switchgear and control gear assemblies with total insulation acc. to EN 60439-1		P
	application of supplementary or reinforced insulation acc. to EN60364-4-41, 413.2		P
6.3.2.3	Electrical separation of an individual circuit to prevent hazardous touch voltage acc. to EN 60364-4-41, cl. 413.5		P
6.3.3	Protection by automatic disconnection of supply:		—
	This measure necessitates co-ordination between:		—
	– the type of supply and earthing system;	Earthing system	N
	– the impedance values of the different elements of the protective bonding system;		N
	– the characteristics of the protective devices that detect insulation fault(s).		N
	Automatic disconnection of the supply of any circuit affected by an insulation fault is intended to prevent a hazardous situation resulting from a touch voltage.		N
	This protective measure comprise both:		—

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EN 60204-1			
Clause	Requirement – Test	Result - Remark	Verdict
	-Connection of all exposed conductive parts to protective earth bonding circuit		N
	And		—
	a) overcurrent protective devices for the automatic disconnection of the supply on detection of an insulation fault in TN systems, or	overcurrent protective devices	N
	b) residual current protective devices to initiate the automatic disconnection of the supply on detection of an insulation fault from a live part to exposed conductive parts or to earth in TT systems, or		N
	c) insulation monitoring or residual current protective devices toinitiate automatic disconnection ofIT systems.		N
	This insulation monitoring device shall initiate an audible and/or visual signal which shall continue as long as the fault persists.		N
6.4	Protection by application of PELV circuit which have to fulfil following requirements:		—
6.4.1	a) nominal voltage not to exceed 25 AC (r.m.s.) or 60 DC (ripple- free) or	/	N
	6VAC or 15VDC for all other cases		N
	b) one side of PELV- circuit or one point of source of supply to be connected to PE- circuit		P
	c) live parts of PELV- circuits to be electrically separated from other live circuits.		P
	Electrical separation shall be not less than that required betweenthe primary and secondary circuits of a safety isolating transformer (see IEC 61558-1 and IEC 61558-2-6);	Switching power supply, safety isolating transformer used	P
	d) conductors of each PELV circuit to be physically separated from those of any other circuit.		P
	When this requirement is impracticable, the insulation provisions of 13.1.3 shall apply;		P
	e) plugs and socket outlets for PELV- circuits shall conform to following requirements:		N
	plugs shall not be able to enter socket outlets of other voltage systems		N
	socket outlets shall not admit plugs of other voltage systems		N
6.4.2	Sources for PELV- circuits to be one of the following:		—
	– a safety isolating transformer in accordance with IEC 61558-1 and IEC 61558-2-6;		N
	– a source of current providing a degree of safety equivalent to that of the safety isolating transformer (for example a motor generator with winding providing equivalent isolation);		N
	– an electrochemical source (for example a battery) or another source independent of a higher voltage circuit (for example a diesel-driven generator);		N

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EN 60204-1			
Clause	Requirement – Test	Result - Remark	Verdict
	-electronic power supply conforming to appropriate standards		N
7	PROTECTION EQUIPMENT		—
7.2	Overcurrent protection:		—
7.2.1	Overcurrent protection device provided	Circuit breaker	N
7.2.2	Supply conductors		—
	Overcurrent protective device at incoming feeder to the electrical equipment (see to cl. 7.2.10 and cl. 18.5)		N
	Electrical equipment supplier state data for overcurrent protective device		N
7.2.3	Power circuits:		
	Devices for detection and interruption of overcurrent, selected in accordance with7.2.10, shall be applied to each live conductor.		N
	The following conductors, as applicable, shall not be disconnected without disconnecting all associated live conductors:		N
	– the neutral conductor of a.c. power circuits;		N
	– the earthed conductor of d.c. power circuits;		N
	– d.c. power conductors bonded to exposed conductive parts ofmobile machines.		N
	Cross section area of neutral conductor to be at least equal to phase conductor, no overcurrent protective/ disconnecting device required	Neutral conductor area same as phase conductor	P
	For neutral earth conductors with cross sections smaller than phase conductors, measures acc. to item b, cl 473.3.2.1 of IEC 60364-4-473 will apply		N
	For IT-systems use of neutral earth conductor (N) is not recommended. Nevertheless if an N-conductor is used, measures acc. to cl. 473.3.2.2 of IEC 60364-4-473 shall apply.	TN system	N
7.2.4	Control circuits:		—
	Conductors of control circuits directly connected to supply voltage and circuits feeding control voltage transformers protected against overcurrent acc. to cl.7.2.3		N
	Conductors of control circuits supplied by a control circuit transformer or d.c. supply shall be protected against overcurrent (see also 9.4.3.1):	Conductors protected overcurrent device	P

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	– in control circuits connected to the protective bonding circuit, by inserting an overcurrent protective device into the switched conductor;		N
	– in control circuits not connected to the protective bonding circuit;		N
	- where the same cross sectional area conductors are used in all control circuits, by inserting an overcurrent protective device into the switched conductor, and;		N
	- where different cross sectional areas conductors are used in different sub-circuits, by inserting an overcurrent protective device into both switched and common conductors of each sub-circuit.		N
7.2.5	Socket outlets and their associated conductors:		—
	Overcurrent protection devices for socket outlets provided for non- earthed live conductors of each circuit feeding such socket outlets	No such circuit	N
7.2.6	Lighting circuits:		—
	All unearthed conductors of local lighting circuits protected by overcurrent protective devices	No lighting	N
7.2.7	Transformers:		—
	Transformers shall be protected against overcurrent in accordance with the manufacturer's instructions. Such protection shall (see also 7.2.10):	Transformer in the switching power supply, have enough protection	N
	– avoid nuisance tripping due to transformer magnetizing inrush currents;		N
	– avoid a winding temperature rise in excess of the permitted valuefor the insulation class oftransformer when it is subjected to the effects of a short circuit at its secondary terminals.		N
	The type and setting of the overcurrent protective device should be in accordance with the recommendations of the transformer supplier.	Overcurrent proteced by inner fuse	N
7.2.8	Location of protective devices:		P
	Overcurrent protective device located at point where conductor is connected to the supply		P
	Current carrying capacity of conductors at least equal to that required for electrical load		P
	Each connecting conductor to overcurrent protective devices not longer than 3 meters		P
	Conductor protected by enclosure or duct		P
7.2.9	Overcurrent protective devices:		—
	Rated short-circuit breaking capacity at least equal to prospective fault current at point of installation	Circuit breaker rating have suitable capacity	P

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Clause	Requirement – Test	Result - Remark	Verdict
	Current other than those coming from supply side taken into account		N
	Reduced breaking capacity is permitted, where another protective device is installed at supply side with the necessary breaking capacity		N
	Back-up protection carefully checked, no destruction of conductor or overcurrent protective device may result		N
	Co-ordination with other protective devices in circuit required		N
	Overcurrent protective devices in power circuits include fuses and circuit breakers. Electronic current limiting devices may also be used in protected circuits		N
7.2.10	Rating and setting of overcurrent protective devices:		—
	Rated current of fuses or overcurrent setting of other protective devices selected as low as possible, but adequate for anticipated overcurrents.	Current ratings of protective device are considered	N
	Settings of overcurrent protective devices appropriately listed in technical documentation		N
7.3	Protection of motors against overheating		P
7.3.1	Overload protection for all motors provided for ratings of > 0.5 kW in continuous operation.		P
	Protective device may be omitted for motors which cannot be overloaded		P
	Protection of motors against overheating can be achieved by:		P
	– overload protection (7.3.2),		P
	– over-temperature protection(7.3.3),		P
	– current-limiting protection(7.3.4).		P
	Automatic restarting of any motor after the operation of protection against overheating shall be prevented where this can cause a hazardous situation or damage to the machine or to the work in progress.		P
7.3.2	Where overload protection is provided, detection of overload(s) shall be provided in each live conductor except for the neutral conductor.		N
	However, where the motor overload detection is not used for cable overload protection (see also Clause D.2), the number ofoverload detection devices may be reduced at the request of the user (see also Annex B).		N
	For motors having single-phase or d.c. power supplies, detection in only one unearthed live conductor is permitted		N

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Clause	Requirement – Test	Result - Remark	Verdict
	Where overload protection is achieved by switching off, the switching device shall switch off all live conductors. The switching of the neutral conductor is not necessary for overload protection.		N
	Appropriate protective devices designed to accommodate special duty motors or over-temperature protection (see 7.3.3) can be necessary. (for example, motors for rapid traverse, locking, rapid reversal, sensitive drilling)		N
	For motors that cannot be overloaded (for exampletorque motors, motion drives that either are protected by mechanical overload protection devices or are adequately dimensioned),overload protection is not required.		N
7.3.3	The provision of motors with over- temperature protection (see IEC60034-11) is recommended insituations where the cooling can be impaired		N
	Depending upon the type of motor, protection under stalled rotor or loss of phase conditions is not always ensured by over- temperature protection, and additional protection should thenbe provided.		N
	Over-temperature protection isalso recommended for motors that cannot be overloaded (forexample torque motors, motion drives that are either protected by mechanical overload protection devices or are adequately dimensioned), where the possibility of over-temperatureexists (for example due to reduced cooling).		N
7.3.4	Where protection against the effects of overheating in three phase motors is achieved by current limitation, the number of current limitation devices may be reduced from 3 to 2 (see 7.3.2).		N
	For motors having single phase a.c or d.c. power supplies, current limitation in only one unearthed live conductor is permitted.		N
7.4	Abnormal temperature protection:		—
	Resistance heating or similar devices which cause excessive heat, equipped with suitable overtemperature detection	No high temperature during operation	P
7.5	Protection against supply interruption or voltage reduction and subsequent restoration		—
	Undervoltage protection provided for applications where loss of supply or undervoltage causes a hazardous condition	No hazardous if undervoltage.	P
	If interruption or reduction of supply voltage is allowed for a short period of time, delayed undervoltage protection provided.		N
	Undervoltage protection not impair any stopping control of the machine		N

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Clause	Requirement – Test	Result - Remark	Verdict
	Upon restoration of supply voltage, automatic or unexpected restarting of machine prevented	Software system inspection all data correct can be start.	N
	Undervoltage protection to initiate appropriate control responses to ensure co-ordination the groups of machines working together		N
7.6	Motor overspeed protection:		—
	Overspeed protection provided where overspeeding causes a hazardous condition	No motor	N
	Overspeed protection initiates appropriate control response and prevents automatic restarting		N
7.7	Earth fault / residual current protection:		—
	To reduce damage to equipment due to earth fault currents below detection level, earth fault/residual protect used		N
	Detection level for earth fault protection set as low as possible		N
7.8	Phase sequence protection:		—
	Protection from incorrect phase sequence of supply voltage provided	Single phase	N
7.9	Protection against overvoltages due to lightning strike or switching action:		—
	Protective devices for the suppression of overvoltages caused by lightning strikes or switching surges provided	No SPD	N
	Devices for suppression of overvoltages due to lightning, connected at incoming terminalsof the supply disconnecting device		N
	Devices for suppression of overvoltages due to switching surges connected across terminals of all equipment requiring such protection		N
8	EQUIPOTENTIAL BONDING		N
8.2.1	General:		—
	All parts of protective bonding circuit capable to withstand max. thermal and mechanical stress, caused by earth-fault currents		N
	Where the conductance of structural parts of the electrical equipment or of the machine is less than that of the smallest protective conductor connected to the exposed conductive parts, a supplementary bonding conductor shall be provided.		N
	This supplementary bonding conductor shall have a cross- sectional area not less than half that of the corresponding protective conductor.	At least 1.0mm^2 copper wire	N
	Any structural part of electrical equipment or of a machine used as part of protective bonding circuit		N

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Clause	Requirement – Test	Result - Remark	Verdict
	If an IT distribution system is used, the machine structure shall be part of the protective bonding circuitand insulation monitoring shall be provided. See 6.3.3 c).		N
	Conductive structural parts of equipment in accordance with6.3.2.2 need not be connected to the protective bonding circuit.		N
	Extraneous conductive parts which form the structure of the machine need not be connected to the protective bonding circuitwhere all the equipment provided is in accordance with 6.3.2.2.		N
	Exposed conductive parts of equipment in accordance with6.3.2.3 shall not be connected to the protective bonding circuit.		N
8.2.2	Protective conductors:		--
	Identification and marking of protective conductors acc. to cl.13.2.2		P
	Copper conductors used as protective conductors	copper	P
	Other conductor materials allowed, if cross section of such conductors is not less than 16mm^2		N
	Cross-sectional area of protective conductors determined acc. to IEC60364-5-54, cl. 543 orEN 60439-1, cl. 7.4.3.1.7, table 4		N
	Relationship between cross- section area of phase conductor and PE acc. to table 1		N
8.2.3	Continuity of protective bonding circuit:		—
	All exposed conductive parts of electrical equipment and machine(s) connected to protective bonding circuit.		N
	In case of removal of parts of PE system, remaining parts not to be interrupted		N
	Current-carrying capacity of connections and bonding points not impaired by mechanical, chemical or electrochemical influences		N
	Particular consideration should be given if enclosure consists of aluminium and its alloys	Not alloys	N
	Metal ducts and cable sheaths not used as protective conductors and not connected to protective bonding circuit		N
	If electrical equipment is mounted on lids, doors or cover plates, continuity of protective bonding circuit ensured		N
	Continuity of protective conductor ensured at cables which are exposed to damage		N
8.2.4	Exclusions of switching devices from protective bonding circuit:		—

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Clause	Requirement – Test	Result - Remark	Verdict
	The protective bonding circuit shall not incorporate a switching device or an overcurrent protective device (for example switch, fuse).		N
	No means of interruption of the protective bonding conductor shall be provided.		N
	Exception: links for test or measurement purposes that cannot be opened without the use of a tool and that are located in an enclosed electrical operating area.		N
	Where the continuity of the protective bonding circuit can be interrupted by means of removable current collectors or plug/socket combinations, the protective bonding circuit shall be interrupted by a first make last break contact.		N
	This also applies to removable or withdrawable plug-in units (see also 13.4.5).		N
8.2.5	Equipment parts that need not to be connected to protective bonding circuit:		—
	Parts which cannot be touched on large surfaces or grasped by hand due to its small size (less than approx. 50 x 50 mm), small parts such as screws, rivets,nameplates or		P
	are located in such way, that either contact with live parts or an insulation failure is unlikely		N
8.2.6	Protective conductor connecting points:		—
	PE conductor connecting points have no other functions and not used for connection of appliances or other parts		N
	Each PE connecting point identified by using the protective earth symbol		N
	Alternatively, terminals for connection of protective conductors identified by bicolour combination GREEN-YELLOW or letter PE	Green-yellow	N
8.2.7	Mobile machines		—
	On mobile machines with on- board power supplies, protective circuits, exposed conductive parts connected to a protective bonding terminal		N
	when mobile machines will be connected to an external incoming power supply, protective bonding terminal (PE) fixed to connecting point for the protective conductor.		N
8.2.8	Additional protective bonding requirements for electrical equipment having earth leakage currents higher than 10 mA a.c. or d.c.	leakage currents <10mA	N

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Clause	Requirement – Test	Result - Remark	Verdict
	Where electrical equipment has an earth leakage current (for example adjustable speed electrical power drive systems and information technology equipment) that is greater than 10 mA a.c. or d.c. in any incoming supply, one or more of the following conditions for the associated protective bonding circuit shall be satisfied:		N
	a) the protective conductor shall have a cross-sectional area of at least 10 mm2 Cu or 16 mm2 Al, through its total run;		N
	b) where the protective conductor has a cross-sectional area of less than 10 mm2 Cu or 16 mm2 Al, a second protective conductor of at least the same cross-sectional area shall be provided up to a point where the protective conductor has a cross-sectional area not less than 10 mm2 Cu or16 mm2 Al.		N
	c) automatic disconnection of the supply in case of loss of continuity of the protective conductor.		N
	In addition, a warning label shall be provided adjacent to the PE terminal, and where necessary on the nameplate of the electrical equipment.		N
	The information provided under 17.2 b)1) shall include information about the leakage current and the minimum cross-sectional area of the external protective conductor.		N
8.3	Functional bonding		—
	Protection against maloperation as a result of insulation failures canbe achieved by connecting to a common conductor in accordance with 9.4.3.1.		N
	For recommendations regarding functional bonding to avoid maloperation due to electromagnetic disturbances, see4.4.2.		N
8.4	Measures to limit the effects of high leakage current		—
	The effects of high leakage current can be restricted to the equipment having high leakage current by connection of that equipment to a dedicated supply transformer having separate windings.		N
	The protective bonding circuit shall be connected to exposed conductive parts of the equipment and, in addition, to the secondary winding of the transformer.		N
	The protective conductor(s) between the equipment and the secondary winding of the transformer shall comply with one or more of the arrangements described in 8.2.8.		N
9	CONTROL CIRCUITS AND CONTROL FUNCTIONS		—
9.1.1	Control circuits supplied by transformers have separately isolated windings	Switching power supply Comply with IEC 61558-2-16	N
	If several transformers used, secondary voltages in phase		N

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Clause	Requirement – Test	Result - Remark	Verdict
	DC- control circuits connected to PE circuit supplied from a separate winding of the control circuit transformer or supplied from another control circuit transformer		N
	Transformers not mandatory for machines with a single motor starter and maximum of two control devices		N
9.1.2	Nominal voltage not exceed 277VAC when supplied from a transformer		N
9.1.3	Control circuits shall be provided with overcurrent protection in accordance with 7.2.4 and 7.2.10.		N
9.2	Control functions:		—
9.2.1	NOTE Subclause 9.2 does not specify requirements for the devices used to implement control functions. Examples of requirements for devices are given in Clause 10.		N
9.2.2	Categories of Stop functions:		—
	Category 0: Stopping by immediate removal of power to machine actuators	Power off, category 0 stop	P
	Category 1: A controlled stop with power available to machine actuators. Then removal of power when stop condition has been achieved.		N
	Category 2: A controlled stop with power left available to machine actuators		N
9.2.3	Operation		P
9.2.3.1	Where a machine has more than one control station, measures shall be provided to ensure that initiation of commands from different control stations do not lead to a hazardous situation.	All door have interlock Software safety inspection	N
9.2.3.2	Start		P
	Start functions shall operate by energizing the relevant circuit.		P
	Start of an operation shall be possible only when all of the relevant safety functions and/or protective measures are in place and are operational.		P
	Where safety functions and/or protective measures cannot be applied for certain operations, manual control of such operations are by hold-to-run controls, together with enabling devices, as appropriate.		P

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Clause	Requirement – Test	Result - Remark	Verdict
	In the case of machines requiring the use of more than one control station to initiate a start, each of these control stations shall have a separate manually actuated start control device. The conditions to initiate a start are: - all required conditions for machine operation shall be met and -all start control devices shall be in the released (off) position, then -all start control devices have to be actuated concurrently (see 3.1.7).		N
9.2.3.3	Stop		N
	Stop category 0 and/or stop category 1 and/or stop category 2 stop functions are provided as indicated by the risk assessment and the functional requirements of the machine (see 4.1).	Stop category 0	N
	Stop functions shall override related start functions		N
	Where more than one control station is provided, stop commands from any control station is effective when required by the risk assessment of the machine.		N
9.2.3.4	Emergency operations (emergency stop, emergency switching off)		N
9.2.3.4.1	Emergency stop or emergency switching off commands shall be sustained until it is reset.		N
	This reset shall be possible only by a manual action at tha location where the command has been initiated.		N
	The reset of the command shall not restart the machinery but only permit restarting.		N
	It shall not be possible to restart the machinery until all emergency stop commands are reset.		N
	It shall not be possible to reenergize the machinery until al emergency switching off commands are reset.		N
9.2.3.4.2	The emergency stop does function either as a stop categc 0 or as a stop category 1.	Emergency stop switch provided category 0 function	N
	- it shall override all other functions and operations in all modes- it shall stop the hazardous motion as uickly as practicable without creating other hazards- a reset shall nc initiate a restart		N
9.2.3.4.3	Emergency switching off should be provided where: - Protection against direct contact is achieved only by placing out of reach or by obstacles (see 6.2.6) or-there is the possibility of other hazards or damage caused by electricity	Circuit breaker used as Emergency switching off	N
	Emergency switching off is accomplished by electromechanical switching devices, effecting a stop category 0 of machine actuators connected to this incoming supply		N

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Clause	Requirement – Test	Result - Remark	Verdict
9.2.3.5	Operating modes		N
	Where machinery uses several control or operating modes requiring different protective measures and having a different impact on safety, it shall be fitted with a mode selector which can be locked in each position		P
	Another selection method can be used (for example an access code)		N
	Mode selection by itself does not initiate machine operation. A separate actuation of the start control has to be stated by the operator.		N
	Indication of the selected operating mode shall be provided (e.g. the position of a mode selector, the provision of an indicating light, a visual display indication)		N
9.2.3.6	Movement or action that can result in a hazardous situation shall be monitored by providing, for example, overtravel limiters, motor overspeed detection, mechanical overload detection or anti-collision devices		N
9.2.3.7	Hold-to-run controls shall require continuous actuation of the control device(s) to achieve operation		N
9.2.3.8	Two-hand controls shall be one of the following types and have the following features		N
	Type I: this type requires: - the provision of two control devices and their concurrent actuation by both hands; - continuous concurrent actuation during the hazardous situation; - machine operation shall cease upon the release		N
	Type II: a Type I control requiring the release of both control devices before machine operation can be reinitiated		N
	Type III: a Type II control requiring concurrent actuation of the control devices as follows: - it shall be necessary to actuate the control devices within a certain time limit of each other, not exceeding 0.5 s - where this time limit is exceeded, both control devices shall be released before machine operation can be initiated		N
9.2.3.9	Enabling control shall be so arranged as to minimize the possibility of defeating, for example by requiring the de- activation of the enabling control device before machine operation may be reinitiated		N

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Clause	Requirement – Test	Result - Remark	Verdict
9.2.3.10	Combined start and stop controls: Push-buttons etc. that alternately initiate and stop motion shall only be provided for functions, which cannot result in a hazardous situation.		N
9.2.4	Cableless control system		N
9.2.4.1	The CCS shall have functionality and a response time suitable for the application based on the risk assessment.	No CCS	N
9.2.4.2	The ability of a CCS to control a machine shall be automatically monitored, either continuously or at suitable intervals.		N
	If the communication signal has degraded (e.g., reduced signal level, low battery power) a warning shall be given		N
	When the ability to control a machine has been lost, an automatic stop of the machine shall be initiated.		N
	Its restoration shall not restart the machine.		N
9.2.4.3	Measures shall be taken to prevent the machine from responding to signals other than those from the intended operator control station(s).		N
	Cableless operator control station(s) shall only control the intended machine(s) and shall affect only the intended machine functions.		N
9.2.4.4	When more than one cableless operator control station is used, then:		—
	- only one control station shall be enabled at a time except as necessary for the operation		N
	- transfer of control shall require a deliberate manual action at the station having control		N
	- transfer shall only be possible if both stations are in the same mode		N
	- a transfer shall not change the mode of operation or function		N
	- on the station that has control, a visual indication shall indicate this		N
9.2.4.5	Portable cableless operator control stations shall be provided with means to prevent unauthorized use		N
	Each machine should have an indication when it is under cableless control		N
	When possible to be connected to several machines, means shall be provided on the portable device to select		N
	Selecting a machine shall not initiate control commands.		N
9.2.4.6	A deliberate disabling shall meet the requirements of 9.2.4.2.		N

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Clause	Requirement – Test	Result - Remark	Verdict
	Where disabling without interrupting machine operation is necessary, appropriate means shall be provided to transfer control		N
9.2.4.7	Emergency stop devices on portable cableless operator control stations shall not be the sole means of initiating an emergency stop		N
	Confusion between active and inactive devices shall be avoided		N
9.2.4.8	Restarting of a cableless control shall not result in a reset of an emergency stop condition		N
	The instructions shall state that a reset shall only be performed when it can be seen that the reason has been cleared		N
9.3	Protective interlocks:		—
9.3.1	Reclosing or resetting of an interlocking safeguard not to initiate a machine motion or operation which can produce a hazardous condition	Interlocking safeguard not to initiate a machine	N
9.3.2	Where an operating limit (for example speed, pressure, position) can be exceeded leading to a hazardous situation, means shallbe provided to detect when a predetermined limit(s) is exceeded and initiate an appropriate control action.		N
9.3.3	Where non-operation of devices for auxiliary functions causes a hazardous condition, damage tothe machine or to the process, appropriate interlocking be provided		N
9.3.4	Interlocks of contactors, relays, etc. between different operations andfor opposite motions, interlocks against such incorrect operation provided		N
	Reversing contactors interlocked in such way, that in normal service no short circuit occurs during switching operation		N
	Where, for safety or for continuous operation, certain functions on the machine are required to beinterrelated, proper co-ordination ensured by suitable interlocks		N
	For a group of machines working together in a co-ordinated manner and having more than one controller, provisions made for co- ordination of this controller		N
	If a failure of a mechanical brake actuator can result that the brake, is applied when the associated machine actuator is energised and a hazardous condition results, interlocks be provided to switch off the machine actuator		N
9.3.5	Reverse current breaking on a motor, effective measures taken to avoid motor starting in opposite direction at end of breaking where that reversal causes a hazardous condition, damage to the machine or to the process		N

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Clause	Requirement – Test	Result - Remark	Verdict
	Control circuits arranged so, that rotation of a motor shaft, not to result in a hazardous condition		N
9.3.6	Where it is necessary to suspend safety functions and/or protective measures, the control or operating mode selector shall simultaneously		N
	disable all other operating (control) modes		N
	permit operation only by the use of a hold-to-run device or by a similar control device positioned so as to permit sight of the hazardous elements		N
	prevent any operation of hazardous functions by voluntary or involuntary action on the machine's sensors		N
	If these four conditions cannot be fulfilled, the mode selector shall activate other protective measures to ensure a safe intervention zone. In addition, the operator shall be able to control operation of the parts he is working on from the adjustment point.		N
9.4	Control functions in the event of failure:		—
	Measures to reduce those risks include but are not limited to:		—
	protective devices on the machine, (e.g. interlocking guards, trip devices)		P
	protective interlocking of electrical circuit		N
	use of proven circuit techniques and components (see cl. 9.4.2.)		P
	provision of partial or complete redundancy (see cl. 9.4.2.2) or diversity (see cl. 9.4.2.3)		P
	provision for functional tests (see cl. 9.4.2.4)		P
	single failures only are to be considered		P
	for higher levels of risks, it may be necessary to ensure, that more than one failure cannot result in a hazardous condition		P
9.4.2	Measures to reduce the risk in case of failure:		—
9.4.2.1	bonding of control circuits to protective circuit for operational purposes (see cl. 9.4.3.1)		P
	connection of control devices in accordance with cl. 9.1.4		P
	stopping by de-energising (see cl.9.2.2)		P
	switching of all live conductors to device being controlled (see cl.9.4.3.1)		P
	use of switching devices having positive (or direct) opening operation (see IEC 60947-5-1)		P
	circuit design to reduce possibility of failures causing undesirable operations		P
9.4.2.2	on-line redundancy for normal operation		N

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Clause	Requirement – Test	Result - Remark	Verdict
	off-line redundancy for protective functions, effective only when operating function fails		N
	where off-line redundancy is use, suitable measures taken, to ensure that those control circuits are available when required		N
9.4.2.3	Use of control circuits having different principles of operation or using different types of devices may reduce faults and failures. Examples include:		—
	Combination of normally open and normally closed contacts operated by interlocking guards		N
	Use of different types of circuit components in control circuit		N
	Combination of electromechanical and electronic circuits in redundant configurations		N
	Combination of electrical and non- electrical systems (e.g. mechanical, hydraulic, pneumatic) may perform redundant functions and provide diversity		N
9.4.2.4	Automatic functional test carried out by the control system		N
	Manual function tests by inspection		N
	Tests at start-up and at predetermined intervals or as a		N
	Combination as appropriate (see cl.18.2 and 18.6)		N
9.4.3	Protection against malfunction of control circuits		—
9.4.3.1	Measures shall be provided to reduce the probability that insulation faults on any control circuit can cause malfunction	Method (b)	P
	Methods to meet these requirements include but are not limited to the following:		—
	a) Control circuits, fed by control transformers:		P
	The common conductor shall be connected to the protective bonding circuit at the point of supply.		N
	All control elements are to be inserted on the other side of the components		N
	Method b) – Non-earthed control circuits fed by transformers shall either	Switching power supply non- earthed transformer	N
	1) have 2-pole control switches that operate on both conductors; or		N
	2) be provided with a device that interrupts the circuit automatically in the event of an earth fault; or		N
	3) where 2) above would increase the risk, it can be sufficient to provide an insulation monitoring device hat will initiate an acoustic and optical signal		N

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Clause	Requirement – Test	Result - Remark	Verdict
9.4.3.1.4	Method c) – Control circuits fed by transformer with an earthed centre-tap winding shall have overcurrent protective devices that break both the conductors		N
	The control switches shall be 2-pole types that operate on both conductors		N
9.4.3.1.5	Method d) – Control circuits not fed by a transformer are only allowed for machines with a maximum of one motor starter and/or maximum of two control devices, in accordance with 9.1.1		N
	Possible cases are:		N
	1) directly connected to an earthed supply system (TN- or TT- system)		N
	If powered between two lines, multi-pole control switches are required		N
	2) directly connected to a supply system that is not earthed or is earthed through a high impedance (IT- system)		N
	A device shall be provided that interrupts the circuit automatically in the event of an earth fault		N
9.4.3.2	Where the loss of memory due to a power failure can result in a hazardous situation, appropriate measures shall be taken	PLC control, memory not loss if power off	N
9.4.3.3	Where the loss of continuity of control circuits depending upon sliding contacts can result in a hazard, appropriate measures shall be taken		N
10	OPERATOR INTERFACE AND MACHINE-MOUNTED CONTROL DEVICES		—
10.1.1	Devices to be selected, mounted and identified or coded acc. to IEC61310 and IEC 60447		P
10.1.2	Machine-mounted control devices readily accessible for service and maintenance and		P
	Mounted to minimise possibility of damage from activities such as material handling		P
	Actuators of hand-operated control devices selected and installed as follows:		—
	Mounted not less than 0.6 m above servicing level, and within easy reach for operator (normal working position)	Control panel highness >0.6m	P
	Placed so that operator is not exposed to a hazardous situation when operating them		P
	Possibility of inadvertent operation is minimised		P
	The actuators of foot-operated control devices shall be selected and installed so that:		—
	– they are within easy reach of the normal working position of the operator;		P

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Clause	Requirement – Test	Result - Remark	Verdict
	– the operator is not placed in a hazardous situation when operating them.		P
10.1.3	Degree of protection sufficient for expected use against:		—
	Effects of aggressive liquids, vapours or gases in environment of machine	No such evnironment	N
	Ingress of contaminants		N
	Operator interface control devices have a minimum degree of protection against direct contact of IPXXD		N
10.1.4	Position sensors arranged so, that they will not be damaged in the event of over travel		N
	Position sensors use in circuits with safety-related functions either have positive opening operation or provide similar reliability		N
10.1.5	Portable or pendant operator control stations and control devices selected or arranged in such wayas to minimise possibility ofinadvertent machine operations caused by shocks and vibrations	control station fixe on ground	N
10.2	Push-buttons		P
10.2.1	Pushbutton actuators colour-coded acc. To table 2		N
10.2.2	Recommendation that pushbuttons are preferably marked directly on actuator with symbols acc. To table3	words instead of symbol	N
10.3	Indicator lights and displays		N
10.3.1	Indicator lights and displays shall be selected and installed in such a manner as to be visible from the normal position of the operator (see also IEC 61310-1).	Suitable color and flash used	N
	Circuits used for visual or audible devices used to warn persons of an impending hazardous event shall be fitted with facilities to check the operability of these devices		N
10.3.2	Unless otherwise agreed between the supplier and the user (see Annex B), indicator lights shall be colour-coded with respect to the condition (status) of the machine in accordance with Table 4.		N
	Indicating towers on machines should have the applicable colours in the following order from the top to down; RED, YELLOW, BLUE, GREEN and WHITE.	No indicating tower	N
10.3.3	Flashing lights for further information may be used for following purposes:		—
	to attract attention or	Panel button flashing for attrct attention	N
	to request immediate action or		N

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	to indicate a discrepancy between command and actual state or		N
	to indicate a change in process(flashing during transition)		N
	higher frequency of flashing lights (pulse/pause ratios) recommended for higher priority of information		N
	Where flashing lights or displays are used to provide higher priority information, audible warning devices should also be provided.		N
10.4	Illuminated push-buttons		N
	Illuminated push-button actuators shall be colour-coded in accordance with Tables 2 and 4.		N
	WHITE colour shall be use, if it is difficult in assigning an appropriate colour		N
	RED colour shall be use, for emergency stop actuators, not depending upon illumination conditions (ON /OFF status) only		N
10.5	Rotary control devices		N
	Rotary control devices having a rotational member such as potentiometers and selector switches, mounted in such way as to prevent rotation of stationary member		N
10.6	Start devices		P
	Start devices use to initiate start functions or movement of machine or elements designed and mounted such as to minimise inadvertent operation	Considered	P
	Mushroom - type actuators use for two-hand control devices		N
10.7	Devices for emergency stop:		—
10.7.1	Devices for emergency stop readily accessible		N
	Emergency stop devices shall be provided at each location where the initiation of an emergency stop can be required		N
	In circumstances where confusion can occur between active and inactive emergency stop devices caused by disabling the operator control station, means (for example, information for use) are provided to minimise confusion.		N
10.7.2	Types of devices for emergency stop include following elements:		—
	push-button operated switch or	Push-button emergency stop	P
	pull-cord operated switch or		N
	pedal-operated switch without mechanical guard		N
	The devices shall be in accordance with IEC 60947-5-5.		P

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Clause	Requirement – Test	Result - Remark	Verdict
10.7.3	Where a stop category 0 is suitable, the supply disconnecting device may serve the function of emergency stop where: – it is readily accessible to the operator; and – it is of the type described in 5.3.2 a), b), c), or d)		P
	Where intended for emergency use, the supply disconnecting device shall meet the colour requirements of 10.2.1		N
10.8	Devices for emergency switching off:		—
10.8.1	Location of emergency switching- off devices normally placed separate from operator control station	emergency switching off switch located inner equipment	P
	Operator control station equipped with separate emergency stop device, since function effects a category 0 emergency stop		N
10.8.2	Types of emergency switching-off devices include:Push- button operated switch or		N
	Pull-cord operated switch		N
	Devices of self-latching type and ensure positive (or direct) opening operation		N
	Push-button operated switch in break-glass enclosure		N
10.8.3	Where the supply disconnecting device is to be locally operated for emergency switching off, it shall be readily accessible and shall meet the colour requirements of 10.2.1	Circuit breaker used as supply disconnecting	P
10.9	Enabling control device		—
	When an enabling control device is provided as a part of a system, it shall signal the enabling control to allow operation when actuated in one position only. In any other position, operation shall bestopped or prevented.		N
	Enabling control devices shall be selected and arranged so as to minimize the possibility of defeating.		N
	Enabling control devices shall be selected that have the following features:		—
	-Designed in consideration with ergonomic principles		N
	-Requirements for a two-position type:		—
	Position 1: OFF-function of switch(actuator is not operated)		N
	Position 2: enabling function(actuator is operated)		N
	-Requirements for a three-position type:		—
	Position 1: OFF-function of switch, (actuator is not operated)		N
	Position 2: enabling function of switch, (actuator is operated and in its mid position)		N

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Clause	Requirement – Test	Result - Remark	Verdict
	Position 3: OFF-function of switch, (actuator is operated past its mid position)		N
	When returning from position 3 to 2, function not enabled		N
11	CONTROLGEAR: LOCATION, MOUNTING, AND ENCLOSURES		—
11.1	All control gear located and mounted so, as to cover the following points:facilitate accessibility and maintain ability		P
	facilitate protection against external influences or operating conditions under which operation is intended		P
	facilitate easy access for operation and maintenance of the machine and its associated equipment		P
11.2	Location and mounting:		—
11.2.1	all control-gear components placed and oriented so, that identificationis possible without moving them or the associated wiring		P
	Components checked for correct operation or possible replacement without dismantling other equipment or parts of the machine		P
	Terminals not associated with control gear also to conform to this requirement		P
	Operation and maintenance of all gear possible control from front of cabinet		P
	Special tools for removal of electronic devices provided with the equipment	No need special tool	N
	Access for regular maintenance or adjustment to equipment, relevant devices located between0.4m to 2.0 m above servicing level		P
	Terminals located at least 0.2 m above servicing level and placed such, that conductors and cables can be easily connected		P
	No devices mounted on doors, except those for operating, indicating, measuring and cooling purposes on normally removable access-covers of enclosure	No devices mounted on doors	P
	Plug-in type control devices belonging functionally together, their association made clear by type (shape), marking or reference designation single or in combination (see cl. 13.4.5)		N
	Plug-in type control devices, that are handled during normal operation, shall be designed with non- interchangeable characteristics, where lack of such facility can result in malfunctioning		N
	Plug/socket combinations, handled during normal operation, shall be located and mounted so as to provide unobstructed access		N

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Clause	Requirement – Test	Result - Remark	Verdict
	If test points are provided, they should be:		—
	mounted so as to provide unobstructed access	No test point	N
	clearly marked to correspond with the documentation (see cl. 17.3)		N
	adequately insulated		N
	sufficiently spaced for connection of test equipment or means		N
11.2.2	Non-electrical parts and devices, not directly associated with the electrical equipment, not located within enclosures containing control gear		P
	Devices such as solenoid valves separated from other electrical equipment	valves separated from other electrical equipment	P
	Control devices mounted at same location and connected to the main supply voltage, or to both main supply and control voltage, are grouped separately from those connected to control voltage only		P
	Terminals separated into groups for:power circuits or		P
	associated control circuits or		P
	other control circuits, fed from external sources		P
	Terminal groups mounted adjacently, providing that each group is readily identified		P
	When arranging the location of devices, clearances and creepage distances specified for them shall be maintained, taking into account external influences or physical conditions of its environment(IEC60664-1)		P
11.2.3	Heat generating components located so, that temperature of each component in its vicinity remains within the permitted limits	No heat generating components	P
11.3	Degrees of protection:		—
	Protection of control gear against ingress of solid foreign objects and liquids shall be adequate. External influences under which the equipment is intended to operate is to be taken into account and is to be	Metal enclosure provided	P
	Its protection sufficient against dust, coolants and swarf		P
	Enclosures of control gear provide a degree of protection of at least IP22		N
	Exceptions:		—
	a) Where an electrical operating area is use as a protective enclosure for an appropriate degree of protection against ingress of solid bodies and liquids	Electrical operating area is in clean house, no water and dust	P
	b) Where removable collectors on collector bar systems are use, and IP22 is not achieved but measures of cl. 6.2.5 are applied		N

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Clause	Requirement – Test	Result - Remark	Verdict
11.4	Enclosures doors and openings:		—
11.4	Enclosures to withstand mechanical, electrical and thermal stress as well as effects of humidity during normal service		P
	Fasteners for doors or covers of captive type		P
	Windows for viewing internally mounted indicating devices, made of material suitable to withstand mechanical stress and chemical attack		P
	Doors of enclosure not wider than0,9 meter	Door width <0.9m	P
	Doors with vertical hinges, preferably lift-off type		P
	Doors with opening angle of at least 95 °		P
	Gaskets of doors, lids, covers and enclosures withstand the chemical effects of aggressive liquids, vapours or gases use on the machine		P
	Means use to maintain degree of protection of an enclosure of doors, lids and covers that require opening or removed for operational or maintenance shall:		—
	be securely attached to either door, cover or enclosure		P
	not deteriorate due to removal or replacement of door or cover and so impair degree of protection		P
	all openings in enclosure closed by supplier(s), ensuring degree of protection specified for equipment		P
	openings for cable entries at enclosure to be easily re-opened on site		P
	suitable opening in base of enclosure within the machine provided, as to enable drainage of moisture due to condensation		P
	no opening between enclosure containing electrical equipment and compartment containing coolant, lubricating or hydraulic fluids	Liquit in water tank with lever sensor	P
	holes in enclosure for mounting purposes not impair required degree of protection		P
	If equipment could attain a surface temperature sufficient to cause a risk of fire during normal or abnormal operation:		—
	located within an enclosure, that can withstand, without risk of fire or harmful effect, the heat emitted by the equipment or	No high temperature risk	N
	mounted and located at sufficient distance from adjacent equipment, so as to allow safe dissipation of heat or		N
	otherwise screened by material that can withstand, without risk of fire or harmful effect, the heat emitted by the equipment		N
11.5	Access to control gear:		—

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Clause	Requirement – Test	Result - Remark	Verdict
	Minimum dimensions of doors and corridors for access to electrical operating areas:at least 0.7 meter wide and 2.0 meter high	No such door	N
	Doors open outwards		N
	Doors equipped with means to allow opening from inside without the use of a key or tool		N
	Enclosures which readily allow a person to fully enter shall be provided with means to allow escape, for example panic bolts on the inside of doors.		N
	Enclosures intended for such access, for example for resetting, adjusting, maintenance, shall have a clear width of at least 0,7 m anda clear height of at least 2,1 m.		N
	In cases where: –equipment is likely to be live during access; and – conducting parts are exposed,		N
	the clear width shall be at least 1,0 m. In cases where such parts are present on both sides of theaccess way, the clear width shall be at least 1,5 m.		N
12	CONDUCTORS AND CABLES		—
12.1	Conductors and cables selected so as to be suitable for operating conditions and external influences that are existing		P
	Requirements not applicable for integral wiring of assemblies, subassemblies and devices that are manufactured and tested acc. to their relevant standard		P
12.2	Conductors		P
	Generally conductors shall be of copper		P
	Where aluminium conductors are used, the cross-sectional area shall be at least 16 mm2.	No aluminium wire	N
	To ensure adequate mechanical strength, the cross-sectional area of conductors should not be less than as shown in Table 5	At least 0,75mm^2	P
	Class 1 and class 2 conductors are primarily intended for use between rigid, non-moving parts.		P
	All conductors that are subject to frequent movement (for example one movement per hour of machine operation) shall have flexible stranding of class 5 or class 6.	No such movement	N
12.3	Insulation		P
	Where insulation of conductors or cables can constitute hazards due to propagation of fire or emission of toxic/ corrosive fumes, guidance from cable supplier to be sought		N

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Clause	Requirement – Test	Result - Remark	Verdict
	Special attention to integrity of a circuit having a safety- related function		N
	The insulation of cables and conductors used, shall be suitable for a test voltage:		
	Dielectric strength of insulation adequate for required test voltage with a 5min. of 2000VAC for cables operating with voltages >50VAC or>120 VDC	2000VAC for a test duration of 5 minutes	P
	For separate PELV circuits, dielectric strength adequate for test voltage of 500VAC for a duration of5 minutes	PELV wire, test duration of 5 minutes	P
	The insulation shall be such that it cannot be damaged in operation or during laying, especially for cables pulled into ducts.		P
12.4	Current-carrying capacity in normal service in accordance with table 6.	1.0mm^2 for control circuit No size requirement for signal wire	P
	Or in accordance with suppliers recommendation.		N
12.5	The voltage drop from the point of supply to the load in any power circuit cable shall not exceed 5 % of the nominal voltage under normal operating conditions.	voltage drop of cable less then 5%	P
	In control circuits, the voltage drop shall not reduce the voltage at any device below the manufacturer's specification for that device, taking into account inrush currents.		N
12.6	Flexible cables		P
12.6.1	Flexible cables have cl. 5 or cl. 6 conductors(see table C.4)		P
	cables exposed to severe duties shall be of adequate construction to protect against:		—
	abrasion due to mechanical handling and dragging across rough surfaces	Not use at severe duty	N
	kinking to operation without cable guides		N
	stress resulting from guide rollers and forced guiding, being wound and re-wound on cable drums		N
12.6.2	Cable handling system of machine designed such, as to keep tensile stress of conductors as low as practicable during machine operation		N
	tensile stress for copper conductors not to exceed 15N/mm2 of copper cross sectionarea		N
	where tensile stress of conductors is exceeding 15 N/mm2 , cables of special design are use		N
	maximum stress for flexible cables agreed with the cable manufacturer		N
12.6.3	Cables wound on drums selected such, as the maximum allowable conductor temperature is not exceeded		N

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Clause	Requirement – Test	Result - Remark	Verdict
	cables for circular cross-section area, installed on drums, max. current-currying capacity in free air as declared acc. to table 7		N
12.7	Collector wires, collector bars and slip-ring assemblies:		—
12.7.1	They shall be installed or enclosed in such way, that during normal access to the machine, protection against direct contact is achieved by application by one of the following protective measures:		—
	protection by partial insulation of live parts		N
	protection by enclosure or barriers provide a degree of protection of at least IP2X	Enclosure protection IP21	P
	horizontal top surfaces of barriers or enclosures which are readily accessible provide a degree of protection of at least IP4X		N
	if required degree of protection is not achieved, protection by placing live parts out of reach in combination with emergency switching- off acc. to cl. 9.2.5.4.3 applied		N
	collector wires and bares placed such and / or protected as to prevent contact, especially for unprotected wires and bars, with conductive items such as, cords of pull-cord switches, strain-relief devices and drive chains and	collector wires in the metal cabinet	N
	prevent damage from a swinging load		N
12.7.2	Where collector wires, collector bars and slip-ring assemblies are installed as part of the PE-circuit, they do not carry current in normal operation	PE collector wire N collector wire	N
12.7.3	Protective conductors of current collectors have a shape or are designed such, so that they are not interchangeable with other current collectors of the sliding contacttype		N
12.7.4	Removable current collectors with disconnector function are designed such, that PE-circuit is interrupted only after live conductors have been disconnected and the continuity of the PE-circuit is re- established before any live conductor is reconnected		N
12.7.5	Clearances between respective conductors and between adjacent systems of collector wires, bars, slip-ring assemblies and their current collectors designed for operation in pollution degree 3 conditions and an overvoltage category III in accordance with IEC60664-1	Clearances comply with IEC60664-1 on wires collector	P
12.7.6	Creepage distances suitable for operation in pollution degree 3	Pollution degree 2	N
	In abnormally dusty, moist or corrosive environments, following creepage distances apply:		—
	for unprotected collector wires, bars and slip-ring assemblies equipped with insulators, the minimum creepage distance is 60 mm		N

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Clause	Requirement – Test	Result - Remark	Verdict
	for enclosed collector wires, insulated multipole collector bars and insulated individual collector bars, the minimum creepage distance is 30 mm		N
	gradual reduction of insulation values due to unfavourable ambient conditions regarded		N
12.7.7	Suitable design measures taken, in order to prevent energisation of adjacent sections by current collectors themselves		N
12.7.8	Collector wires, collector bar systems and slip-ring assemblies use for power circuits kept separately from those use for control circuit applications		N
	above systems capable of withstanding without damage to mechanical forces and thermal effects of short circuit currents		N
	removable covers to above systems, laid underground or under floor, designed that they cannot be opened by one person without the use of a tool		N
	collector bars which are installed in a common metal enclosure, the individual section of it bonded together and earthed at several points depending upon their length		N
	Metal covers of collector bars laid underground or under floor, bonded together end earthed		N
	Underground and under floor collector bar ducts have drainage facilities		N
13	WIRING PRACTICES		—
13.1.1	All connections, especially those of the protective bonding circuit, secured against accidental loosening		P
	Means of connection suitable for cross-sectional areas and nature of conductors being terminated		P
	Connection of two or more conductors to one terminal only where terminal is designed for that purpose		N
	Only one PE-conductor connected to one terminal connecting point		P
	Soldered connections only, where terminals are provided which are suitable for soldering connections		N
	Terminals on terminal blocksplainly identified to correspond with markings on wiring diagrams		P
	Installation of flexible conduits and cables such, that liquids are drained away from fittings and joints		P
	Means to retain stranded conductors together when terminating conductors at terminals/ devices provided		P
	Solder not use for that purpose		N

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Clause	Requirement – Test	Result - Remark	Verdict
	Shielded conductors terminated so, as to prevent fraying of strands and to permit easy disconnection		N
	Identification tags legible, permanent and appropriate for physical environment		P
	Terminal blocks mounted and wired so, that internal and external wiring does not cross over terminals		P
13.1.2	Conductors and cables shall be run from terminal to terminal without splices or joints		P
	Connections using plug/socket combinations with suitable protection against accidental disconnection are not considered to be splices or joints for the purpose of this subclause		P
	Exceptions are possible as described		N
	Terminations of cables shall be adequately supported to prevent mechanical stresses at the terminations of the conductors		P
	Protective conductor shall be placed close to the associated live conductors in order to decrease the impedance of the loop		P
	Conductors and cables shall be run from terminal to terminal without splices or joints		P
13.1.3	Conductors of different circuits		P
	Conductors of different circuits laid side by side and occupy the same duct or be in same multiconductor cable, provided that such arrangement does not impair proper functioning of respective circuits		P
	Where circuits operate at different voltage levels, conductors separated by suitable barriers or insulated for maximum voltage to which any conductor within the same duct is subjected		P
13.1.4	Conductors of AC circuits installed in ferromagnetic enclosures shall be arranged so that all conductors of each circuit, including the protective conductor of each circuit, are contained in the same enclosure		N
	Single-core cables armoured with steel wire or steel tape should not be used for AC circuits		N
13.1.5	The cable between the pick-up and the pick-up converter as specified by the manufacturer of theinductive power supply shall be:		N
	– as short as practicable;		N
	– adequately protected against mechanical damage.		N
13.2	Identification of conductors:		—
13.2.1	Conductors identifiable at each termination point acc. to technical documentation(see Clause 17).		P

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Clause	Requirement – Test	Result - Remark	Verdict
	It is recommended (for example to facilitatemaintenance) that conductors be identified by number, alphanumeric, colour (either solid or with one or more stripes), or a combination of colour and numbers or alphanumeric.		P
	When numbers are used, they shall be Arabic; letters shall be Roman (either upper or lower case).		P
13.2.2	Protective conductor readily distinguishable by shape, location, marking or colour		P
	Bicolour combination GREEN-AND- YELLOW use throughout the length of the conductor	GREEN-AND- YELLOW use throughout the length	P
	For insulated conductors, the bicolour combination GREEN- AND-YELLOW shall be such that on any 15 mm length, one of the colours covers at least 30 % and not more than 70 % of the surface of the conductor, the other colour covering the remainder of the surface.		N
	This colour identification is strictly reserved for the protective conductor, so that it can be easily identified by its shape		N
	Ends or accessible positions of a protective conductor clearly identified by graphical symbol or by bicolour combination GREEN-AND- YELLOW		N
13.2.3	Where a circuit includes a neutral conductor identified by colour, the colour is LGHT BLUE	N wire use ligh blue	N
	LIGHT BLUE must not be use for identification of any other conductor where confusion is possible		N
	Where bare conductors are use as neutral conductors and identification by colour is use, they either be coloured by LIGHT BLUE stripes, 15 to 100 mm wide in each compartment or unit, or at each accessible position		N
	Bare conductor colour colouredLIGHT BLUE over its full length		N
13.2.4	Where colour-coding is used, BLACK, BROWN, RED, ORANGE, YELLOW, GREEN, BLUE (including LIGHT BLUE), VIOLET, GREY, WHITE, PINK, TURQUOISE may be used	Each wire indicated by letter	N
	GREEN and YELLOW should not be used where there is a possibility of confusion with the bicolour combination GREEN-AND-YELLOW		N
13.3	Wiring inside enclosures		N
	Conductors inside enclosures shall be supported where necessary	All conduct inside trunking system	N
	Non-metallic supports shall be made with a flame-retardant insulating material (see IEC 60332 series)		N
	Connections to devices mounted on doors or to other movable parts shall be made using flexible conductors in accordance with 12.2 and 12.6.		N

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Clause	Requirement – Test	Result - Remark	Verdict
	Conductors and cables that do not run in ducts shall be adequately supported		N
13.4	Wiring outside enclosures:		—
13.4.1	Conductors of a circuit shall not be distributed over different multi-core cables, conduits, etc.		N
13.4.2	External ducts		N
	Conductors and their connections external to the electrical equipment shall be placed in suitable ducts (see cl.13.5) Exceptions: --Cables with special suitable protection. -Position switches or proximity switches supplied with a dedicated cable which is sufficiently short	Cables with PVC protection	N
13.4.3	Connections to moving parts shall take into account the foreseeable frequency of movement and shall be made using conductors in accordance with 12.2 and 12.6		N
	The bending radius of the cable shall be at least 10 times the diameter of the cable		N
	Flexible cables of machines shall be so installed or protected as to minimize the possibility of external damage (run over, forces, rubbing, heat, etc.)		N
	Cables close to moving parts, shall maintain a space of at least 25 mm between the moving parts and the cables or barriers are provided		N
	Cable handling systems: Lateral cable angles not exceeding 5°at being wound on and off cable drums or approaching and leaving cable guidance devices. The bending radius shall be in accordance with Table 8		N
	Flexible conduit shall not be used for connections subject to rapid or frequent movements except when specifically designed for that purpose		N
13.4.4	Where several machine-mounted devices are connected in series or in parallel, it is recommended that the connections between those devices be made through terminals forming intermediate test points		N
13.4.5	Plug/socket combinations	No plug/socket	N
	Components or devices inside an enclosure, terminated by fixed plug/socket combinations (no flexible cable), or components connected to a bus system by a plug/socket combination, are excluded		N
	Where the plug/socket contains a contact for the protective bonding circuit, it shall have a first make last break contact (see also 8.2.4).		N

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Clause	Requirement – Test	Result - Remark	Verdict
	Plug/socket combinations intended to be connected or disconnected during load conditions shall have sufficient load-breaking capacity		N
	Where the plug/socket combination is rated at 30 A, or greater, it shall be interlocked		N
	Plug/socket combinations that are rated at more than 16 A shall have a retaining means to prevent unintended or accidental disconnection.		N
	Where an unintended or accidental disconnection of plug/socket combinations can cause a hazardous situation, they shall have a retaining means.		N
	The installation of plug/ socket combinations shall fulfil the following requirements as applicable:		N
	a) The component which remains live after disconnection shall have a degree of protection of at least IP2X or IPXXB		N
	b) Metallic housings of plug/ socket combinations shall be connected to the protective bonding circuit		N
	c) Plug/ socket combinations intended to carry power loads but not to be disconnected during load conditions shall have a retaining means to prevent unintended or accidental disconnection and shall be clearly marked accordingly		N
	d) Where more than one plug/ socket combination is provided in the same electrical equipment, the associated combinations shall be clearly identifiable. Mechanical coding is recommended		N
	e) Plug/ socket combinations used in control circuits shall fulfil the applicable requirements of IEC 61984. Exception: combinations in accordance with IEC 60309- 1, only those contacts shall be used for control circuits which are intended for those purposes. This exception does not apply to control circuits using high frequency signals superimposed on the power circuits.		N
13.4.6	Dismantling for shipment		P
	If wiring needs to be disconnected for shipment, terminals or plug/socket combinations are provided at the disconnecting points		P
13.4.7	Additional wiring for maintenance or repair purposes provided		N
13.5	Ducts, connection boxes and other boxes:		—
13.5.1	Ducts shall provide a degree of protection suitable for the application (see IEC 60529).	No such duct	N
	All sharp edges, flash, burrs, rough surfaces or threads which the insulation of conductors may come into contact, removed from ducts and conduits		N

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EN 60204-1			
Clause	Requirement – Test	Result - Remark	Verdict
	In order to avoid confusion between conduits for electrical installation and those for oil, water or air, either physically separated or suitably identified		N
	Ducts or cable trays rigidly supported and positioned at sufficient distance from moving parts		N
	Ducts or cable trays mounted at least 2 meters above the working surface in areas where human passage is required		N
	Ducts provided only for mechanical protection (see cl. 8.2.3)		N
	Cable trays which are partially covered, not to serve as cable trays or installation trunking		N
	Conductors and cables suitable for installation in cable trays		N
13.5.2	Cable trays dimensioned or located such, as to enable easy access for installation of additional conductors and cables		N
	Consideration given on percentage of filling of such ducts.		N
13.5.3	Rigid metal conduits or trays consist of galvanised steel or corrosion-resistant material, suitable for the environmental conditions.		N
	Application of cable trays of different metal avoided, due to electrolytic corrosion		N
	Installation conduits secured, held in place and supported at each end		N
	Joints and fittings compatible with conduits and appropriate for its application		N
	Conduit-bends fabricated such, as to avoid damage or reduction of internal cross-section		N
13.5.4	Flexible metallic conduits and fittings consist of flexible metal tubing or wire mesh armour.		N
	They are suitable for its application and environmental conditions		N
13.5.5	Flexible non-metallic conduits are resistant to buckling and with similar characteristics as the sheath of multicore cables	Flexible non-metallic conduits are resistant to buckling	P
	They shall be suitable for its application and environmental conditions		N
	Joints and fittings compatible with conduits and appropriate for its application		N
13.5.6	Cable trunking systems outside of enclosures are rigidly supported and kept clear of moving and contaminating parts of the machine	All cable trunking systems inside of enclosures	N

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EN 60204-1			
Clause	Requirement – Test	Result - Remark	Verdict
	Covers of cable trunking designed such, as to overlap at both sides of cable trunking(see cl. 14.5.6)		N
13.5.7	Installation of cables layed in cable trays with covers permitted within the machine-foundations, providing that they are completely closedand separated from coolant and lubrication systems(see cl. 14.5.6)		N
13.5.8	Cable connection boxes and junction boxes use for wiring purposes are readily accessible for maintenance (see cl. 12.3)		N
	provide protection against ingress of solids or liquids, taking into account external influences during operation of the machine (see cl. 12.3)		N
	Junction boxes not have openings for cable entries and are designed so, as to avoid ingress of entrained dust, lubricants and coolant		N
13.5.9	Motor terminal boxes use for motor cable connection and for devices attached to the motor		N
14.	ELECTRIC MOTORS AND ASSOCIATED EQUIPMENT		—
14.1	Electric motors are conform to EN60034-1	Only fan, no motor	N
	Electric motors and associated equipment protected against following risks:		—
	overcurrent (see cl. 7.2)		N
	thermal overload (see cl. 7.3)		N
	overspeed (see cl. 7.6)		N
	Compliance ensured with the requirements stated (see clauses5.3, 5.4, 5.5, 7.5, 7.6 and 9.4)		N
	Motor control equipment located and mounted acc. to cl. 12		N
14.2	Selection of motor enclosure recommended acc. to EN 60034-5		N
	Degree of protection at least IP23		N
	Incorporated motors mounted such, as to provide adequate protection against mechanical damage		N
14.3	Dimensions of motors conform to those given in IEC regulations(see EN 60072-1 and EN 60072-2)		N
14.4	Each motor with associated coupling, belt, pulley or chain mounted such, as to provide adequate protection and easy access for inspection, maintenance, adjustment or alignment, lubrication and replacement		N
	Motors mounted such, as to allow easy access to all terminal boxes		N
	Motors mounted such, as to ensure proper cooling Temperature rise to be within limits of relevantinsulation class		N

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EN 60204-1			
Clause	Requirement – Test	Result - Remark	Verdict
	Temperature rise within limits of relevant insulation class		N
	If possible, motor compartments stay clean and dry and when required, ventilated directly to the outside of the machine		N
	Motor-vents at an acceptable level and designed such, as to avoid ingress of swarf, dust or water spray		N
	No opening between motor compartment and any other compartment, which does not fulfil the requirement for motor compartments		N
14.5	Electric motors selected acc. to service and environmental conditions		N
	Design criteria for evaluation include: type of motor and		N
	type of duty cycle (see IEC 60034-1) and		N
	fixed speed or variable speed operation and		N
	mechanical vibrations and		N
	type of converter for motor speed control and		N
	influence of the harmonic spectrum of voltage and/or current when supplied from static converter on the temperature rise and		N
	method of starting and possible influence of inrush current		N
	variation of counter torque load with time and speed		N
	influence of loads with large inertia and		N
	influence of constant torque or constant power operation and		N
	possible need of inductive reactors between motor and converter		N
14.6	Operation of overload or overcurrent protective devices for mechanical brake-actuators initiate simultaneous de-energisation(release) of associated machine actuators		N
15.	ACCESSORIES AND LIGHTING		—
	No accessories and lighting		—
15.1	Where the machine or its associated equipment is provided with socket-outlets for auxiliary equipment, the following will apply:		—
	socket-outlets are conform to regulations	No socket-outlet	N
	if not possible, they are clearly marked with voltage and current ratings		N
	continuity of protective bonding circuit to be ensured		N
	all unearthed conductors connected to socket-outlets, protected against overcurrent		N

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EN 60204-1			
Clause	Requirement – Test	Result - Remark	Verdict
	when required, protection against overload in accordance with cl. 7.2 and cl. 7.3 separately from protection of other circuits		N
	if power supply to socket-outlets is not disconnected, than requirements of cl.5.3.5 apply		N
15.2.1	Connection to PE-circuit acc. to cl.8.2.2		N
	ON-OFF switch not incorporated in lampholder or in flexible connecting cord		N
	Stroboscopic effects from lights avoided		N
	If fixed lighting is provided in an enclosure, electromagnetic compatibility (EMC) taken into account		N
	Application of EMC requirements acc. to principles stated in cl. 4.4.2		N
15.2.2	Nominal voltage of local lighting circuits not exceeding 50 V		N
	If higher voltages are applied, value not exceeding 250 V between conductors	Voltage Less than 250V	N
	Lighting circuits supplied from one of the following sources:		—
	from a dedicated isolating transformer connected to load side or		N
	overcurrent protection provided in secondary circuit or		N
	a dedicated isolating transformer connected to line side provided or		N
	source permitted for maintenance purpose or		N
	lighting circuits placed in control enclosures only or		N
	overcurrent protection provided in secondary circuit or		N
	from a machine-circuit with dedicated overcurrent protection or		N
	from an isolating transformer connected to line side of supply disconnecting device, when a dedicated primary disconnecting means and a secondary overcurrent protection are provided or		N
	for an externally supplied lighting circuit, which is only permitted in a control enclosures		N
	where fixed lighting is out of reach for operator during normal operations, provisions of this subclause do not apply		N
15.2.3	local lighting circuits protected		N
15.2.4	adjustable lighting fittings suitable for the physical environment provided		N
	lampholders in accordance with relevant IEC-publications and		N

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EN 60204-1			
Clause	Requirement – Test	Result - Remark	Verdict
	designed of an insulating material protecting the lamp cap, as to prevent unintentional contact		N
	reflectors supported by a bracket and not by the lampholder		N
	where fixed lighting is out of reach for operator during normal operations, provisions of this subclause do not apply		N
16.	MARKING, WARNING SIGNS AND REFERENCE DESIGNATIONS		—
16.1	Warning signs, nameplates, markings- and identification plates of sufficient durability to withstand the physical environment involved		P
16.2	Warning signs		P
16.2.1	Enclosures that do not otherwise clearly show that they contain electrical shall be marked with the graphical symbol ISO 7010-W012 	Symbol marked on outer enclosure	P
	It may be omitted (see also 6.2.2 b)) for: – an enclosure equipped with a supply disconnecting device – an operator- machine interface or control station – a single device with its own enclosure (for example position sensor)		P
16.2.2	Hot surfaces hazard		N
	Where the risk assessment shows the need to warn against the possibility of hazardous surface temperatures, the graphical symbol ISO 7010-W017 shall be used 	No hot surface	N
16.3	Control devices and visual indicators, shall be clearly and durably marked with regard to their functions		P
16.4	The following information shall be legibly and durably marked - plainly visible after installation on enclosures that receive incoming power supplies: • name or trade mark of supplier • certification mark or other marking where applicable • type designation or model, where applicable • serial number where applicable • main document number (see IEC 62023) where applicable • rated voltage, number of phases and frequency (if AC), and full-load current for each incoming supply It is recommended that this information is provided adjacent to the main incoming supply(ies)	See marking plate(page 6)	P
16.5	All enclosures, assemblies, control devices, and components shall be plainly identified with the same reference designation as shown in the technical documentation		P
17	TECHNICAL DOCUMENTATION		P

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EN 60204-1			
Clause	Requirement – Test	Result - Remark	Verdict
17.1	The information necessary for identification, transport, installation, use, maintenance, decommissioning and disposal of the electrical equipment shall be supplied		P
	Annex I should be considered as guidance for the preparation of information and documents		P
17.2	Information provided with electrical equipment		—
	The following shall be supplied:		—
	a) where more than one document is provided, a main document for the electrical equipment as a whole, listing the complementary documents		P
	b) identification of the electrical equipment		P
	c) information on installation and mounting including: • a description of installation and mounting, and its connection to the electrical and other supplies • short-circuit current rating for each incoming power supply • rated voltage, number of phases and frequency (if AC.), type of distribution system (TT, TN, IT) and full-load current for each incoming supply • any additional electrical supply(ies) requirements (for example maximum supply source impedance, leakage current) for each incoming supply • space required for servicing • installation requirements regarding cooling • environmental limitations (for example lighting, vibration, EMC environment, atmospheric contaminants) • functional limitations (for example peak starting currents and permitted voltage drops) • precautions to be taken for the installation regarding electromagnetic compatibility		P
	d) an instruction for the connection of conductive-parts in the vicinity of the machine to the protective bonding circuit: • metallic pipes • fences • ladders • handrails	No such parts	N
	e) information on the functioning and operation as applicable: • an overview of the structure of the electrical equipment • procedures for programming or configuring • procedures for restarting after an unexpected stop • a sequence of operation		P

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EN 60204-1			
Clause	Requirement – Test	Result - Remark	Verdict
	f) information on maintenance, as appropriate: • frequency and method of functional testing • instructions for safe maintenance and where necessary suspend a safety function and/or protective measure (see 9.3.6) • guidance on the adjustment, repair, and frequency and method of preventive maintenance • details of the interconnections subject to replacement • required special devices or tools; • spare parts; • possible residual risks, indication of particular training and specification of personal protective equipment • instructions to restrict availability of keys or too(s to skilled or instructed persons • settings (DIP-switches, programmable parameter values, etc); • information for validation of safety related control functions after repair or modification, and for periodic testing where necessary;		P
	g) information on handling, transportation and storage		P
	h) information for proper disassembly and handling of components		N
18	TESTING AND VERIFICATION		—
18.1	The extent of verification will be given in the dedicated product standard for a particular machine. Where there is no such standard, the verifications shall always include the items a), b), c) and h) and may include one or more of the items d) to g): a) verification that the electrical equipment complies with its technical documentation b) verification of continuity of the protective bonding circuit (Test 1 of 18.2.2) c) in case of fault protection by automatic disconnection of supply, conditions shall be verified according to 18.2; d) insulation resistance test (see 18.3) e) voltage test (see 18.4) f) protection against residual voltage (see 18.5) g) verification that the relevant requirements of 8.2.6 are met h) functional tests (see 18.6)		P
	The results of the verification shall be documented		P
18.2	Verification of conditions forprotection by automatic disconnection of supply		P

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EN 60204-1			
Clause	Requirement – Test	Result - Remark	Verdict
18.2.1	Test 1 verifies the continuity of the protective bonding circuit. Test 2 verifies the conditions for protection by automatic disconnection of the supply in TN systems For TN-systems, those test methods are described in 18.2.2 and 18.2.3; their application for different conditions of supply are specified in 18.2.4 For TT systems, see Clause A.2 For IT systems, see IEC 60364-6		P
	Where RCDs are used in the electrical equipment, their function shall be verified in accordance with the manufacturer's instructions. The test procedure and test interval shall be specified in the maintenance instructions		P
18.2.2	Test 1: Verification of the continuity of the protective bonding circuit		P
	Test 1 verifies the continuity of the protective bonding circuit.		P
	The resistance between the PE terminal (see 5.2 and Figure 4) and relevant points that are part of the protective bonding circuit shall be measured with a current between 0.2 A and approximately 10 A derived from an electrically separated supply source having a maximum no-load voltage of 24 V	See appended table	P
	The resistance measured shall be in the expected range		P
18.2.3	Test 2: Fault loop impedance verification and suitability of the associated overcurrent protective device		P
	The connections of each power supply including the connection of the associated protective conductor to the PE terminal of the machine, shall be verified by inspection		P
	The conditions for the protection by automatic disconnection of supply in accordance with 6.3.3 and Annex A shall be verified by both		P
	a) verification of the fault loop impedance by - calculation, or - measurement in accordance with A.4, and		P
	b) confirmation that the setting and characteristics of the associated overcurrent protective device are in accordance with the requirements of Annex A, and		N
	Where a power drive system (PDS) is used, confirmation that the setting and characteristics of the protective device(s) are in accordance with the converter manufacturer's and protective device manufacturer's instructions		N
18.2.4	Application of the test methods for TN-systems		P

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EN 60204-1			
Clause	Requirement – Test	Result - Remark	Verdict
	When Test 2 of 18.2.3 is carried out by measurement, it shall always be preceded by Test 1 of 18.2.2		P
	The tests that are necessary for machines of different status are specified in Table 9		P
18.3	Insulation resistance tests (optional)		P
	When insulation resistance tests are performed, the insulation resistance measured at 500 V DC between the power circuit conductors and the protective bonding circuit shall be not less than 1 MΩ	>1 MΩ	P
	If the electrical equipment of the machine contains surge protection devices which are likely to operate during the test, it is permitted to either: – disconnect these devices, or – reduce the test voltage to a value lower than the voltage protection level of the surge protection devices		P
18.4	Voltage tests (optional)		P
	The test voltage shall be at a nominal frequency of 50 Hz or 60 Hz.		P
	The maximum test voltage shall have a value of twice the rated supply voltage of the equipment or 1 000 V, whichever is the greater		P
	The test voltage shall be applied between the power circuit conductors and the protective bonding circuit for at least 1 s		—
	Components and devices that are not rated to withstand the test voltage and surge protection devices shall be disconnected		P
18.5	Protection against residual voltages		P
	Where appropriate, tests shall be performed to ensure compliance with 6.2.4		P
18.6	Functional tests		
	The functions of electrical equipment shall be tested		P
18.7	Retesting		
	Where a portion of the machine or its associated equipment is changed or modified, the need for re-verification and testing of the electrical equipment shall be considered		N

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1. Risk assessment

This risk assessment report is based on the methods in the EN ISO 12100:2010 and EN ISO 14121-2 standards, and the 4 factors S-A-G-W have been used for evaluating the level of risks.

S：Severity of possible harm

- S1：Slight（normally reversible）
- S2：Serious（normally irreversible）
- S3：Cause a few men die
- S4：Calamity or cause many men die

A：Frequency any duration of exposure

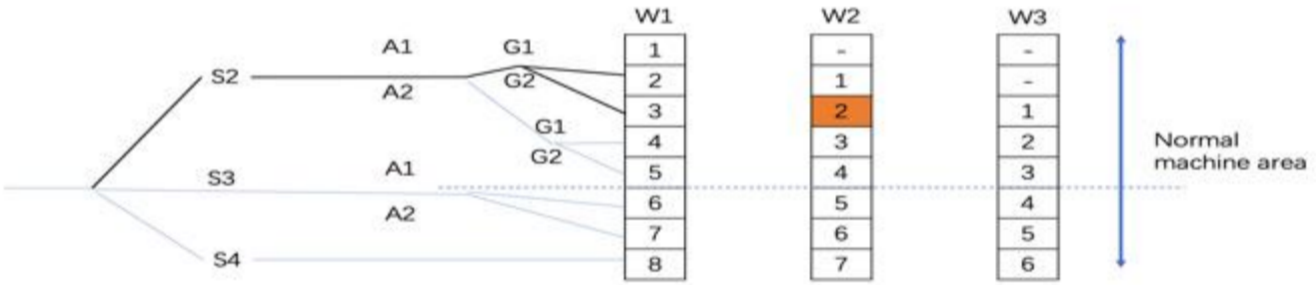
- A1：Seldom to very often
- A2：Frequent to continuous

G：Possibilities of avoidance

- G1：Possible
- G2：Impossible

W：Probability of occurrence of harm

- W1：Low
- W2：Medium



- W3：High

Solutions for the level of hazards

1：Protected by warning sign

2：Protected by guard and warning sign

3：Consider the other design, choose the best one, add both guard and warning sign

4：Consider another two design, choose the best one, add both guard and warning sign

5：Consider another three design, choose the best one, add both guard and warning sign

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NO.	Hazards source	S	A	G	W	Level
Mechanical hazards						
1.0-1	Mechanical hazards due to machine parts or work pieces					
1.0-2	Mechanical hazards due to accumulation of energy inside the machinery					
1.1	Crushing					-
1.2	Shearing					
1.3	Cutting or severing					
1.4	Entanglement	***1***	***1***	***1***	***1***	***1***
1.5	Drawing-in or trapping					
1.6	Impact					
1.7	Stabbing or puncture					
1.8	Friction or abrasion					
1.9	High pressure fluid injection or ejection					
Electrical hazards						
2.1	Contact with live parts					
2.2	Contact with parts which have become live under faulty conditions					
2.3	Approach to live part under high voltage					
2.4	Electrostatic phenomena					
2.5	Thermal radiation or other phenomena such as projection of molten particles and chemical effects form short-circuits, overloads etc.					
Thermal hazards						
3.1	Burns, scalds and other injuries by a possible contact of persons with objects or materials with an extreme high or low temperature, by flames or explosions and also by the radiation of heat sources					
3.2	Damage to health by hot or cold working environment					
Hazards generated by noise						
4.1	Hearing loss (deafness), other physiological disorders					
4.2	Interference with speech communication, acoustic signals, etc.					
Hazards generated by vibration						
5.1	Use of hand-help machines resulting in a variety of neurological and vascular disorder					
5.2	Whole body vibration, particular when combined with poor postures					
Hazards generated by radiation						
6.1	Low frequency, radio frequency radiation, microwaves					
6.2	Infrared, visible and ultraviolet light					
6.3	X and gamma rays					
6.4	Alpha, beta rays, electron or ion beams, neutrons					
6.5	Lasers					

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Hazards generated by materials and substances processed or used by the machinery						
7.1	Hazards from contact with or inhalation of harmful fluids, gases, mists, fumes and dusts					
7.2	Fire and explosion hazard					
7.3	Biological and micro-biological (viral or bacterial) hazards					
Hazards generated by neglecting ergonomic principles in machine design						
8.1	Unhealthy postures or excessive effort	***1***	***1***	***1***	***1***	
8.2	Inadequate consideration of hand-arm or foot-leg anatomy					
8.3	Neglected use of personal protection equipment					
8.4	Inadequate local lighting					
8.5	Mental overload or underload, stress					
8.6	Human error, human behavior	***1***	***1***	***1***	***1***	
8.7	Inadequate design, location or identification of manual controls					
8.8	Inadequate design, location or identification of manual controls					
Combination of hazards						
9	Combination of hazards					
Unexpected start-up, unexpected overrun/over-speed						
10.1	Failure/disorder of the control system					
10.2	Restoration of energy on supply after an interruption					
10.3	External influences on electrical equipment					
10.4	Other external influences (gravity, wind, etc.)					
10.5	Errors in the software					
10.6	Error made by the operator (due to mismatch of machinery with human characteristics and abilities, see 8.6)					
Impossibility of stopping the machine in the best possible conditions						
11	Impossibility of stopping the machine in the best possible conditions					
Variations in the rotational speed of tools						
12	Variations in the rotational speed of tools	***1***	***1***	***1***	***1***	
Failure of the power supply						
13	Failure of the power supply					
Failure of the control circuit						
14	Failure of the control circuit					
Errors of fitting						
15	Errors of fitting					
Break-up during operation						
16	Break-up during operation	***1***	***1***	***1***	***1***	
Falling or ejected objects or fluids						
17	Falling or ejected objects or fluids					
Loss of stability / overturning of machinery						
18	Loss of stability / overturning of machinery					
Slip, trip and fall of persons (related to machinery)						
19	Slip, trip and fall of persons(related to					

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	machinery)					
Additional hazards, hazardous situations and hazardous events due to mobility						
20	Relating to the traveling function					
20.1	Movement when starting the engine					
20.2	Movement without a driver at the driving position					
20.3	Movement without all parts in a safe position					
20.4	Excessive speed of pedestrian controlled machinery					
20.5	Excessive oscillations when moving					
20.6	Insufficient ability of machinery to be slowed down, stopped and immobilisated					
Linked to the work position (including driving station) on the machine						
21.1	Fall of persons during access to (or at/from) the work position					
21.2	Exhaust gases/lack of oxygen at the work position					
21.3	Fire（flammability of the cab, lack of extinguishing means）					
21.4	Mechanical hazards at the work position: contact with the wheels; rollover; fall of objects, penetration by objects; break-up of parts rotation at high speed; contact of persons with machine parts or tools（pedestrian controlled machines）					
21.5	Insufficient visibility form the work positions					
21.6	Inadequate lighting					
21.7	Inadequate seating					
21.8	Noise at the work position					
21.9	Vibration at the work position					
21.1	Insufficient means for evacuation/emergency exit					
Due to the control system						
22.1	Inadequate location of manual controls					
22.2	Inadequate design of manual controls and their mode of operation					
Form handling the machine (lack of stability)						
23	Form handling the machine（lack of stability）					
Due to the power source and to the transmission of power						
24.1	Hazards form the engine and the batteries					
24.2	Hazards form the transmission of power between machines					
24.3	Hazards form coupling and towing					
Form/to third persons						
25.1	Unauthorized start-up/use	***1***	***1***	***1***	***2***	**-**

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25.2	Drift of a part away from its stopping position					
25.3	Lack or inadequacy of visual or acoustic warning means					
Insufficient instructions for the driver/operator						
26	Insufficient instructions for the driver/operator					-
Additional hazards, hazardous situations and hazardous events due to lifting						
27	Mechanical hazards and hazardous events					
27.1	Form load falls, collisions, machine tipping caused by:					
27.1.1	Lack of stability					
27.1.2	Uncontrolled loading-overloading-overturning moments exceeded					
27.1.3	Uncontrolled amplitude of movements					
27.1.4	Unexpected/unintended movement of loads					
27.1.5	Inadequate holding devices/accessories					
27.1.6	Collision of more then one machine					
27.2	Form access of persons to load support					
27.3	Form derailment					
27.4	Form insufficient mechanical strength of parts					
27.5	Form inadequate selection of chains, ropes, lifting and accessories and their inadequate integration into the machine					
27.6	Form inadequate selection of chains, ropes, lifting and accessories and their inadequate integration into the machine					
27.7	Form lowering of the load under the control of friction brake					
27.8	Form abnormal conditions of assembly/testing/use/maintenance					
27.9	Form the effect of load on persons （impact by load or counterweight）					
Electrical hazards						
28.1	Form lightning					
Hazards generated by neglecting ergonomic principles						
29.1	Insufficient visibility from the driving position					
Additional hazards, hazardous and situations and hazardous events due to underground work						
30	Mechanical hazards and hazardous events due to:					
30.1	Lack of stability of powered roof supports					
30.2	Failing accelerator or brake control of machinery running on rails					
30.3	Failing or lack of dead man’s control of machinery running on rails					
31	Restricted movement of persons					
32	Fire and explosion					
33	Emission of dust, gases etc.					
Additional hazards, hazardous situations and hazardous events due to the lifting or moving of						

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persons						
34	Mechanical hazards and hazardous events due to:					
34.1	Inadequate mechanical strength-inadequate working coefficients					
34.2	Failing of loading control					
34.3	Failing of controls in person carrier (function, priority)					
34.4	Over speed of person carrier					
35	Falling of person from person carrier					
36	Falling or overturning of person carrier					
37	Human error, human behavior					

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NO.	Hazards source	S	A	G	W	Level
1.4	Entanglement	1	1	1	1	1
Where	*The moving part of the machine*					
When	*The machine is working*					
Improvement result						
Method		**S**	**A**	**G**	**W**	**Level**
1. Affixing suitable warning signs. *2. Only operation by training/authorized persons.* *3. Operation of the machine shall conform to the instructions of the instruction manual.*		1	1	1	1	-

NO.	Hazards source	S	A	G	W	Level
8.1	Unhealthy postures or excessive effort					
Where	*The tools*					
When	*The machine is working*					
Improvement result						
Method		**S**	**A**	**G**	**W**	**Level**
1. Affixing suitable warning signs. *2. Only operation by training/authorized persons.* *3. Operation of the machine shall conform to the instructions of the instruction manual.*		1	1	1	1	-

NO.	Hazards source	S	A	G	W	Level
8.6	Human error, human behavior	1	1	1	1	-
Where	*The machine is working*					
When	*The machine is power on*					
Improvement result						
Method		**S**	**A**	**G**	**W**	**Level**
1. Only operation by training/authorized persons. *2. Operation of the machine shall conform to the instructions of the instruction manual.* *3. Check and inspection according to the specified durations of the instruction manual.* *4. Using safety components in accordance with those relevant international standards.* *5. Use of warning label.*		1	1	1	1	-

NO.	Hazards source	S	A	G	W	Level
12	Variations in the rotational speed of tools	1	1	1	1	-
Where	*The tools*					
When	*The machine is working*					
Improvement result						
Method		**S**	**A**	**G**	**W**	**Level**

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1. Only operation by training/authorized persons. *2. Operation of the machine shall conform to the instructions of the instruction manual.* *3. Check and inspection according to the specified durations of the instruction manual.* *4. Using safety components in accordance with those relevant international standards.* *5. Use of warning label.*	***1***	***1***	***1***	***1***	**-**

NO.	**Hazards source**	**S**	**A**	**G**	**W**	**Level**
16	Break-up during operation	***1***	***1***	***1***	***1***	**-**
Where	*At the work possion*					
When	*Work protection*					
Improvement result						
Method		**S**	**A**	**G**	**W**	**Level**
1. Use of warning label. *2. Use the necessary protective measures.*		***1***	***1***	***1***	***1***	**-**

NO.	**Hazards source**	**S**	**A**	**G**	**W**	**Level**
25.1	Unauthorized start-up/use	***1***	***1***	***1***	***1***	**-**
Where	*Control system*					
When	*Operation, adjustment or maintenance of the machine*					
Improvement result						
Method		**S**	**A**	**G**	**W**	**Level**
1. Always starting the machine by training/authorized persons. *2. During adjustment or maintenance, put a warning nameplate near the working area.* *3. Lock the power switch of the machine.*		***1***	***1***	***1***	***1***	**-**

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NO.	Hazards source	S	A	G	W	Level
1.7	Stabbing or puncture	*1*	*1*	*1*	*1*	-
Where	*The moving part of the machine*					
When	*The machine is working*					
Improvement result						
Method		**S**	**A**	**G**	**W**	**Level**
3. Use of warning label. *4. Use the necessary protective measures.*		*1*	*1*	*1*	*1*	-

NO.	Hazards source	S	A	G	W	Level
1.8	Friction or abrasion	*1*	*1*	*1*	*1*	-
Where	*The moving part of the machine*					
When	*The machine is working*					
Improvement result						
Method		**S**	**A**	**G**	**W**	**Level**
5. Use of warning label. *1. Use the necessary protective measures.*		*1*	*1*	*1*	*1*	-

NO.	Hazards source	S	A	G	W	Level
2.5	Thermal radiation or other phenomena such as projection of molten particles and chemical effects form short-circuits, overloads etc.	*1*	*1*	*1*	*1*	-
Where	*The moving part of the machine*					
When	*The machine is working*					
Improvement result						
Method		**S**	**A**	**G**	**W**	**Level**
1. Only operation by training/authorized persons. *2. Operation of the machine shall conform to the instructions of the instruction manual.* *3. Check and inspection according to the specified durations of the instruction manual.* *4. Using safety components in accordance with those relevant international standards.* *Use of warning label.*		*1*	*1*	*1*	*1*	-

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NO.	Hazards source	S	A	G	W	Level
2.5	Loss of stability / overturning of machinery	*1*	*1*	*1*	*1*	-
Where	*The moving part of the machine*					
When	*The machine is working*					
Improvement result						
Method		**S**	**A**	**G**	**W**	**Level**
1. Affixing suitable warning signs. *2. Only operation by training/authorized persons.* *Operation of the machine shall conform to the instructions of the instruction manual.*		*1*	*1*	*1*	*1*	-

NO.	Hazards source	S	A	G	W	Level
25.1	Unauthorized start-up/use	*1*	*1*	*1*	*1*	-
Where	*Control system*					
When	*Operation, adjustment or maintenance of the machine*					
Improvement result						
Method		**S**	**A**	**G**	**W**	**Level**
4. Always starting the machine by training/authorized persons. *5. During adjustment or maintenance, put a warning nameplate near the working area.* *6. Lock the power switch of the machine.*		*1*	*1*	*1*	*1*	-

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2.1 EN ISO 12100:2010			
EN ISO 12100:2010 General principles for design–Risk assessment and risk reduction			
6 Risk reduction			
	The objective of risk reduction can be achieved by the elimination of hazards, or by separately or simultaneously reducing each of the two elements that determine the associated risk: —severity of harm from the hazard under consideration; —probability of occurrence of that harm. All protective measures intended for reaching this objective shall be applied in the following sequence, referred to as the three-step method (see also Figures 1 and 2). **Step 1: Inherently safe design measures** **Step 2: Safeguarding and/or complementary protective measures** **Step 3: Information for use**		P
6.2	**Inherently safe design measures**		
6.2.1	**General**		
	Inherently safe design measures are the first and most important step in the risk reduction process. This is because protective measures inherent to the characteristics of the machine are likely to remain effective, whereas experience has shown that even well-designed safeguarding can fail or be violated and information for use may not be followed. Inherently safe design measures are achieved by avoiding hazards or reducing risks by a suitable choice of design features for the machine itself and/or interaction between the exposed persons and the machine.		P
6.2.2	**Consideration of geometrical factors and physical aspects**		
6.2.2.1	**Geometrical factors**		
	Such factors include the following. a)The form of machinery is designed to maximize direct visibility of the working areas and hazard zones from the control position —reducing blind spots, for example —and choosing and locating means of indirect vision where necessary (mirrors, etc.) so as to take into account the characteristics of human vision, particularly when safe operation requires permanent direct control by the operator, for example: —the travelling and working area of mobile machines; —the zone of movement of lifted loads or of the carrier of machinery for lifting persons; —the area of contact of the tool of a hand-held or hand-guided machine with the material being worked. The design of the machine shall be such that, from the main control position, the operator is able to ensure that there are no exposed persons in the danger zones. b) The form and the relative location of the mechanical components parts: for instance, crushing and shearing hazards are avoided by increasing the minimum gap between the moving parts, such that the part of the body under consideration can enter the gap safely, or by		P

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	reducing the gap so that no part of the body can enter it (see ISO 13854 and ISO 13857). c) Avoiding sharp edges and corners, protruding parts: in so far as their purpose allows, accessible parts of the machinery shall have no sharp edges, no sharp angles, no rough surfaces, no protruding parts likely to cause injury, and no openings which can "trap" parts of the body or clothing. In particular, sheet metal edges shall be deburred, flanged or trimmed, and open ends of tubes which can cause a "trap" shall be capped. d) The form of the machine is designed so as to achieve a suitable working position and provide accessible manual controls (actuators).		
6.2.2.2	**Physical aspects**		
	Such aspects include the following: a) limiting the actuating force to a sufficiently low value so that the actuated part does not generate a mechanical hazard; b) limiting the mass and/or velocity of the movable elements, and hence their kinetic energy; c) limiting the emissions by acting on the characteristics of the source using measures for reducing 1) noise emission at source (see ISO/TR 11688-1), 2) the emission of vibration at source, such as redistribution or addition of mass and changes of process parameters [for example, frequency and/or amplitude of movements (for hand-held and hand-guided machinery, see CR 1030-1)], 3) the emission of hazardous substances, including the use of less hazardous substances or dust-reducing processes (granules instead of powders, milling instead of grinding), and 4) radiation emissions, including, for example, avoiding the use of hazardous radiation sources, limiting the power of radiation to the lowest level sufficient for the proper functioning of the machine, designing the source so that the beam is concentrated on the target, increasing the distance between the source and the operator or providing for remote operation of the machinery [measures for reducing emission of non-ionizing radiation are given in 6.3.4.5 (see also EN 12198-1 and EN 12198-3)].		P
6.2.3	**Taking into account general technical knowledge of machine design**		
	This general technical knowledge can be derived from technical specifications for design (standards, design codes, calculation rules, etc.), which should be used to cover a) mechanical stresses such as —stress limitation by implementation of correct calculation, construction and fastening methods as regards, for example, bolted assemblies and welded assemblies, —stress limitation by overload prevention (bursting disk, pressure-limiting valves, breakage points,torque-limiting devices, etc.), —avoiding fatigue in elements under variable stresses		P

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	(notably cyclic stresses), and —static and dynamic balancing of rotating elements, b) materials and their properties such as —resistance to corrosion, ageing, abrasion and wear, —hardness, ductility, brittleness, —homogeneity, —toxicity, and —flammability, and c) emission values for —noise, —vibration, —hazardous substances, and —radiation. When the reliability of particular components or assemblies is critical for safety (for example, ropes, chains, lifting accessories for lifting loads or persons), stress limits shall be multiplied by appropriate workingcoefficients.		
6.2.4	**Choice of appropriate Testing**		
	One or more hazards can be eliminated or risks reduced by the choice of the Testing to be used in certainapplications such as the following: a)on machines intended for use in explosive atmospheres, using —appropriately selected pneumatic or hydraulic control system and machine actuators, —intrinsically safe electrical equipment (see IEC 60079-11); b)for particular products to be processed (for example, by a solvent), by using equipment that ensures thetemperature will remain far below the flash point; c)the use of alternative equipment to avoid high noise levels, such as —electrical instead of pneumatic equipment, —in certain conditions, water-cutting instead of mechanical equipment.		N
6.2.5	**Applying principle of positive mechanical action**		
	Positive mechanical action is achieved when a moving mechanical component inevitably moves another component along with it, either by direct contact or via rigid elements. An example of this is positive opening operation of switching devices in an electrical circuit (see IEC 60947-5-1 and ISO 14119).		P
6.2.6	**Provisions for stability**		
	Machines shall be designed so that they have sufficient stability to allow them to be used safely in their specified conditions of use. Factors to be taken into account include —the geometry of the base, —the weight distribution, including loading, —the dynamic forces due to movements of parts of the machine, of the machine itself or of elements held by the machine which can result in an overturning moment, —vibration, —oscillations of the centre of gravity, —characteristics of the supporting surface in case of travelling or installation on different sites (ground		P

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	conditions, slope, etc.), and —external forces, such as wind pressure and manual forces. Stability shall be considered in all phases of the life cycle of the machine, including handling, travelling, installation, use, dismantling, disabling and scrapping. Other protective measures for stability relevant to safeguarding are given in 6.3.2.6.		
6.2.7	**Provisions for maintainability**		
	When designing a machine, the following maintainability factors shall be taken into account to enable maintenance of the machine: —accessibility, taking into account the environment and the human body measurements, including the dimensions of the working clothes and tools used; —ease of handling, taking into account human capabilities; —limitation of the number of special tools and equipment.		P
6.2.8	**Observing ergonomic principles**		
	Ergonomic principles shall be taken into account in designing machinery so as to reduce the mental or physical stress of, and strain on, the operator. These principles shall be considered when allocating functions to operator and machine (degree of automation) in the basic design. NOTE Also improved are the performance and reliability of operation and hence the reduction in the probability of errors at all stages of machine use. Account shall be taken of body sizes likely to be found in the intended user population, strengths and postures, movement amplitudes, frequency of cyclic actions (see ISO 10075 and ISO 10075-2). All elements of the operator–machine interface, such as controls, signalling or data display elements shall be designed to be easily understood so that clear and unambiguous interaction between the operator and the machine is possible. See EN 614-1, EN 13861 and IEC 61310-1. The designer's attention is particularly drawn to following ergonomic aspects of machine design. a) Avoid the necessity for stressful postures and movements during the use of the machine (for example, providing facilities to adjust the machine to suit the various operators). b) Design machines, especially hand-held and mobile machines, so as to enable them to be operated easily, taking into account human effort, actuation of controls and hand, arm and leg anatomy. c) Limit as far as possible noise, vibration and thermal effects such as extreme temperatures. d) Avoid linking the operator's working rhythm to an automatic succession of cycles. e) Provide local lighting on or in the machine for the illumination of the working area and of adjusting, setting-up and frequent maintenance zones when the design features of the machine and/or its guards render the		P

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	ambient lighting inadequate. Flicker, dazzling, shadows and stroboscopic effects shall be avoided if they can cause a risk. If the position or the lighting source has to be adjusted, its location shall be such that it does not cause any risk to persons making the adjustment. f) Select, locate and identify manual controls (actuators) so that —they are clearly visible and identifiable, and appropriately marked where necessary (see 6.4.4), —they can be safely operated without hesitation or loss of time and without ambiguity (for example, a standard layout of controls reduces the possibility of error when an operator changes from a machine to another one of similar type having the same pattern of operation), —their location (for push-buttons) and their movement (for levers and hand wheels) are consistent with their effect (see IEC 61310-3), and —their operation cannot cause additional risk. See also ISO 9355-3.		
6.2.9	**Electrical hazards**		
	For the design of the electrical equipment of machines, IEC 60204-1 gives general provisions about disconnection and switching of electrical circuits and for protection against electric shock. For requirements related to specific machines, see corresponding IEC standards (for example, IEC 61029, IEC 60745 or IEC 60335).		P
6.2.10	**Pneumatic and hydraulic hazard**		
	Pneumatic and hydraulic equipment of machinery shall be designed so that —the maximum rated pressure cannot be exceeded in the circuits (using, for example, pressure-limiting devices), —no hazard results from pressure fluctuations or increases, or from loss of pressure or vacuum, —no hazardous fluid jet or sudden hazardous movement of the hose (whiplash) results from leakage or component failures, —air receivers, air reservoirs or similar vessels (such as in gas-loaded accumulators) comply with the applicable design standard codes or regulations for these elements, —all elements of the equipment, especially pipes and hoses, are protected against harmful external effects, —as far as possible, reservoirs and similar vessels (for example, gas-loaded accumulators) are automatically depressurized when isolating the machine from its power supply (see 6.3.5.4) and, if not possible, means are provided for their isolation, local depressurizing and pressure indication (see also ISO 14118:2000, Clause 5), and —all elements which remain under pressure after isolation of the machine from its power supply are provided with clearly identified exhaust devices, and there is a warning label drawing attention to the necessity of depressurizing those elements before any setting or maintenance activity on the machine.		N

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6.2.11	**Applying inherently safe design measures to control systems**		
6.2.11.1	**General**		
	The design measures of the control system shall be chosen so that their safety-related performance provides a sufficient amount of risk reduction (see ISO 13849-1 or IEC 62061). The correct design of machine control systems can avoid unforeseen and potentially hazardous machine behavior. Typical causes of hazardous machine behavior are —an unsuitable design or modification (accidental or deliberate) of the control system logic, —a temporary or permanent defect or failure of one or several components of the control system, —a variation or a failure in the power supply of the control system, and —inappropriate selection, design and location of the control devices. Typical examples of hazardous machine behavior are —unexpected start-up (see ISO 14118), —uncontrolled speed change, —failure to stop moving parts, —dropping or ejection of part of the machine or of a workpiece clamped by the machine, and —machine action resulting from inhibition (defeating or failure) of protective devices. In order to prevent hazardous machine behaviour and to achieve safety functions, the design of control systems shall comply with the principles and methods presented in this subclause (6.2.11) and in 6.2.12. These principles and methods shall be applied singly or in combination as appropriate to the circumstances (see ISO 13849-1, IEC 60204-1 and IEC 62061). Control systems shall be designed to enable the operator to interact with the machine safely and easily. This requires one or several of the following solutions: —systematic analysis of start and stop conditions; —provision for specific operating modes (for example, start-up after normal stop, restart after cycle interruption or after emergency stop, removal of the workpieces contained in the machine, operation of a part of the machine in case of a failure of a machine element); —clear display of the faults; —measures to prevent accidental generation of unexpected start commands (for example, shrouded start device) likely to cause dangerous machine behaviour (see ISO 14118:2000, Figure 1); —maintained stop commands (for example, interlock) to prevent restarting that could result in dangerous machine behaviour (see ISO 14118:2000, Figure 1). An assembly of machines may be divided into several zones for emergency stopping, for stopping as a result of protective devices and/or for isolation and energy		P

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	dissipation. The different zones shall be clearly defined and it shall be obvious which parts of the machine belong to which zone. Likewise, it shall be obvious which control devices (for example, emergency stop devices, supply disconnecting devices) and/or protective devices belong to which zone. The interfaces between zones shall be designed such that no function in one zone creates hazards in another zone which has been stopped for an intervention. Control systems shall be designed to limit the movements of parts of the machinery, the machine itself, or workpieces and/or loads held by the machinery, to the safe design parameters (for example, range, speed, acceleration, deceleration, load capacity). Allowance shall be made for dynamic effects (swinging of loads, etc.). For example: —the travelling speed of mobile pedestrian controlled machinery other than remote-controlled shall be compatible with walking speed; —the range, speed, acceleration and deceleration of movements of the person-carrier and carrying vehicle for lifting persons shall be limited to non-hazardous values, taking into account the total reaction time of the operator and the machine; —the range of movements of parts of machinery for lifting loads shall be kept within specified limits. When the machinery contains various elements that can be operated independently, the control system shall be designed to prevent risks arising out of a lack of coordination (for example, collision prevention system).		
6.2.11.2	**Starting of an internal power source/switching on an external power supply**		
	The starting of an internal power source or switching-on of an external power supply shall not result in a hazardous situation. For example: —starting the internal combustion engine shall not lead to movement of a mobile machine; —connection to mains electricity supply shall not result in the starting of working parts of a machine. See IEC 60204-1:2005, 7.5 (see also Annexes A and B).		P
6.2.11.3	**Starting/stopping of a mechanism**		
	The primary action for starting or accelerating the movement of a mechanism should be performed by the application or an increase of voltage or fluid pressure, or — if binary logic elements are considered — by passage from state 0 to state 1 (where state 1 represents the highest energy state). The primary action for stopping or slowing down should be performed by removal or reduction of voltage or fluid pressure, or — if binary logic elements are considered — by passage from state 1 to state 0 (where state 1 represents the highest energy state). In certain applications, such as high-voltage switchgear, this principle cannot be followed, in which case other measures should be applied to achieve the same level of confidence		P

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	for the stopping or slowing down. When, in order for the operator to maintain permanent control of deceleration, this principle is not observed (for example, a hydraulic braking device of a self-propelled mobile machine), the machine shall be equipped with a means of slowing and stopping in case of failure of the main braking system.		
6.2.11.4	**Restart after power interruption**		
	If a hazard could be generated, the spontaneous restart of a machine when it is re-energized after power interruption shall be prevented (for example, by use of a self-maintained relay, contactor or valve).		NN
6.2.11.5	**Interruption of power supply**		
	Machinery shall be designed to prevent hazardous situations resulting from interruption or excessive fluctuation of the power supply. At least the following requirements shall be met: —the stopping function of the machinery shall remain; —all devices whose permanent operation is required for safety shall operate in an effective way to maintain safety (for example, locking, clamping devices, cooling or heating devices, power-assisted steering of self-propelled mobile machinery); —parts of machinery or workpieces and/or loads held by machinery which are liable to move as a result of potential energy shall be retained for the time necessary to allow them to be safely lowered.		N
6.2.11.6	**Use of automatic monitoring**		
	Automatic monitoring is intended to ensure that a safety function or functions implemented by a protective measure do not fail to be performed if the ability of a component or an element to perform its function is diminished, or if the process conditions are changed such that hazards are generated. Automatic monitoring either detects a fault immediately or carries out periodic checks so that a fault is detected before the next demand upon the safety function. In either case, the protective measure can be initiated immediately or delayed until a specific event occurs (for example, the beginning of the machine cycle). The protective measure may be, for example, —the stopping of the hazardous process, —preventing the restart of this process after the first stop following the failure, or —the triggering of an alarm.		N
6.2.11.7	**Safety functions implemented by programmable electronic control systems**		
6.2.11.7.1	**General**		
	A control system that includes programmable electronic equipment (for example, programmable controllers) can, where appropriate, be used to implement safety functions at machinery. Where a programmable electronic control system is used, it is necessary to consider its performance requirements in relation to the requirements for the safety		P

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	functions. The design of the programmable electronic control system shall be such that the probability of random hardware failures and the likelihood of systematic failures that can adversely affect the performance of the safety-related control function(s) is sufficiently low. Where a programmable electronic control system performs a monitoring function, the system behavior on detection of a fault shall be considered (see also the IEC 61508 series for further guidance). NOTE Both ISO 13849-1 and IEC 62061, specific to machinery safety, provide guidance applicable to programmable electronic control systems. The programmable electronic control system should be installed and validated to ensure that the specified performance [for example, safety integrity level (SIL) in IEC 61508] for each safety function has been achieved. Validation comprises testing and analysis (for example, static, dynamic or failure analysis) to show that all parts interact correctly to perform the safety function and that unintended functions do not occur.		
6.2.11.7.2	**Hardware aspects**		
	The hardware (including, for example, sensors, actuators and logic solvers) shall be selected, and/or designed and installed, to meet both the functional and performance requirements of the safety function(s) to be performed, in particular, by means of —architectural constraints (the configuration of the system, its ability to tolerate faults, its behaviour on detection of a fault, etc.), —selection, and/or design, of equipment and devices with an appropriate probability of dangerous random hardware failure, and —the incorporation of measures and techniques within the hardware so as to avoid systematic failures and control systematic faults.		P
6.2.11.7.3	**Software aspects**		
	The software, including internal operating software (or system software) and application software, shall be designed so as to satisfy the performance specification for the safety functions (see also IEC 61508-3). Application software should not be reprogrammable by the user. This may be achieved by use of embedded software in a non-reprogrammable memory [for example, micro-controller, application-specific integrated circuit (ASIC)]. When the application requires reprogramming by the user, the access to the software dealing with safety functions should be restricted (for example, by locks or passwords for the authorized persons).		N
6.2.11.8	**Principles relating to manual control**		
	These are as follows.		N

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	a) Manual control devices shall be designed and located according to the relevant ergonomic principles given in 6.2.8, item f). b) A stop control device shall be placed near each start control device. Where the start/stop function is performed by means of a hold-to-run control, a separate stop control device shall be provided when a risk can result from the hold-to-run control device failing to deliver a stop command when released. c) Manual controls shall be located out of reach of the danger zones (see IEC 61310-3), except for certain controls where, of necessity, they are located within a danger zone, such as emergency stop or teach pendant. d) Whenever possible, control devices and control positions shall be located so that the operator is able to observe the working area or hazard zone. 1) The driver of a ride-on mobile machine shall be able to actuate all control devices required to operate the machine from the driving position, except for functions which can be controlled more safely from other positions. 2) On machinery intended for lifting persons, controls for lifting and lowering and, if appropriate, for moving the carrier shall generally be located in the carrier. If safe operation requires controls to be situated outside the carrier, the operator in the carrier shall be provided with the means of preventing hazardous movements. e) If it is possible to start the same hazardous element by means of several controls, the control circuit shall be so arranged that only one control is effective at a given time. This applies especially to machines which can be manually controlled by means of, among others, a portable control unit (such as a teach pendant), with which the operator can enter danger zones. f) Control actuators shall be designed or guarded so that their effect, where a risk is involved, cannot occur without intentional operation (see ISO 9355-1, ISO 9355-3 and ISO 447). g) For machine functions whose safe operation depends on permanent, direct control by the operator, measures shall be implemented to ensure the presence of the operator at the control position (for example, by the design and location of control devices). h) For cableless control, an automatic stop shall be performed when correct control signals are not received, including loss of communication (see IEC 60204-1).		
6.2.11.9	**Control mode for setting, teaching, process changeover, fault-finding, cleaning or maintenance**		
	Where, for setting, teaching, process changeover, fault-finding, cleaning or maintenance of machinery, a guard has to be displaced or removed and/or a protective device has to be disabled, and where it is necessary for the purpose of these operations for the machinery or part of the machinery to be put into operation, the safety of the operator shall be achieved using a specific control mode which		P

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	simultaneously a) disables all other control modes, b) permits operation of the hazardous elements only by continuous actuation of an enabling device, a two-hand control device or a hold-to-run control device, c) permits operation of the hazardous elements only in reduced risk conditions (for example, reduced speed, reduced power/force, step-by-step, for example, with a limited movement control device), and d) prevents any operation of hazardous functions by voluntary or involuntary action on the machine's sensors. NOTE For some special machinery other protective measures can be appropriate. This control mode shall be associated with one or more of the following measures: —restriction of access to the danger zone as far as possible; —emergency stop control within immediate reach of the operator; —portable control unit (teach pendant) and/or local controls (allowing sight of the controlled elements). See IEC 60204-1.		
6.2.11.10	**Selection of control and operating modes**		
	If machinery has been designed and built to allow for its use in several control or operating modes requiring different protective measures and/or work procedures (for example, to allow for adjustment, setting, maintenance, inspection), it shall be fitted with a mode selector which can be locked in each position. Each position of the selector shall be clearly identifiable and shall exclusively allow one control or operating mode. The selector may be replaced by another selection means which restricts the use of certain functions of the machinery to certain categories of operators (for example, access codes for certain numerically controlled functions).		N
6.2.11.11	**Applying measures to achieve electromagnetic compatibility (EMC)**		
	For guidance on electromagnetic compatibility, see IEC 60204-1 and IEC 61000-6.	Exceed evaluation scope	N
6.2.11.12	**Provision of diagnostic systems to aid fault-finding**		
	Diagnostic systems to aid fault-finding should be included in the control system so that there is no need to disable any protective measure. NOTE Such systems not only improve availability and maintainability of machinery, they also reduce the exposure of maintenance staff to hazards.		N
6.2.12	**Minimizing probability of failure of safety functions**		
6.2.12.1	**General**		
	Safety of machinery is not only dependent on the reliability of the control systems but also on the reliability of all parts of the machine.		P

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	The continued operation of the safety functions is essential for the safe use of the machine. This can be achieved by the measures given in 6.2.12.2 to 6.2.12.4.		
6.2.12.2	**Use of reliable components**		
	"Reliable components" means components which are capable of withstanding all disturbances and stresses associated with the usage of the equipment in the conditions of intended use (including the environmental conditions), for the period of time or the number of operations fixed for the use, with a low probability of failures generating a hazardous malfunctioning of the machine. Components shall be selected taking into account all factors mentioned above (see also 6.2.13). NOTE 1 "Reliable components" is not a synonym for "well-tried components" (see ISO 13849-1:2006, 6.2.4). NOTE 2 Environmental conditions for consideration include impact, vibration, cold, heat, moisture, dust, corrosive and/or abrasive substances, static electricity and magnetic and electric fields. Disturbances which can be generated by those conditions include insulation failures and temporary or permanent failures in the function of control system components.		P
6.2.12.3	**Use of "oriented failure mode" components**		
	"Oriented failure mode" components or systems are those in which the predominant failure mode is known in advance and which can be used so that the effect of such a failure on the machine function can be predicted. NOTE In some cases, it will be necessary to take additional measures to limit the negative effects of such a failure. The use of such components should always be considered, particularly in cases where redundancy (see 6.2.12.4) is not employed.		N
6.2.12.4	**Duplication (or redundancy) of components or subsystems**		
	In the design of safety-related parts of the machine, duplication (or redundancy) of components may be used so that, if one component fails, another component or components continue to perform the respective function(s), thereby ensuring that the safety function remains available. In order to allow the proper action to be initiated, component failure shall be detected by automatic monitoring (see 6.2.11.6) or in some circumstances by regular inspection, provided that the inspection interval is shorter than the expected lifetime of the components. Diversity of design and/or Testing can be used to avoid common cause failures (for example, from electromagnetic disturbance) or common mode failures.		N
6.2.13	**Limiting exposure to hazards through reliability of equipment**		
	Increased reliability of all component parts of machinery reduces the frequency of incidents requiring intervention, thereby reducing exposure to hazards. This applies to power systems (operative part, see Annex A) as well as to control systems, and to safety functions as well as to other functions of machinery. Safety-related components (for example, certain sensors) of		P

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	known reliability shall be used. The elements of guards and of protective devices shall be especially reliable, as their failure can expose persons to hazards, and also because poor reliability would encourage attempts to defeat them.		
6.2.14	**Limiting exposure to hazards through mechanization or automation of loading (feeding)/unloading (removal) operations**		
	Mechanization and automation of machine loading/unloading operations and, more generally, of handling operations — of workpieces, materials or substances — limits the risk generated by these operations by reducing the exposure of persons to hazards at the operating points. Automation can be achieved by, for example, robots, handling devices, transfer mechanisms and air-blast equipment. Mechanization can be achieved by, for example, feeding slides, push-rods and hand-operated indexing tables. While automatic feeding and removal devices have much to offer in preventing accidents to machine operators, they can create danger when any faults are being corrected. Care shall be taken to ensure that the use of these devices does not introduce further hazards, such as trapping or crushing, between the devices and parts of the machine or workpieces/materials being processed. Suitable safeguards (see 6.3) shall be provided if this cannot be ensured. Automatic feeding and removal devices with their own control systems and the control system of the associated machine shall be interconnected after thorough study of how all safety functions are performed in all the control and operation modes of the entire equipment.		N
6.2.15	**Limiting exposure to hazards through location of setting and maintenance points outside danger zones**		
	The need for access to danger zones shall be minimized by locating maintenance, lubrication and setting points outside these zones.		P
6.3	**Safeguarding and complementary protective measures**		
6.3.1	**General**		
	Guards and protective devices shall be used to protect persons whenever an inherently safe design measure does not reasonably make it possible either to remove hazards or to sufficiently reduce risks. Complementary protective measures involving additional equipment (for example, emergency stop equipment) may have to be implemented. NOTE The different kinds of guards and protective devices are defined in 3.27 and 3.28. Certain safeguards may be used to avoid exposure to more than one hazard. EXAMPLE A fixed guard preventing access to a zone where a mechanical hazard is present used to reduce noise levels and collect toxic emissions.		P

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6.3.2	**Selection and implementation of guards and protective devices**		
6.3.2.1	**General**		
	This subclause gives guidelines for the selection and the implementation of guards and protective devices the primary purpose of which is to protect persons against hazards generated by moving parts, according to the nature of those parts (see Figure 4) and to the need for access to the danger zone(s). The exact choice of a safeguard for a particular machine shall be made on the basis of the risk assessment for that machine. In selecting an appropriate safeguard for a particular type of machinery or hazard zone, it shall be borne in mind that a fixed guard is simple and shall be used where the access of an operator into a danger zone is not required during the normal operation (operation without malfunction) of the machinery. As the need for frequency of access increases, this inevitably leads to the fixed guard not being replaced. This requires the use of an alternative protective measure (movable interlocking guard, sensitive protective equipment). A combination of safeguards can sometimes be required. For example, where, in conjunction with a fixed guard, a mechanical loading (feeding) device is used to feed a workpiece into a machine, thereby removing the need for access to the primary hazard zone, a trip device can be required to protect against the secondary drawing-in or shearing hazard between the mechanical loading (feeding) device, when reachable, and the fixed guard. Consideration shall be given to the enclosure of control positions or intervention zones to provide combined protection against several hazards including a) hazards from falling or ejected objects, using, for example, protection in the form of a falling object protection structure (FOPS), b) emission hazards (protection against noise, vibration, radiation, substances hazardous to health, etc.), c) hazards due to the environment (protection against heat, cold, foul weather, etc.), d) hazards due to tipping over or rolling over of machinery, using, for example, protection in the form of roll-over or tip-over protection structures (ROPS and TOPS). The design of enclosed work stations, such as cabs and cabins, shall take into account ergonomic principles concerning visibility, lighting, atmospheric conditions, access, posture.		P
6.3.2.2	**Where access to the hazard zone is not required during normal operation**		
	Where access to the hazard zone is not required during normal operation of the machinery, safeguards should be selected from the following: a) fixed guards (see also ISO 14120); b) interlocking guards with or without guard locking (see also 6.3.3.2.3, ISO 14119 and ISO 14120);		N

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	c) self-closing guards (see ISO 14120:2002, 3.3.2); d) sensitive protective equipment, such as electrosensitive protective equipment (see IEC 61496) or pressure-sensitive protective devices (see ISO 13856).		
6.3.2.3	**Where access to the hazard zone is required during normal operation**		
	Where access to the hazard zone is required during normal operation of the machinery, safeguards should be selected from the following: a) interlocking guards with or without guard locking (see also ISO 14119, ISO 14120 and 6.3.3.2.3 of this document); b) sensitive protective equipment, such as electrosensitive protective equipment (see IEC 61496); c) adjustable guards; d) self-closing guards (see ISO 14120:2002, 3.3.2); e) two-hand control devices (see ISO 13851); f) interlocking guards with a start function (control guard) (see 6.3.3.2.5).		P
6.3.2.4	**Where access to the hazard zone is required for machine setting, teaching, process changeover, fault-finding, cleaning or maintenance**		
	production operator also ensure the protection of personnel carrying out setting, teaching, process changeover, fault-finding, cleaning or maintenance, without hindering them in the performance of their task. Such tasks shall be identified and considered in the risk assessment as parts of the use of the machine (see 5.2). NOTE Isolation and energy dissipation for machine shut-down (see 6.3.5.4, and also ISO 14118:2000, 4.1 and Clause 5) ensure the highest level of safety when carrying out tasks (especially maintenance and repair tasks) that do not require the machine to remain connected to its power supply.		N
6.3.2.5	**Selection and implementation of sensitive protective equipment**[1)]		
6.3.2.5.1	Due to the great diversity of the technologies on which their detection function is based, all types of sensitive protective equipment are far from being equally suitable for safety applications. The following provisions are intended to provide the designer with criteria for selecting, for each application, the most suitable device(s). Types of sensitive protective equipment include —light curtains, —scanning devices, for example, laser scanners, —pressure-sensitive mats, and —trip bars, trip wires. Sensitive protective equipment can be used —for tripping purposes, —for presence sensing, —for both tripping and presence sensing, or —to re-initiate machine operation — a practice subject to stringent conditions. NOTE Some types of sensitive protective equipment can be unsuitable either for presence sensing or for tripping purposes. The following characteristics of the machinery, among		P

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	others, can preclude the sole use of sensitive protectiveequipment: —tendency for the machinery to eject materials or component parts; —necessity to guard against emissions (noise, radiation, dust, etc.); —erratic or excessive machine stopping time; —inability of a machine to stop part-way through a cycle.		
6.3.2.5.2	**Implementation**		
	Consideration should be given to a) the size, characteristics and positioning of the detection zone (see ISO 13855, which deals with the positioning of some types of sensitive protective equipment), b) the reaction of the device to fault conditions (see IEC 61496 for electrosensitive protective equipment), c) the possibility of circumvention, and d) detection capability and its variation over the course of time (as a result, for example, of its susceptibility to different environmental conditions such as the presence of reflecting surfaces, other artificial light sources and sunlight or impurities in the air). NOTE 1 IEC 61496 defines the detection capability of electrosensitive protective equipment. Sensitive protective equipment shall be integrated in the operative part and associated with the control system of the machine so that —a command is given as soon as a person or part of a person is detected, —the withdrawal of the person or part of a person detected does not, by itself, restart the hazardous machine function(s), and therefore the command given by the sensitive protective equipment ismaintained by the control system until a new command is given, —restarting the hazardous machine function(s) results from the voluntary actuation by the operator of a control device placed outside the hazard zone, where this zone can be observed by the operator, —the machine cannot operate during interruption of the detection function of the sensitive protective equipment, except during muting phases, and —the position and the shape of the detection field prevents, possibly together with fixed guards, a person or part of a person from entering or being present in the hazard zone without being detected. NOTE 2 Muting is the temporary automatic suspension of a safety function(s) by safety-related parts of the control system (see ISO 13849-1). For detailed consideration of the fault behaviour of, for example, active optoelectronic protective devices, IEC 61496 should be taken into account.		P
6.3.2.5.3	**Additional requirements for sensitive protective equipment when used for cycle initiation**		
	In this exceptional application, the starting of the machine cycle is initiated by the withdrawal of a person or of the		N

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	detected part of a person from the sensing field of the sensitive protective equipment, without any additional start command, hence deviating from the general requirement given in the second point of the dashed list in 6.3.2.5.2, above. After switching on the power supply, or when the machine has been stopped by the tripping function of the sensitive protective equipment, the machine cycle shall be initiated only by voluntary actuation of a start control. Cycle initiation by sensitive protective equipment shall be subject to the following conditions: a) only active optoelectronic protective devices (AOPDs) complying with IEC 61496 series shall be used; b) the requirements for an AOPD used as a tripping and presence-sensing device (see IEC 61496) are satisfied — in particular, location, minimum distance (see ISO 13855), detection capability, reliability and monitoring of control and braking systems; c) the cycle time of the machine is short and the facility to re-initiate the machine upon clearing of the sensing field is limited to a period commensurate with a single normal cycle; d) entering the sensing field of the AOPD(s) or opening interlocking guards is the only way to enter the hazard zone; e) if there is more than one AOPD safeguarding the machine, only one of the AOPDs is capable of cycle re-initiation; f) with regard to the higher risk resulting from automatic cycle initiation, the AOPD and the associated control system comply with a higher safety-related performance than under normal conditions. NOTE 1 The hazard zone as referred to in d) is any zone where the hazardous function (including ancillary equipment and transmission elements) is initiated by clearing of the sensing field. NOTE 2 See also IEC/TS 62046.		
6.3.2.6	**Protective measures for stability**		
	If stability cannot be achieved by inherently safe design measures such as weight distribution (see 6.2.6), it shall be maintained by the use of protective measures such as —anchorage bolts, —locking devices, —movement limiters or mechanical stops, —acceleration or deceleration limiters, —load limiters, and —alarms warning of the approach to stability or tipping limits.		P
6.3.2.7	**Other protective devices**		
	error of the operator can generate a hazardous situation, this machine shall be equipped with the necessary devices to enable the operation to remain within specified limits, in particular —when the operator has insufficient visibility of the hazard zone,		P

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	—when the operator lacks knowledge of the actual value of a safety-related parameter (distance, speed,mass, angle, etc.), and —when hazards can result from operations other than those controlled by the operator. The necessary devices include a) devices for limiting parameters of movement (distance, angle, velocity, acceleration), b) overloading and moment limiting devices, c) devices to prevent collisions or interference with other machines, d) devices for preventing hazards to pedestrian operators of mobile machinery or other pedestrians, e) torque limiting devices, and breakage points to prevent excessive stress of components and assemblies, f) devices for limiting pressure or temperature, g) devices for monitoring emissions, h) devices to prevent operation in the absence of the operator at the control position, i) devices to prevent lifting operations unless stabilizers are in place, j) devices to limit inclination of the machine on a slope, and k) devices to ensure that components are in a safe position before travelling. Automatic protective measures triggered by such devices that take operation of the machinery out of the control of the operator (for example, automatic stop of hazardous movement) should be preceded or accompanied by a warning signal to enable the operator to take appropriate action (see 6.4.3).		
6.3.3	**Requirements for design of guards and protective devices**		
6.3.3.1	**General requirements**		
	Guards and protective devices shall be designed to be suitable for the intended use, taking into account mechanical and other hazards involved. Guards and protective devices shall be compatible with the working environment of the machine and designed so that they cannot be easily defeated. They shall provide the minimum possible interference with activities during operation and other phases of machine life, in order to reduce any incentive to defeat them. NOTE For additional information, see ISO 14120, ISO 13849-1, ISO 13851, ISO 14119, ISO 13856, IEC 61496 and IEC 62061. Guards and protective devices shall a) be of robust construction, b) not give rise to any additional hazard, c) not be easy to bypass or render non-operational, d) be located at an adequate distance from the danger zone (see ISO 13855 and ISO 13857), e) cause minimum obstruction to the view of the production process, and f) enable essential work to be carried out for the installation and/or replacement of tools and for maintenance by		P

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	allowing access only to the area where the work has to be carried out — if possible, without the guard having to be removed or protective device having to be disabled. For openings in the guards, see ISO 13857.		
6.3.3.2	**Requirements for guards**		
6.3.3.2.1	**Functions of guards**		
	The functions that guards can achieve are —prevention of access to the space enclosed by the guard, and/or —containment/capture of materials, workpieces, chips, liquids which can be ejected or dropped by the machine, and reduction of emissions (noise, radiation, hazardous substances such as dust, fumes, gases) that can be generated by the machine. Additionally, they could need to have particular properties relating to electricity, temperature, fire, explosion, vibration, visibility (see ISO 14120) and operator position ergonomics (for example, usability, operator's movements, postures, repetitive movements).		P
6.3.3.2.2	**Requirements for fixed guards**		
	Fixed guards shall be securely held in place either —permanently (for example by welding), or —by means of fasteners (screws, nuts) making removal/opening impossible without using tools; they should not remain closed without their fasteners (see ISO 14120). NOTE A fixed guard can be hinged to assist in its opening.		P
6.3.3.2.3	**Requirements for movable guards**		
	Movable guards which provide protection against hazards generated by moving transmission parts shall a) as far as possible when open remain fixed to the machinery or other structure (generally by means of hinges or guides), and b) be interlocking (with guard locking when necessary) (see ISO 14119). See Figure 4. Movable guards against hazards generated by non-transmission moving parts shall be designed and associated with the machine control system so that —moving parts cannot start up while they are within the operator's reach and the operator cannot reach moving parts once they have started up, with this able to be achieved by interlocking guards, with guard locking when necessary, —they can be adjusted only by an intentional action, such as the use of a tool or a key, and —the absence or failure of one of their components either prevents starting of the moving parts or stops them, with this able to be achieved by automatic monitoring (see 6.2.11.6). See Figure 4 and ISO 14119.		P
6.3.3.2.4	**Requirements for adjustable guards**		
	Adjustable guards may only be used where the hazard zone		P

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	cannot for operational reasons be completely enclosed. Manually adjustable guards shall be —designed so that the adjustment remains fixed during a given operation, and —readily adjustable without the use of tools.		
6.3.3.2.5	**Requirements for interlocking guards with a start function (control guards)**		
	An interlocking guard with a start function may only be used provided that a) all requirements for interlocking guards are satisfied (see ISO 14119), b) the cycle time of the machine is short, c) the maximum opening time of the guard is preset to a low value (for example, equal to the cycle time) and, when this time is exceeded, the hazardous function(s) cannot be initiated by the closing of the interlocking guard with a start function and resetting is necessary before restarting the machine, d) the dimensions or shape of the machine do not allow a person, or part of a person, to stay in the hazard zone or between the hazard zone and the guard while the guard is closed (see ISO 14120), e) all other guards, whether fixed (removable type) or movable, are interlocking guards, f) the interlocking device associated with the interlocking guard with a start function is designed such that —for example, by duplication of position detectors and use of automatic monitoring (see 6.2.11.6) — its failure cannot lead to an unintended/unexpected start-up, and g) the guard is securely held open (for example, by a spring or counterweight) such that it cannot initiate a start while falling by its own weight.		N
6.3.3.2.6	**Hazards from guards**		
	Care shall be taken to prevent hazards which could be generated by —the guard construction (sharp edges or corners, material, noise emission, etc.), —the movements of the guards (shearing or crushing zones generated by power-operated guards and by heavy guards which are liable to fall).		P
6.3.3.3	**Technical characteristics of protective devices**		
	Protective devices shall be selected or designed and connected to the control system such that correct implementation of their safety function(s) is ensured. Protective devices shall be selected on the basis of their having met the appropriate product standard (for example, IEC 61496 for active optoelectronic protective devices) or shall be designed according to one or several of the principles formulated in ISO 13849-1 or IEC 62061. Protective devices shall be installed and connected to the control system so that they cannot be easily defeated.		P
6.3.3.4	**Provisions for alternative types of safeguards**		
	Provisions should be made to facilitate the fitting of		P

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	alternative types of safeguards on machinery where it is known that it will be necessary to change the safeguards because of the range of work to be carried out.		
6.3.4	**Safeguarding to reduce emissions**		
6.3.4.1	**General**		
	If the measures for the reduction of emissions at source specified in 6.2.2.2 are not adequate, the machine shall be provided with additional protective measures (see 6.3.4.2 to 6.3.4.5).		P
6.3.4.2	**Noise**		
	Additional protective measures against noise include —enclosures (see ISO 15667), —screens fitted to the machine, and —silencers (see ISO 14163).		P
6.3.4.3	**Vibration**		
	Additional protective measures against vibration include —vibration isolators, such as damping devices placed between the source and the exposed person, —resilient mounting, and —suspended seats. For measures for vibration isolation of stationary industrial machinery see EN 1299.		P
6.3.4.4	**Hazardous substances**		
	Additional protective measures against hazardous substances include —encapsulation of the machine (enclosure with negative pressure), —local exhaust ventilation with filtration, —wetting with liquids, and —special ventilation in the area of the machine (air curtains, cabins for operators). See ISO 14123-1.		N
6.3.4.5	**Radiation**		
	Additional protective measures against radiation include —use of filtering and absorption, and —use of attenuating screens or guards.		N
6.3.5	**Complementary protective measures**		
6.3.5.1	**General**		
	Protective measures which are neither inherently safe design measures, nor safeguarding (implementation of guards and/or protective devices), nor information for use, could have to be implemented as required by the intended use and the reasonably foreseeable misuse of the machine. Such measures include, but are not limited to, those dealt with in 6.3.5.2 to 6.3.5.6.		P
6.3.5.2	**Components and elements to achieve emergency stop function**		
	If, following a risk assessment, a machine needs to be fitted with components and elements to achieve an emergency stop function for enabling actual or impending emergency situations to be averted, the following requirements apply: —the actuators shall be clearly identifiable, clearly visible and readily accessible; —the hazardous process shall be stopped as quickly as		P

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	possible without creating additional hazards, but if this is not possible or the risk cannot be reduced, it should be questioned whether implementation of an emergency stop function is the best solution; —the emergency stop control shall trigger or permit the triggering of certain safeguard movements where necessary. NOTE For more detailed provisions, see ISO 13850. Once active operation of the emergency stop device has ceased following an emergency stop command, the effect of this command shall be sustained until it is reset. This reset shall be possible only at the location where the emergency stop command has been initiated. The reset of the device shall not restart the machinery, but shall only permit restarting. More details for the design and selection of electrical components and elements to achieve the emergency stop function are provided in IEC 60204.		
6.3.5.3	**Measures for the escape and rescue of trapped persons**		
	Measures for the escape and rescue of trapped persons may consist, among others, of —escape routes and shelters in installations generating operator-trapping hazards, —arrangements for moving some elements by hand, after an emergency stop, —arrangements for reversing the movement of some elements, —anchorage points for descender devices, —means of communication to enable trapped operators to call for help.		P
6.3.5.4	**Measures for isolation and energy dissipation**		
	Machines shall be equipped with the technical means to achieve isolation from power supply(ies) and dissipation of stored energy by means of the following actions: a) isolating (disconnecting, separating) the machine (or defined parts of the machine) from all power supplies; b) locking (or otherwise securing) all the isolating units in the isolating position; c) dissipating or, if this is not possible or practicable, restraining (containing) any stored energy which can give rise to a hazard; d) verifying, by means of safe working procedures, that the actions taken according to a), b) and c) above have produced the desired effect. See ISO 14118:2000, Clause 5, and IEC 60204-1:2005, 5.5 and 5.6.		N/A
6.3.5.5	**Provisions for easy and safe handling of machines and their heavy component parts**		
	Machines and their component parts which cannot be moved or transported by hand shall be provided or be capable of being provided with suitable attachment devices for transport by means of lifting gear.		N

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	These attachments may be, among others, —standardized lifting appliances with slings, hooks, eyebolts, or tapped holes for appliance fixing, —appliances for automatic grabbing with a lifting hook when attachment is not possible from the ground, —fork locating devices for machines to be transported by a lift truck, —lifting and stowing gear and appliances integrated into the machine. Parts of machinery which can be removed manually in operation shall be provided with means for their safe removal and replacement. See also 6.4.4 c), item 3).		
6.3.5.6	**Measures for safe access to machinery**		
	Machinery shall be so designed as to enable operation and all routine tasks relating to setting and/or maintenance to be carried out as far as possible by a person remaining at ground level. Where this is not possible, machines shall have built-in plaJewelry welding machineorms, stairs or other facilities to provide safe access for those tasks; however, care should be taken to ensure that such plaJewelry welding machineorms or stairs do not give access to danger zones of machinery. The walking areas shall be made from materials which remain as slip resistant as practicable under working conditions and, depending on the height from the ground, shall be provided with suitable guard-rails (see ISO 14122-3). In large automated installations, particular attention shall be given to safe means of access, such as walkways, conveyor bridges or crossover points. Means of access to parts of machinery located at height shall be provided with collective means of protection against falls (for example, guard-rails for stairways, stepladders and plaJewelry welding machineorms and/or safety cages for ladders). As necessary, anchorage points for personal protective equipment against falls from height shall also be provided (for example, in carriers of machinery for lifting persons or with elevating control stations). Openings shall, whenever possible, open towards a safe position. They shall be designed to prevent hazards due to unintended opening.		N

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	The necessary aids for access shall be provided (steps, handholds, etc.). Control devices shall be designed and located to prevent their being used as aids for access. When machinery for lifting goods and/or persons includes landings at fixed levels, these shall be equipped with interlocking guards for preventing falls when the plaJewelry welding machineorm is not present at a level. Movement of the lifting plaJewelry welding machineorm shall be prevented while the guards are open. For detailed provisions see ISO 14122.		
6.4	**Information for use**		
6.4.1	**General requirements**		
6.4.1.1	Drafting information for use is an integral part of the design of a machine (see Figure 2).Information for use consists of communication links, such as texts, words, signs, signals, symbols or diagrams,used separately or in combination to convey information to the user. Information for use is intended for professional and/or non-professional users. NOTE See also IEC 62079 for structuring and presentation of information for use.		P
6.4.1.2	Information shall be provided to the user about the intended use of the machine, taking into account, notably, all its operating modes. The information shall contain all directions required to ensure safe and correct use of the machine. With this in view, it shall inform and warn the user about residual risk. The information shall indicate, as appropriate, —the need for training, —the need for personal protective equipment, and —the possible need for additional guards or protective devices (see Figure 2, Footnote d). It shall not exclude uses of the machine that can reasonably be expected from its designation and description and shall also warn about the risk which would result from using the machine in other ways than the ones described in the information, especially considering its reasonably foreseeable misuse.		P
6.4.1.3	Information for use shall cover, separately or in combination, transport, assembly and installation, commissioning, use of the machine (setting, teaching/programming or process changeover, operation, cleaning, fault-finding and maintenance) and, if necessary, dismantling, disabling and scrapping.		P
6.4.2	**Location and nature of information for use**		
	Depending on the risk, the time when the information is needed by the user and the machine design, it shall be decided whether the information — or parts thereof — are to be given a) in/on the machine itself (see 6.4.3 and 6.4.4),		P

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	b) in accompanying documents (in particular instruction handbook, see 6.4.5), c) on the packaging, d) by other means such as signals and warnings outside the machine. Standardized phrases shall be considered where important messages such as warnings are given (see also IEC 62079).		
6.4.3	**Signals and warning devices**		
	Visual signals, such as flashing lights and audible signals such as sirens may be used to warn of an impending hazardous event such as machine start-up or overspeed. Such signals may also be used to warn the operator before the triggering of automatic protective measures (see 6.3.2.7). It is essential that these signals a) be emitted before the occurrence of the hazardous event, b) be unambiguous, c) be clearly perceived and differentiated from all other signals used, and d) be clearly recognized by the operator and other persons. The warning devices shall be designed and located such that checking is easy. The information for use shall prescribe regular checking of warning devices. The attention of designers is drawn to the possibility of “sensorial saturation”, which can result from too many visual and/or acoustic signals and which can also lead to defeating the warning devices. NOTE Consultation of the user on this subject is often necessary.		P
6.4.4	**Markings, signs (pictograms) and written warnings**		
	Machinery shall bear all markings which are necessary a) for its unambiguous identification, including at least 1) the name and address of the manufacturer, 2) the designation of series or type, and 3) the serial number, if any, b) in order to indicate its compliance with mandatory requirements, comprising 1) marking, and 2) written indications, such as the authorized representative of the manufacturer, designation of the machinery, year of construction, and intended use in potentially explosive atmospheres), c) for its safe use, for example, 1) maximum speed of rotating parts, 2) maximum diameter of tools, 3) mass (in kilograms) of the machine itself and/or of removable parts, 4) maximum working load,		P

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	5) necessity of wearing personal protective equipment, 6) guard adjustment data, and 7) frequency of inspection. Information printed directly on the machine should be permanent and remain legible throughout the expected life of the machine. Signs or written warnings indicating only “Danger” shall not be used. Markings, signs and written warnings shall be readily understandable and unambiguous, especially as regards the part of the function(s) of the machine to which they are related. Readily understandable signs (pictograms) should be used in preference to written warnings. Signs and pictograms should only be used if they are understood in the culture in which the machinery is to be Used. Written warnings shall be drawn up in the language(s) of the country in which the machine will be used for the first time and, on request, in the language(s) understood by operators. NOTE In some countries the use of specific language(s) is covered by legal requirements. Markings shall comply with recognized standards (for example, ISO 2972 or ISO 7000, for pictograms,symbols and colours in particular). See IEC 60204-1 as regards marking of electrical equipment. See ISO 4413 and ISO 4414 for hydraulic and pneumatic equipment.		
6.4.5	**Accompanying documents (in particular — instruction handbook)**		
6.4.5.1	**Contents**		
	The instruction handbook or other written instructions (for example, on the packaging) shall contain, among others, the following: a) information relating to transport, handling and storage of the machine, such as 1) storage conditions for the machine, 2) dimensions, mass value(s), position of the centre(s) of gravity, and 3) indications for handling (for example, drawings indicating application points for lifting equipment); b) information relating to installation and commissioning of the machine, such as 1) fixing/anchoring and dampening of noise and vibration requirements,		P

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	2) assembly and mounting conditions, 3) space needed for use and maintenance, 4) permissible environmental conditions (for example, temperature, moisture, vibration, electromagnetic radiation), 5) instructions for connecting the machine to power supply (particularly on protection against electrical overloading), 6) advice on waste removal/disposal, and 7) if necessary, recommendations related to protective measures which have to be implemented by the user — for example, additional safeguards (see Figure 2, Footnote d), safety distances, safety signs and signals; c) information relating to the machine itself, such as 1) detailed description of the machine, its fittings, guards and/or protective devices, 2) the comprehensive range of applications for which the machine is intended, including prohibited usages, if any, taking into account variations of the original machine if appropriate, 3) diagrams (especially schematic representation of safety functions), 4) data on noise and vibration generated by the machine, and on radiation, gases, vapours and dust emitted by it, with reference to the measuring methods (including measurement uncertainties) used, 5) technical documentation of electrical equipment (see IEC 60204), and 6) documents attesting that the machine complies with mandatory requirements; d) information relating to the use of the machine, such as that related to or describing 1) intended use, 2) manual controls (actuators), 3) setting and adjustment, 4) modes and means for stopping (especially emergency stop), 5) risks which could not be eliminated by the protective measures implemented by the designer, 6) particular risks which can be generated by certain applications, by the use of certain fittings, and about specific safeguards necessary for such applications, 7) reasonably foreseeable misuse and prohibited applications, 8) fault identification and location, for repair and for restarting after an intervention, and 9) personal protective equipment needed to be used and the training that is required; e) information for maintenance, such as 1) the nature and frequency of inspections for safety functions, 2) specification of the spare parts to be used when these can affect the health and safety of operators, 3) instructions relating to maintenance operations which		

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	require a definite technical knowledge or particular skills and hence need to be carried out exclusively by skilled persons (for example, maintenance staff, specialists), 4) instructions relating to maintenance actions (replacement of parts, etc.) which do not require specific skills and hence may be carried out by users (for example, operators), and 5) drawings and diagrams enabling maintenance personnel to carry out their task rationally (especially fault-finding tasks); f) information relating to dismantling, disabling and scrapping; g) information for emergency situations, such as 1) the operating method to be followed in the event of accident or breakdown, 2) the type of fire-fighting equipment to be used, and 3) a warning of possible emission or leakage of hazardous substance(s) and, if possible, an indication of means for fighting their effects; h) maintenance instructions provided for skilled persons [item e) 3) above] and maintenance instructions provided for unskilled persons [item e) 4) above], that need to appear clearly separated from each other.		
6.4.5.2	**Production of instruction handbook**		
	The following applies to the production and presentation of the instruction handbook. a) The type fount and size of print shall ensure the best possible legibility. Safety warnings and/or cautions should be emphasized by the use of colours, symbols and/or large print. b) The information for use shall be given in the language(s) of the country in which the machine will be used for the first time and in the original version. If more than one language is to be used, each should be readily distinguished from another, and efforts should be made to keep the translated text and relevant illustration together. NOTE In some countries the use of specific language(s) is covered by legal requirements. c) Whenever helpful to the understanding, text should be supported by illustrations. These illustrations should be supplemented with written details enabling, for example, manual controls (actuators) to be located and identified. They should not be separated from the accompanying text and should follow sequential operations. d) Consideration should be given to presenting information in tabular form where this will aid understanding.Tables should be adjacent to the relevant text. e) The use of colours should be considered, particularly in relation to components requiring quick identification.		P

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	f) When information for use is lengthy, a table of contents and/or an index should be provided. g) Safety-relevant instructions which involve immediate action should be provided in a form readily available to the operator.		
6.4.5.3	**Drafting and editing information for use**		
	The following applies to the drafting and editing of information for use. a) Relationship to model: the information shall clearly relate to the specific model of machine and, if necessary, other appropriate identification (for example, by serial number). b) Communication principles: when information for use is being prepared, the communication process "see – think – use" should be followed in order to achieve the maximum effect and should follow sequential operations. The questions, "How?" and "Why?" should be anticipated and the answers provided. c) Information for use shall be as simple and as brief as possible, and should be expressed in consistent terms and units with a clear explanation of unusual technical terms. d) When it is foreseen that a machine will be put to non-professional use, the instructions should be written in a form that is readily understood by the non-professional user. If personal protective equipment is required for the safe use of the machine, clear advice should be given, for example, on the packaging as well as on the machine, so that this information is prominently displayed at the point of sale. e) Durability and availability of the documents: documents giving instructions for use should be produced in durable form (i.e. they should be able to survive frequent handling by the user). It can be useful to mark them "keep for future reference". Where information for use is kept in electronic form (CD, DVD, tape, hard disk, etc.), information on safety-related issues that need immediate action shall always be backed up with a hard copy that is readily available.		P
7 Documentation of risk assessment and risk reduction			
	The documentation shall demonstrate the procedure that has been followed and the results that have been achieved. This includes, when relevant, documentation of a) the machinery for which the risk assessment has been made (for example, specifications, limits, intended use); b) any relevant assumptions that have been made (loads, strengths, safety factors, etc.); c) the hazards and hazardous situations identified and the hazardous events considered in the risk assessment; d) the information on which risk assessment was based (see 5.2): 1) the data used and the sources (accident histories, experience gained from risk reduction applied to similar machinery, etc.);		P

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	2) the uncertainty associated with the data used and its impact on the risk assessment; e) the risk reduction objectives to be achieved by protective measures; f) the protective measures implemented to eliminate identified hazards or to reduce risk; g) residual risks associated with the machinery; h) the result of the risk assessment (see Figure 1); i) any forms completed during the risk assessment. Standards or other specifications used to select protective measures referred to in f) above should be referenced. NOTE No requirement is given in this International Standard to deliver the risk assessment documentation together with the machine. See ISO/TR 14121-2 for information on documentation.		

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EN ISO 10472-1			
Clause	Requirement - Test	Result - Remark	Verdict

5	Safety requirements and/or measures for the hazards identified in clause 4		P
5.1	Mechanical hazards		P
5.1.1	Escape and rescue of trapped persons		P
	Where there is a residual risk of entrapment, for example due to malfunction of a safety device or during maintenance, the manufacturer shall provide means and instructions for releasing an entrapped person to minimize injury.	Pass muster	P
5.1.2	Guards and safety devices		P
	The following safety requirements and/or measures apply.		P
5.1.3	Fault-finding, cleaning or maintenance		P
	For fault-finding, cleaning or maintenance (e.g. clearing of blockages), safety measures in accordance with ISO/TR 12100, 3.7.10 shall be taken and described in the instruction handbook.		P
5.1.4	Complex installation		P
	For complex installations comprising a combination of machines and service equipment, arranged to work as one integrated production unit and subject to an overall control system, the following safety requirements and/or measures shall be taken:		P
	a) there shall be a power supply disconnecting device (master isolator) for the entire complex installation, and each machine or section shall be provided with individual power supply disconnecting devices, where such can be operated individually (see EN 1037:1995, 4.1);		P
	b) additional guards and safety devices shall be installed as necessary for either the complex installation in its entirety or on individual constituent machines, together with the interfaces between any given machine and those adjoining		P
	c) all movable guards and safety devices shall be in position and activated before it is possible to start the entire complex installation for normal operation. It is permitted to have guards and safety devices out of position or inactivated on any constituent machine whilst it is purposely inoperative and at standstill, provided that access to dangerous parts on adjacent operating machines is prevented;		P

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	d) in the case of a machine, or a combination of machines, comprising unit items selected from the proprietary range of products of two or more manufacturers, it shall be ensured that a		P
	comprehensive complement of safety measures is provided by the party responsible for the overall installation according to how this responsibility is defined in the ruling contract(s). Particular attention shall be given to the interfaces between the unit items.		
5.2	Electrical hazards		P
	The electrical equipment of machines shall be designed in accordance with EN 60204-1:1992, option 1, or IEC 335 [see b)] as specified in 5.3 of ISO 10472-2, ISO 10472-4 and ISO 10472-5, depending on the intended use of the machine.	EN ISO 10472-2	p
	a) If EN 60204-1 applies, the appropriate clauses given in Table 3 shall be used.		P
	These machines shall be equipped with an emergency stop device in accordance with ISO 13850:1996, 4.1.5 — category 0, unless specified otherwise in ISO 10472-2 to ISO 10472-6. The manufacturer shall fit emergency stop devices as required in ISO 13850:1996, 4.4 and at each loading and unloading position.		P
	In addition, the manufacturer shall ensure that there are sufficient devices so that at least one is visible from any normal operator access area within 2 m from the machine, and that each device is located within 8 m of any such operator position. If the device is an emergency stop button, it shall be positioned at a height from the working floor or platform of between 700 mm and 1 700 mm.		P
	This emergency stop device may be omitted on machines designed for coin, token or similar operation for use in self-service situations; in such cases, the instruction handbook shall describe the arrangement for a remote-located emergency stop device, which shall be provided by the user and connected to each machine.		P
	b) If IEC 335 applies, the following parts shall be used:		P
5.3	Thermal hazards		P
	When a machine contains parts that could create burn hazards, the equipment shall be designed so as to minimize the risk of burn injury caused by contact with or proximity to machine parts at high temperatures.		P

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	This can be achieved when the surface temperatures for incidental contact (less than 1 s contact time) do not exceed the following values		P
	under normal processing conditions, unless otherwise specified in ISO 10472-2 to ISO 10472-6:		
	For machines that may occasionally process at higher temperatures, the manufacturer shall describe in the instruction handbook these particular circumstances and give advice to the user for staff training and preparation of safety instructions.		P
5.4	Hazards generated by noise		P
	ISO 10472 does not contain specific measures concerning noise reduction. At an early stage of design, consideration should be given to the possible noise hazard likely to arise. The selection of appropriate measures should be based on the latest technology (see ISO/TR 11688-1).		P
5.5	Hazards associated with materials and substances		P
5.5.1	Contact with or inhalation of harmful fluids, gases, mists, fumes and dusts		P
	The instruction handbook shall contain information concerning the correct use of the machine to prevent exposure to harmful substances (see EN 626-1). It shall also require the user to consult with the chemical supplier as to the risk of the products used and their combinations. See the appropriate parts of ISO 10472 for specific measures.		P
5.5.2	Fire and explosion		P
5.5.3	Decomposition of substances		N
	For gas- and oil-fired machines, the manufacturer shall include a warning in the instruction handbook that some substances, for example dry-cleaning solvents, may decompose into toxic and/or corrosive substances if drawn into the burners, and that ducting for gas- and oil-fired machines should lead to a safe external location.		N
5.5.4	Biological hazards		P
	The manufacturer shall advise the user in the instruction handbook of biological hazards from the non-completion of a disinfection cycle.		
5.6	Hazards due to neglect of ergonomic principles in machine design		P
	ISO 10472 does not contain specific measures about elimination or reduction of hazards due to		P

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	neglect ofergonomic principles in machine design. Advice is given in EN 614-1:1995, Annex A, for avoiding unhealthy postures.		
5.7	Failure of energy supply and control systems		P
6	Verification of safety requirements and/or measures		P
	The verification clauses of ISO 10472-2 to ISO 10472-6 and other normative references shall apply.	EN ISO 10472-2	P
7	Information concerning machine use		P
7.1	Instruction handbook		P
	The manufacturer shall provide an instruction handbook as described in ISO/TR 12100-2:1992, 5.5.		P
	The manufacturer shall provide information on noise emission in accordance with ISO/TR 12100 A.1.7.4.		P
7.2	Warning signs		P
	The manufacturer shall provide machine marking in accordance with ISO/TR 12100-2, 5.4, EN 60204-1, clauses 18 and 19, EN 746-2, ISO 9398-1 to ISO 9398-4.		P
	Graphical symbols shall comply with ISO 5232.		P
	The machine shall be clearly marked with the total mass, lifting points and centre of gravity.		P

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EN IEC 61400-1-2019 Test Report & EN 61400-2:2018 Test Report			
Clause	Requirement - Test	Result - Remark	Verdict
1	Scope		
2	Normative references		
3	Terms and definitions		
4	Symbols and abbreviated terms		
4.1	General		
	NOTE Symbols and abbreviations can vary in some annexes, and if so they are defined internally within the annex.		P
4.2	Symbols		
	A cross section area [m2] Aproj the component area projected on to a plane perpendicular or parallel to the wind direction [m2] a slope parameter for turbulence standard deviation model [-] B number of blades [-] C scale parameter of the Weibull distribution function [m/s] Cd drag coefficient [-] Cf force coefficient [-] Cl lift coefficient [-] CT thrust coefficient [-] Coh coherency function [-] D rotor diameter [m] er distance from the centre of gravity of the rotor to the rotation axis [m] F force [N] FzB force on the blade at the blade root in the spanwise direction [N] Fx-shaftaxial shaft load [N] f fk frequency characteristic value for material strength [Hz] [-] G ratio between rated torque and short circuit torque for a generator [-] g acceleration due to gravity: 9,81 [m/s2] i electrical current [A] IB mass moment of inertia of the blade about the blade root flap axis [kgm2] I15 characteristic value of hub-height turbulence intensity at a 10-min average wind speed of 15 m/s [-] K modified Bessel function [-]		P

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EN IEC 61400-1-2019 Test Report & EN 61400-2:2018 Test Report			
Clause	Requirement - Test	Result - Remark	Verdict
	k shape parameter of the Weibull distribution function [-] L isotropic turbulence integral scale parameter [m] Llt distance between the lifting point and the top of the tower [m] Lrt distance between the rotor centre and the yaw axis [m] Lrb distance between rotor centre and first bearing [m] Lc coherency scale parameter [m] Lk velocity component integral scale parameter [m] MxB, MyB blade root bending moments [Nm] Mbrake torque on the low speed shaft caused by the brake [Nm] Mx-shaft torsion moment on the rotor shaft at the first bearing [Nm] Mshaft combined bending moment for the shaft at the first bearing (nearest to rotor) [Nm] Mtower the bending moment in the tower at the lifting point attachment [Nm] mB blade mass [kg] moverhang the mass of the tower between the lifting point and the top of the tower [kg] mr rotor mass being the mass of the blades plus the mass of the hub [kg] mtowertop the mass of the nacelle and rotor combined [kg] N(.)is the number of cycles to failure as a function of the stress (or strain) indicated by the argument (i.e. the characteristic S-N curve) [-] N recurrence period for extreme situations [yr] n rotor speed [r/min] ndesign design rotational speed [r/min] ni counted number of fatigue cycles in load bin i [-] nmax maximum rotational speed [r/min] O P PR(V0) operational time fraction electrical power Rayleigh cumulative probability distribution, i.e. the probability that V<V0 [%] [W] [-] PW(V0) Weibull cumulative probability distribution [-] PH harmonic multiple of fundamental excitation frequency, being rotor speed [Hz] p survival probability [-] Q rotor torque [Nm] Qdesign design shaft torque [Nm]		

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EN IEC 61400-1-2019 Test Report & EN 61400-2:2018 Test Report			
Clause	Requirement - Test	Result - Remark	Verdict
	R radius of the rotor [m] Rcog radial distance between the centre of gravity of a blade and the rotor centre [m] r magnitude of separation vector projection [m] S1(f) power spectral density function [m2/s2] Sk single sided velocity component spectrum [m2/s2] si the stress (or strain) level associated with the counted number of cycles in bin i [-] T gust characteristic time [s] t time [s] Td design life [s] TE excluded time [h] TN time during which the turbine was not operational [h] TT total time elapsed in the duration test [h] TU unknown time [h] U electrical potential difference (voltage) [V] V wind speed [m/s] V(z) wind speed at height z [m/s] Vave annual average wind speed at hub height [m/s] Vcg extreme coherent gust magnitude over the whole rotor swept area [m/s] Vdesign design wind speed [m/s] VeN expected extreme wind speed (averaged over 3 s), with a recurrence time interval of N years. Ve1 and Ve50 for 1 year and 50 years, respectively [m/s] VgustN largest gust magnitude with an expected recurrence period of N years. [m/s] Vhub wind speed at hub height averaged over 10 min [m/s] Vin cut-in wind speed [m/s] Vmaint wind speed (10-min average) below which safe shutdown of the SWT for performing inspections, service or maintenance is possible [m/s] Vmax,shutdown the maximum wind speed at which the manufacturer allows a normal shutdown[m/s] V0 limit wind speed in wind speed distribution model [m/s] Vout cut-out wind speed [m/s] Vref reference wind speed averaged over 10 min [m/s] Vtip speed of the blade tip [m/s]		

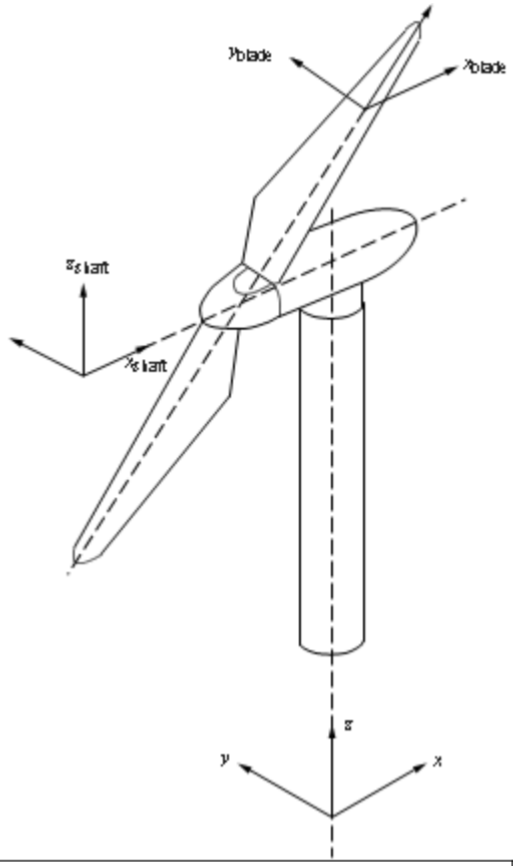
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EN IEC 61400-1-2019 Test Report & EN 61400-2:2018 Test Report			
Clause	Requirement - Test	Result - Remark	Verdict
	V(t,z) longitudinal wind velocity component to describe transient variation for extreme gust and shear conditions [m/s] W section modulus used in stress calculations [m3] x, y, z co-ordinate system used for the wind field description; along wind (longitudinal), across wind (lateral) and height respectively [m] zhub hub height of the Wind generator [m] zr reference height above ground [m] z0 roughness length for the logarithmic wind profile [m] wind shear power law exponent [-] parameter for extreme direction change model and extreme operating gust model[-] gamma function[-] f partial safety factor for loads [-] m partial safety factor for materials [-] range [-] (t) wind direction change transient [°] cg angle of maximum deviation from the direction of the average wind speed under gust conditions [°] eN extreme direction change with a recurrence period of N years [°] efficiency of the components between the electric output and the rotor (typically generator, gearbox and conversion system) [-] 1 turbulence scale parameter defined as the wave length where the non-dimensional, longitudinal power spectral density, fS1(f)/ 12, is equal to 0,05 [m] tip speed ratio [-] air density, here assumed 1,225 [kg/m3] 1 hub-height longitudinal wind velocity standard deviation [m/s] 2 hub-height vertical wind velocity standard deviation [m/s] 3 hub-height lateral wind velocity standard deviation [m/s] d design stress [MPa] k kth hub-height component wind velocity standard deviation (k = 1, 2, or 3) [m/s]		

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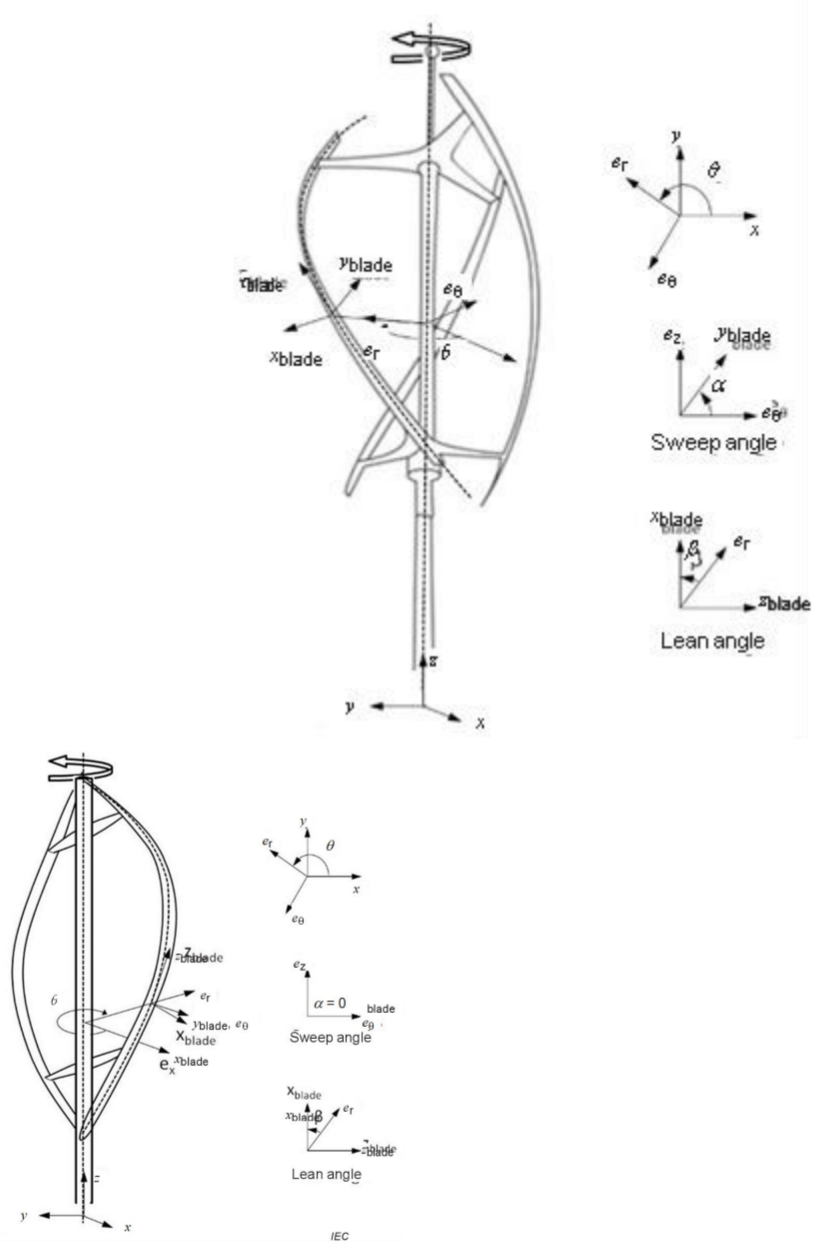
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	n rotational speed of the rotor [rad/s] yaw yaw rate [rad/s] yaw,max maximum yaw rate [rad/s] Subscripts: ave average B blad design input parameter for the simplified design equations e1 once per year extreme (averaged over 3 s) e50 once per 50 year extreme (averaged over 3 s) hub hub max maximum overhang description of section of tower between lifting point and tower top r rotor shaft shaft x in the x-direction y in the y-direction z in the z-direction Abbreviations: asl above sea level AEP Annual Energy Production RAE Reference Annual Energy AC Alternating current DC Direct current CFD Computational Fluid Dynamics DLC Design load case ECD Extreme coherent gust with direction change ECG Extreme coherent gust EDC Extreme wind direction change EMC Electromagnetic compatibility EOG Extreme operating gust EWC Extreme wind conditions EWM Extreme wind speed model F Fatigue FMEA Failure Mode and Effects Analysis FMECA Failure Mode Effects and Criticality Analysis GFCI Ground fault circuit interrupter HAWT Horizontal axis Wind generator NTM Normal turbulence model NWC Normal wind conditions NWP Normal wind profile model OWC Other wind conditions S Special IEC Wind generator class SWC Standard wind conditions SWT Small Wind generator U Ultimate UV Ultra violet (radiation) VAWT Vertical axis Wind generator		
4.3	Coordinate system		
	To define the directions of the loads of a horizontal axis Wind generator (HAWT), the system of axes shown in		P

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	Figure 1 is used.		
			
	The following notes form part of the above figure: Tower: x is positive in the downwind direction, z is pointing up, y completes right hand coordinate system the tower system is fixed Shaft: xshaft is such that a positive moment about the x axis acts in the rotational direction yshaft and zshaft are not used, only the combined moment is used the shaft axis system rotates with the nacell Blade: xblade is such that a positive moment about the x-axis acts in the rotational direction yblade is such that a positive moment acts to bend the blade tip downwind zblade is positive towards blade tip the blade coordinate system follows the right-hand convention for a rotor that spins clockwise and the left-hand convention for a rotor that spins counter clockwise when viewed from an upwind location. the blade axis system rotates with the rotor Figure 1 – Definition of the system of axes for HAWT To define the directions of the loads of a vertical axis		

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	Wind generator (VAWT), the system of axes shown in Figure 2 is used.		



Tower:

x is positive in the downwind direction, z pointing up, y completes the right hand coordinate system.

Rotor:

The rotor coordinate system is cylindrical of axis z, the angle θ=(ex,er) is positive from the downwind axis x. (er, eθ, ez) is a right hand coordinate system.

Blade:

zblade is tangent to the reference line of the blade, and points upward.

yblade is perpendicular to zblade and to the radial vector er; points in the opposite direction to the rotation

xblade completes the right hand coordinate system (and is normal to the blade)

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NOTE In the case of a rotor with planar straight blades (lean and sweep angle are both zero) spinning in the negative z direction, the blade coordinate system is coincident with the rotor coordinate system. Figure 2 – Definition of the system of axes for VAWT			
5	Principal elements		
5.1	General		
	The engineering and technical requirements to ensure the safety of the structural, mechanical, electrical and control systems of the Wind generator are given in the following Clauses 5 through 12. This specification of requirements applies to the design, manufacture, installation and maintenance of the Wind generator, and the associated quality management process, together with appropriate and sufficient documentation.		P
5.2	Design methods		
	The design method for turbines covered under this standard is depicted in Figure 3. A simplified approach is permitted for a variety of turbine configurations. For turbines with a swept rotor area of 2 m2 or less only the sample support structure is considered part of the design (however see 11.2.3.2). The design loads shall be obtained in one or a combination of the following three ways. The design loads shall be verified by measured “design data test” (See 13.2): It is recommended that in-house tests for design data are conducted early in the development. 1) Simplified loads methodology For certain turbine configurations a simplified calculation method is given. A limited set of load cases and configurations is given in 7.4 with simple formulas and simplified external conditions. The turbine data assumed within the simplified equations shall be verified by the “Tests to verify design data” (see 13.2). 2) Simulation model A model shall be used to determine the loads over a range of wind speeds, using the turbulence conditions and other extreme wind conditions defined in 6.3.3, and design situations defined in 7.5. This approach uses a structural dynamics simulation model in combination with Wind generator and application adequate assumptions. The assumptions shall be verified by the “Tests to verify design data” (see 13.2). All relevant combinations of external conditions and design situations shall be analysed. A minimum set of such combinations has been defined as load cases in this standard. 3) Full scale load measurement Full scale load measurement with load extrapolation (see		P

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	7.6). Each of these methods has different uncertainties. Therefore, different sets of safety factors shall be applied depending upon the load estimation method used (see 7.8). For all turbines a static blade test is required (see 13.5.2). To verify the adequacy of other load carrying components, either calculations or testing is required or a combination of both. Test conditions shall reflect the design loads including the relevant safety factors. Finally, for all turbines a safety and function test (see 13.6) and duration test (see 13.4) are required.		
5.3	Quality assurance		
	Quality assurance shall be an integral part of the design, procurement, manufacture, installation, operation and maintenance of the Wind generator and all its components. It is recommended that the quality system complies with the requirements of the ISO 9000 series. Design evaluation		P
6	External conditions		
6.1	General		
	SWTs are subjected to environmental and electrical conditions that may affect their loading, durability and operation. To ensure the appropriate level of safety and reliability, the environmental, electrical and soil parameters shall be taken into account in the design and shall be explicitly stated in the design documentation. The environmental conditions are divided into wind conditions and other environmental conditions. The electrical conditions refer to either network conditions or local electrical conditions like batteries, hybrid systems or local grid. Soil properties are relevant to the design of SWT foundations. Wind conditions are the primary external consideration for structural integrity. Other environmental conditions also affect design features such as control system function, durability, corrosion, etc. Each type of external condition may be subdivided into a normal external condition and an extreme external condition. The normal external conditions generally concern long-term structural loading and operating conditions, while the extreme external conditions represent the rare but potentially critical external design conditions. The design load cases shall consist of a combination of these external conditions with Wind generator operational modes.		P
6.2	SWT classes		
	The external conditions to be considered in design are		P

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	dependent on the intended site or site type for a SWT installation. SWT classes are defined in terms of wind speed and turbulence parameters. The values of wind speed and turbulence parameters are intended to represent the characteristic values of many different sites and do not give a precise representation of any specific site. The goal is to achieve SWT classification with clearly varying robustness governed by the wind. Table 1 specifies the basic parameters, which define the SWT classes. The intention of the classes is to cover most applications, and reference should be made to Annex L for other wind conditions that may be experienced. In cases where a special design (e.g. special wind conditions, or other wind conditions (per Annex L) or other external conditions or a special safety class) is necessary, a further SWT class, class S, is defined. The design values for the SWT class S shall be chosen by the designer and specified in the design documentation (see Annex B). For such special designs, the values chosen for the design conditions shall reflect a more severe environment than anticipated for the use of the SWT. The particular external conditions defined for classes I, II, III and IV are neither intended to cover offshore conditions nor wind conditions experienced in tropical storms such as hurricanes, cyclones and typhoons. Such conditions may require Wind generator class S design (see Annex B, Annex K, and Annex L).		

Table 1 – Basic parameters for SWT classes

SWT class		I	II	III	IV	S
V_{ref}	(m/s)	50	42,5	37,5	30	Values to be specified by the designer
V_{ave}	(m/s)	10	8,5	7,5	6	
I_{15} (Note 2)	(-)	0,18	0,18	0,18	0,18	
a	(-)	2	2	2	2	

NOTE

1) the values apply at hub height, and;

2) I_{15} is the dimensionless characteristic value of the turbulence intensity at 15 m/s, where 0,18 is the minimum value that shall be used, and noting that Annex M discusses observations regarding turbulence intensity;

3) a is the dimensionless slope parameter to be used in Equation (7).

	In addition to these basic parameters, several important further parameters are required to completely specify the external conditions used in SWT design. In the case of the SWT classes I through IV later referred to as standard SWT classes, the values of these additional parameters are specified in 6.3, 6.4 and 6.6. The abbreviations added in parentheses in the subclause headings in the remainder of Clause 6 are used for describing the wind conditions for the design load cases defined in 7.5, simulation modelling		

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	(note that for the simple load calculations, the wind conditions are simplified as well). For the SWT class S the manufacturer shall in the design documentation describe the models used and values of essential design parameters. Where the models in the present subclause 6.2 are adopted, statement of the values of the parameters will be sufficient. The design documentation of SWT class S shall contain the information listed in Annex B. The design lifetime shall be clearly specified in the design documentation.		
6.3	Wind conditions		
6.3.1	General		
	A SWT shall be designed to safely withstand the wind conditions defined by the selected SWT class. The design values of the wind conditions shall be clearly specified in the design documentation. The wind regime for load and safety considerations is divided into the normal wind conditions (NWC) which will occur frequently during normal operation of a SWT, and the extreme wind conditions (EWC) which are defined as having a 1-year or 50-year recurrence period. In this standard the combination of the NWC and EWC in conjunction with the four SWT classes I-IV define the standard wind conditions (SWC). In Annex L other wind conditions (OWC) are discussed. In all cases the influence of an inclination of mean flow with respect to the horizontal plane of up to 8° shall be considered. The flow inclination angle may be assumed to be invariant with height. Note that oblique inflow can have an effect on furling if the furl direction is chosen poorly with respect to the rotational direction of the rotor.		P
6.3.2	Normal wind conditions		
6.3.2.1	Wind speed distribution		
	The wind speed distribution at the site is significant for the SWT design because it determines the frequency of occurrence of the individual load conditions. In case of the standard SWT classes, the mean value of the wind speed over a time period of 10 min shall be assumed to be Rayleigh distributed for the purposes of design load calculations. In this case, the cumulative probability distribution at hub height is given by:		P
6.3.2.2	Normal wind profile model (NWP)		
	The wind profile, V(z), denotes the average wind speed as a function of height, z, above the ground. In the case of standard Wind generator classes, the normal wind speed profile shall be assumed to be given by the power		P

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	law: The power law exponent, , shall be assumed to be 0,2. The assumed wind profile is used to define the average vertical wind shear across the rotor swept area.		
6.3.2.3	Normal turbulence model (NTM)		
	The normal turbulence model shall include a wind shear as described under NWP, in 6.3.2.2. The expression "wind turbulence" denotes stochastic variations in the wind velocity from the 10-min average. The turbulence model shall include the effects of varying wind speed, varying direction, and rotational sampling. For the standard SWT classes, the power spectral densities of the random wind velocity vector field, whether used explicitly in the model or not, shall satisfy the following requirements: a) The characteristic value of the standard deviation of the longitudinal wind velocity component shall be given by1: Values for I15 and a are given in Table 1. The characteristic values of the standard deviation, 1, and of the turbulence intensity, 1/Vhub, are shown below in Figure 4. b) Towards the high frequency end of the inertial subrange the power spectral density of the longitudinal component of the turbulence, S1(f), shall asymptotically approach the form: c) The turbulence scale parameter, 1,shall be given by: Specifications for stochastic turbulence models, which satisfy these requirements, are given in Annex C. In Annex D a simplified deterministic model, which is based on a stochastic description of the turbulence, is given. This deterministic model may be used when it can be demonstrated that the turbine blade response to rotationally sampled wind velocity is sufficiently well damped. Guidance for this validation is also given in Annex D.		P
6.3.3	Extreme wind conditions		
6.3.3.1	General		
	The extreme wind conditions are used to determine extreme wind loads on SWTs. These conditions include peak wind speeds due to storms and rapid changes in wind speed and direction. These extreme conditions include the potential effects of wind turbulence so that only the deterministic effects need to be considered in the design calculations.		P
6.3.3.2	Extreme wind speed model (EWM)		
	The 50-year extreme wind speed Ve50 and the one year extreme wind speed Ve1 shall be based on the		P

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	reference wind speed Vref. For SWT designs in the standard SWT classes, the 3-s gust Ve50 and Ve1 shall be computed using the following equations: where zhub is hub height, and 1,4 is the gust factor at hub height. Short-term deviations from the mean wind direction of 15° shall be assumed.		
6.3.3.3	Extreme operating gust (EOG)		
	The hub height gust magnitude VgustN for a recurrence period of N years shall be given for the standard SWT classes by the following relationship: where 1 is the standard deviation, according to Equation (7); 1 is the turbulence scale parameter, according to Equation (9); D is the rotor diameter; = 4,8 for N = 1; and = 6,4 for N = 50. The wind speed shall be defined for a recurrence period of N years by the equation: where V(z) is defined in Equation (6); T = 10,5 s for N = 1; and T = 14,0 s for N = 50. As an example, the extreme operating gust with a recurrence period of one year and Vhub = 25 m/s is shown in Figure 5: The parameter values for both recurrence periods were selected to give the same maximum rise rate.		P
6.3.3.4	Extreme direction change (EDC)		
	The extreme direction change magnitude, eN, for a recurrence period of N years shall be calculated using the following relationship: where eN is limited to the interval 180 ; 1 is the turbulence scale parameter, according to Equation (9); D is the rotor diameter; = 4,8 for N = 1; and = 6,4 for N = 50. The extreme direction change transient for a recurrence period of N years, N(t),shall be given by: where T = 6 s is the duration of the extreme direction change transient. The sign shall be chosen so that the worst transient loading occurs. At the end of the direction change transient the direction is assumed to remain		P

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	unchanged. As an example, the extreme direction change with a recurrence period of 50 years and Vhub = 25 m/s is shown in Figure 6 and Figure 7.		
6.3.3.5	Extreme coherent gust (ECG)		
	For Wind generator designs for the standard SWT classes, an extreme coherent gust with a magnitude of Vcg = 15 m/s shall be assumed. The wind speed shall be defined by the relations: where T = 10 s is the rise time. The normal wind profile model of wind speed as specified in Equation (6) shall be used. The extreme coherent gust is illustrated in Figure 8 for Vhub = 25 m/s.		P
6.3.3.6	Extreme coherent gust with direction change (ECD)		
	In this case, the rise in wind speed (described by ECG, see Figure 8) shall be assumed to occur simultaneously with the direction change cg, where cg is defined by the relations: The direction change, cg, as a function of Vhub and as a function of time for Vhub = 25 m/s is shown in Figure 9 and Figure 10, respectively. The simultaneous direction change is then given by:		P
6.4	Other environmental conditions		
6.4.1	General		
	Environmental (climatic) conditions other than wind can affect the integrity and safety of the SWT, by thermal, photochemical, corrosive, mechanical, electrical or other physical action. Moreover, combinations of the climatic parameters given may increase their effect. At least the following other environmental conditions shall be taken into account and the action taken stated in the design documentation (see Annex J for further information): 1) temperature; 2) humidity; 3) air density; 4) solar radiation; 5) rain, hail, snow and ice; 6) chemically active substances; 7) mechanically active particles (e.g. sand and dust particles); 8) lightning; 9) earthquakes; and 10) marine environment - corrosion. A marine environment requires special additional consideration. The climatic conditions for the design shall be defined in terms of representative values or by the limits of the variable conditions. The probability of		P

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	simultaneous occurrence of the climatic conditions shall be taken into account when the design values are selected. Variations in the climatic conditions within the normal limits, which correspond to a one-year recurrence period shall not interfere with the designed normal operation of a SWT. Unless correlation exists, other extreme environmental conditions according to 6.4.3 shall be combined with the normal wind conditions according to 6.3.2.		
6.4.2	Other normal environmental conditions		
	The other normal environmental condition values, which shall be taken into account are: 1) normal system operation ambient temperature range of –10 °C to +40 °C; 2) relative humidity of up to 95 %; 3) atmospheric content equivalent to that of a non-polluted inland atmosphere (see IEC 60721-2-1); 4) solar radiation intensity of 1 000 W/m2; and, 5) air density of 1,225 kg/m3. When the designer specifies additional external condition parameters, these parameters and their values shall be stated in the design documentation and shall conform to the requirements of IEC 60721-2-1.		P
6.4.3	Other extreme environmental conditions		
6.4.3.1	General		
	Other extreme environmental conditions, which shall be considered for SWT design, are temperature, lightning, ice and earthquakes.		P
6.4.3.2	Temperature		
	The design values for the extreme temperature range shall be at least –20 °C to +50 °C for the standard SWT classes.		P
6.4.3.3	Lightning		
	The provisions of lightning protection required in 9.5 may be considered as adequate for Wind generators in the standard SWT classes.		P
6.4.3.4	Ice		
	No ice requirements are given for the standard SWT classes. In case the manufacturer wants to include ice loading in their design load estimation, a minimum of 30 mm layer of ice with a density of 900 kg/m3 on all exposed areas is recommended. This static ice load would then be combined with the drag loads on the parked turbine system at 3 Vave. Ice loads on the support structure including guy wires should be considered in the design		P

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	loads of the support structure.		
6.4.3.5	Earthquakes		
	No minimum earthquake requirements are given for the standard SWT classes.		P
6.5	Controlled test conditions		
	Room temperature is +10 °C to +35 °C. For tests under controlled test conditions the controlled room temperature shall always be in the range of +18 °C to +28 °C (+23 5) °C).		P
6.6	Electrical load conditions		
6.6.1	General		
	The electrical conditions which need to be considered in the design depend on the application of the turbine.		P
6.6.2	For turbines connected to the electrical power network		
6.6.2.1	Normal electrical conditions		
	The normal conditions at the Wind generator terminals to be considered in design are listed below. Normal electrical power network conditions apply when the following parameters fall within the ranges stated below: • Voltage Nominal value (according to IEC 60038) 10 %; • Frequency Nominal value 2 %; • Voltage imbalance The ratio of the negative-sequence component of voltage to the positive-sequence component will not exceed 2 %; • Auto-reclosing cycles Auto-reclosing cycle periods of 0,2 s to 5,0 s for the first reclosure and 10 s to 90 s for a second reclosure; and • Outages Electrical network outages shall be assumed to occur 20 times per year. An outage of up to 24 h shall be considered a normal condition.		P
6.6.2.2	Extreme electrical conditions		
	At least the following extreme electrical power network conditions at the wind turbine terminals shall be considered in the design: • voltage – deviations from nominal value of 20 %; • frequency – nominal value 10 %; • voltage imbalances of 15 %; • symmetrical and unsymmetrical faults; and		P

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Clause	Requirement - Test	Result - Remark	Verdict
	• outages – an outage of up to 1 week shall be considered an extreme condition.		
6.6.3	For turbines not connected to the electrical power network		
6.6.3.1	Battery-charging turbine		
	The turbine shall be able to operate over the full range of battery voltages listed below: • voltage range –15 % or +30 % of nominal voltage (example 12 V, 24 V, 36 V, etc.); or • 5 % beyond upper and lower settings of charge controller.		P
6.6.3.2	Local-grid		
	Turbines connected to a local grid thus not connected to a large electrical network will be expected to encounter larger variations in voltage and frequency. The turbine system shall be able to operate within the following constraints: • voltage: deviation from nominal values of 15 %; and • frequency: nominal 5 Hz.		P
7	Structural design		
7.1	General		
	Wind generator system structural design shall be based on verification of the structural integrity of the components in the critical load paths from the rotor blades to the foundation. The ultimate and fatigue strength of all structural members (for example: rotor blade, rotor hub, rotor shaft, nacelle, yaw shaft, tower, connections) shall be verified by calculations or tests, or a combination of both, to determine the structural integrity of a SWT with the appropriate safety level. The scope of verification is the same regardless of the design methodology chosen (7.2). The structural analysis shall be based on ISO 2394 or equivalent, where applicable.		P
7.2	Design methodology		
	It shall be verified that the limit states are not exceeded for the Wind generator design. There are three ways given to determine the design loads for the turbine which are described in 5.2 as being: 1) simplified loads methodology; 2) simulation model; 3) full scale load measurement.		P
7.3	Loads and load cases		
7.3.1	General		

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Clause	Requirement - Test	Result - Remark	Verdict
	The types of loads described in 7.3.2 to 7.3.6 shall be considered.		P
7.3.2	Vibration, inertial and gravitational loads		
	Inertial and gravitational loads are static and dynamic loads acting on the SWT resulting from inertia, gyroscopic, vibration, rotation, gravity and seismic activity or motion of the support structure such as boats, etc. A resonance analysis, such as provided by a Campbell diagram, shall be provided for the main structural components of the Wind generator system (see Annex I).		P
7.3.3	Aerodynamic loads		
	Aerodynamic loads are static and dynamic loads, which are caused by the airflow and its interaction with the stationary and moving parts of the SWT. The airflow shall be considered to be dependent upon the rotational speed of the rotor, the wind speed across the rotor plane, turbulence, the density of the air, and the aerodynamic shapes of the wind turbine components and their interactive effects, including aero-elastic effects.		P
7.3.4	Operational loads		
	Operational loads result from the operation and control of the turbine system. Operational loads can be caused by yawing, braking, furling, pitching, grid connection, etc.		P
7.3.5	Other loads		
	All loads that may occur due to special operating environments specified by the manufacturer shall also be considered (e.g. wave loads, wake loads, ice loads, transport, assembly, maintenance and repair loads, etc.).		P
7.3.6	Load cases		
	For design purposes, the life of a SWT can be represented by a set of design situations covering the most significant conditions which the turbine system may experience. The load cases shall be determined from the combination of specific assembly, erection, maintenance, and operational modes or design situations with the external conditions. All relevant load cases with a reasonable probability of occurrence shall be considered, together with the behaviour of the control and protection system. Generally the design load cases used to determine the structural integrity of a SWT may be calculated from the following combinations: • turbine operation without fault and with normal external conditions; • turbine operation without fault and with extreme external conditions;		P

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	• turbine operation with fault and appropriate external conditions; and • transportation, installation and maintenance design situations and appropriate external conditions (see also 10.6). If a significant correlation exists between an extreme external condition and a fault situation, a realistic combination of the two shall be considered as a design load case. Within each design situation several design load cases shall be considered to verify the structural integrity of SWT components. As a minimum the design load cases in Table 2 or Table 4 shall be considered. In those tables, the design load cases are specified for each design situation by the description of the wind, electrical and other external conditions. Where the control and protection system does not monitor and limit certain turbine parameters, this shall be taken into account in the load cases. Examples of such parameters are: • cable twist; • vibrations; • rotor speed; and • flutter.		
7.4	Simplified loads methodology		
7.4.1	General		
	For certain turbine configurations the loads can be derived using simple, conservative equations for a limited set of load cases. Annex F provides background information for these equations. If the turbine configuration does not meet those configuration requirements the simplified loads methodology cannot be used, instead the alternative simulation modelling (7.5) or load measurements shall be used (7.6). The turbine configurations that are able to use the simplified loads methodology shall meet all of the following requirements: • horizontal axis; • 2 or more bladed propeller-type rotor; • cantilever blades; • coordinated blade movement (not independent and uncoordinated pitching, coning, etc.); and • rigid hub (not teetering or hinged hub). The turbine configuration may use an upwind or downwind rotor; it may operate at either variable or constant speed; it may have an active or passive pitch mechanism (provided that the pitch mechanism coordinates all blades simultaneously), as well as fixed		P

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pitch; and it may furl about vertical, horizontal, or intermediate axes, as well as not furling.

The simplified load methodology uses input parameters which shall be determined as described in 13.2, noting especially the clause regarding yaw 13.2.3. These parameters are:

- design rotational speed, ndesign;
- design wind speed, Vdesign;
- design shaft torque, Qdesign;
- maximum yaw rate, yaw,max; and
- maximum rotational speed, nmax.

Further the design tip speed ratio is defined as:

Vdesign

ndesign

The load cases for the simplified load methodology are summarised in Table 2. The load components for the simplified load methodology are found in each clause discussing the load case.

For each design situation, the appropriate type of analysis is stated by "F" and "U" in Table 2. F refers to analysis of fatigue loads, to be used in the assessment of fatigue strength. U refers to the analysis of ultimate loads such as analysis of exceeding the maximum material strength, analysis of tip deflection, and stability analysis.

Table 2 – Design load cases for the simplified load calculation method

Design situation	Load cases		Wind inflow	Type of analysis	Remarks
Power production	A	Normal operation		F	
	B	Yawing	$V_{hub}=V_{design}$	U	
	C	Yaw error	$V_{hub}=V_{design}$	U	
	D	Maximum thrust	$V_{hub}=2,5$ V_{ave}	U	Rotor spinning but could be furling or fluttering
Power production plus occurrence of fault	E	Maximum rotational speed		U	
	F	Short at load connection	$V_{hub}=V_{design}$	U	Maximum short-circuit generator torque
Shutdown	G	Shutdown (Braking)	$V_{hub}=V_{design}$	U	
Extreme wind Loading	H	Extreme wind loading	$V_{hub}=V_{e50}$	U	The turbine may be parked (idling or standstill) or governing. No manual intervention has occurred.
Parked and fault conditions	I	Parked wind loading, maximum exposure	$V_{hub}=V_{ref}$	U	Turbine is loaded with most unfavourable exposure
Transport, assembly, maintenance and repair	J	To be stated by manufacturer		U	

Key

F analysis of fatigue loads

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Clause	Requirement - Test	Result - Remark	Verdict
U analysis of ultimate loads			
	Other design load cases relevant for safety shall be considered, if required by the specific SWT design.		
7.4.2	Load case A: normal operation		
	The design load for “normal operation” is a fatigue load. The load case assumes constant range fatigue loading for the blade and shaft, these ranges are given below. The ranges are to be considered in the fatigue assessment as peak-to-peak values. The mean values of the load ranges can be ignored. NOTE See Clause F.3. The fatigue loading on the blade would be considered to occur at the airfoil – root junction or at the root – hub junction, whichever is determined to have the lowest ultimate strength. The calculated stresses are the combination of the centrifugal loading (FzB) and the bending moments (MxB and MyB) Shaft loads: where er = 0,005R, unless through design documents it can be proven that a lower value is reasonable. The fatigue load on the rotor shaft shall be considered at the rotor shaft at the first bearing (nearest to the rotor). The range of the stress shall be calculated from the combination of the thrust loading (Fx-shaft), the torsion moment (Mx-shaft) and the bending moment (Mshaft).		P
7.4.3	Load case B: yawing		
	For this load case, the ultimate loads (gyroscopic forces and moments) shall be calculated assuming the maximum yaw speed yaw,max occurring with ndesign. For a passive yaw system, the maximum yaw rate is given by the following equation: For all turbines with a swept rotor area of less than 2 m2, the maximum yaw rate shall be 3 rad/s. For an active yaw system the maximum yaw rate shall be determined by measurement in calm winds. If the maximum yaw rate is expected to occur under special conditions such as emergency yawing at higher rate, the active yaw rate shall be measured under those conditions. The loads due to the bending moment MyB on the blade and the shaft bending moment Mshaft shall be calculated using the following equations: where ΔFx-shaft is given by Equation (24). For the shaft, the loads are dependent on the number of blades. For a two bladed rotor: For a three or more bladed rotor:		P

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Clause	Requirement - Test	Result - Remark	Verdict
7.4.4	Load case C: yaw error		
	All turbines operate with a certain yaw error. In this load case a yaw error of 30° is assumed. The flapwise bending moment caused by the yaw error is given by Equation (31) If no data is available on the maximum lift coefficient, Cl,max, a value of 2,0 shall be used.		P
7.4.5	Load case D: maximum thrust		
	The SWT can be exposed to high thrust loads on the rotor. The thrust load acts parallel to the rotor shaft and has a maximum value given by: where CT is the thrust coefficient, equal to 0,5. However, caution should be exercised with Wind generators that operate at high rotational speeds at 2,5 Vave, where a CT of 8/9 may be more appropriate.		P
7.4.6	Load case E: maximum rotational speed		
	The centrifugal load in the blade root szB and the shaft bending moment Mshaft due to centrifugal load and rotor unbalance shall be calculated from equations below. The maximum possible rotor speed n,max = (/30) nmax shall be derived by measurements as described in 13.2.4.		P
7.4.7	Load case F: short at load connection		
	In the case of a direct electrical short at the output of the SWT or internal short in the generator, a high moment is created about the rotor shaft due to the short circuit torque of the alternator. In the absence of any proven more accurate values, two times the Qdesign is to be taken as the short circuit torque acting on the generator shaft. In the absence of any proven more accurate values, G shall be 2,0.		P
7.4.8	Load case G: shutdown (braking)		
	In the case of Wind generators with a mechanical or electrical braking system in the drive train, the braking moment can be greater than the maximum driving moment. In these cases, the braking moment Mbrake, derived from testing or calculations, shall be used in the design calculations of the SWT. The maximum shaft torque is assumed to be equal to the brake plus the design torque (thus assuming that the brake is applied while the generator still delivers design torque). The brake torque shall be multiplied by the gearbox ratio to yield Mbrake if the brake is on the high speed shaft. The blade load during shutdown is assumed to be determined by the shaft torque and blade mass. Thus being:		P

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	where Mx-shaft is the shaft torque as calculated in Equation (36). In case the turbine has a gearbox and a high-speed shaft brake, the shaft torque calculated in Equation (36) should be increased to account for drive train dynamics. In the absence of any proven more accurate values the shaft torque shall be multiplied by a factor of two.		
7.4.9	Load case H: extreme wind loading		
	In this load case, the Wind generator is functioning as per the design intent during extreme wind speeds. The loads on the exposed parts of the SWT shall be calculated assuming wind speed of Ve50 found in 6.3.3.2. NOTE See Clause F.3. If the spinning rotor is controlled to a very low speed then the higher thrust given by Equation (40) shall be used instead of the lower thrust given by Equation (41). For turbines which will be parked, the out of plane blade root bending moment is dominated by drag and thus defined as: Cd is the drag coefficient and shall be taken as 1,5; and Aproj,B is the planform area of the blade. For turbines that have their rotor spinning at Ve50, it is expected that, at some location on the rotor Cl,max will occur on one of the blades due to variations in wind direction. Thus the blade root bending moment is: M yB Cl,max 16 If no data is available on Cl,max a value of 2,0 shall be used. For the thrust load: For a parked rotor the shaft thrust load is calculated as given by Equation (40). here e50 is the tip speed ratio at Ve50, which if not known can be estimated by: The maximum tower bending moment shall be calculated using the thrust force calculated with either Equation (40) or (41) (depending on the turbine design). The drag or lift force on the tower and nacelle need to be taken into account as well. Equation (43) shall be used to calculate those forces. For free standing towers the maximum bending moment will occur at the tower base. For guyed towers the maximum bending moment will occur at the upper guy wire attachment. The load for each component is given by: where Cf is the force coefficient (see Table 3); and Aproj is the component area projected on to a plane perpendicular to the wind direction. From the loads on the individual components the blade,		P

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	shaft and tower loads need to be calculated.		
7.4.10	Load case I: parked wind loading, maximum exposure		
	In the case of a failure in the yaw mechanism, the SWT can be exposed to the wind from all directions. Thus, for design purposes, the forces on the SWT blades, nacelle, tower, and tail (if applicable) shall be calculated for all possible exposures including winds from the front, side or rear of the rotor. The load on each component is given by: where Cf is the force coefficient, which may result from lift or drag; and Aproj is the component area (in its most unfavourable position) that is appropriate for the force coefficient. For blunt (or bluff) bodies (e.g. nacelle covers and tower sections) the area shall be the projected area on a plane perpendicular to the wind direction. For airfoil shapes the area shall be the planform area.		P
	Table 3 – Force coefficients (Cf)		

For all cross sections wind direction is from left to right ⇉	○	⯃	□	⇉▯	⇉◊	⇉◠
Characteristic length[a] < 0,1 m	1,3	1,3	1,5	1,5	1,5	2,0
Characteristic length [a] > 0,1 m	0,7	1,2	1,5	1,5	1,5	2,0

[a] Characteristic length is the top to bottom dimension (perpendicular to the flow) as illustrated here except in the case of the oblique aerofoil for which an aerofoil data book should be consulted.

7.4.11	Load case J: transportation, assembly, maintenance and repair		
	The manufacturer shall consider loads on the turbine system caused by the transportation, assembly, installation, and maintenance and repair of the system. Examples of such loads are: • gravity loads on turbine during transportation in other than upright position; • loads caused by special installation tools; • wind loads during installation or maintenance; • loads introduced by hoisting the turbine onto the foundation; • loads on a tilt up tower during erection; and • load on a support structure from climbing it. As an example the equation to calculate loads during tower tilt up are given below. where Mtower is the bending moment of the tower at the lifting point attachment [Nm];		P

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	mtower top is the mass of the nacelle and rotor combined [kg]; moverhang is the mass of the tower between the lifting point and the tower top [kg]; and Llt is the distance between the lifting point and the top of the tower [m]. Equation (45) is based on the following assumptions: • dynamic amplification factor is 2; • centre of gravity of turbine is along the rotor axis; and • the rotor is parked; and • maximum bending moment occurs when tower is horizontal.		
7.5	Simulation modelling		
7.5.1	General		
	In case the design loads are determined by simulation (aero-elastic) modelling the load cases in this subclause 7.5 shall be considered. A minimum set of design load cases (DLC) is given in Table 4. In Table 4 the design load cases are specified for each design situation by the description of the wind, electrical and other external conditions. In load cases evaluated where a wind speed range is given, the load case shall be evaluated over the entire wind speed range to ensure the worst load is identified. Other design load cases relevant for safety shall be considered, if required by the specific Wind generator design. For each design situation, the appropriate type of analysis is stated by "F" and "U" in Table 4. F refers to analysis of fatigue loads, to be used in the assessment of fatigue strength. U refers to the analysis of ultimate loads such as analysis of exceeding the maximum material strength, analysis of tip deflection, and stability analysis.		P

Table 4 – Minimum set of design load cases (DLC) for simulation by aero-elastic models

Design situation	DLC	Wind condition	Other conditions	Type of analysis
1) Power production	1.1	NTM $V_{in} < V_{hub} < V_{out}$ or $3\times V_{ave}$		F, U
	1.2	ECD $V_{hub} < V_{design}$		U
	1.3	EOG_{50} $V_{in} < V_{hub} < V_{out}$ or $3\times V_{ave}$		U
	1.4	EDC_{50} $V_{in} < V_{hub} < V_{out}$ or $3\times V_{ave}$		U
	1.5	ECG $V_{hub} = V_{design}$		U
2) Power production plus occurrence of fault	2.1	NWP $V_{hub} = V_{design}$ or V_{out} or $2,5\times V_{ave}$	Control system fault	U
	2.2	NTM $V_{in} < V_{hub} <$	Control or protection	F, U

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Clause	Requirement - Test			Result - Remark	Verdict
			V_{out}	system fault	
		2.3	EOG$_1$ $V_{in}<V_{out}$ or $2,5\times V_{ave}$	Loss of electrical connection	U
	3) Normal shutdown	3.1	NTM $V_{in} < V_{hub} < V_{out}$		F
		3.2	EOG$_1$ $V_{hub} = V_{out}$ or $V_{max,shutdown}$		U
	4) Emergency or manual shutdown	4.1	NTM To be stated by the manufacturer		U
	5) Extreme wind loading (standing still or idling; or spinning)	5.1	EWM $V_{hub} = V_{e50}$	Possible loss of electrical power network	U
		5.2	NTM $V_{hub} < 0,7\ V_{ref}$		F
	6) Parked and fault condition	6.1	EWM $V_{hub} = V_{e1}$		U
	7) Transport, assembly, maintenance and repair	7.1	To be stated by the manufacturer		U
	Key F analysis of fatigue loads U analysis of ultimate loads				
7.5.2	Power production (DLC 1.1 to 1.5)				
	In these load cases, a Wind generator is running and connected to the electric load. The assumed Wind generator configuration shall take into account rotor imbalance. The maximum mass and aerodynamic imbalances (e.g. blade pitch and twist deviations) specified for manufacturing the rotor shall be used in the design calculations. In addition, deviations from theoretical optimum operating situations such as yaw misalignment and control system tracking errors shall be taken into account in the analyses of operational loads. The worst combination of conditions shall be assumed in the calculation, e.g. direction change with characteristic yaw misalignment in DLC 1.4. Design load case 1.1 embodies the requirements for loads resulting from atmospheric turbulence. DLC 1.2 to 1.5 specify transient cases, which have been selected as potentially critical events in the life of a wind turbine.				P
7.5.3	Power production plus occurrence of fault (DLC 2.1 to 2.3)				
	Any fault in the control or protection systems, or internal fault in the electrical system significant for Wind generator loading (such as generator short circuit) shall be assumed to occur during power production. For DLC 2.1 the occurrence of a fault in the control system which is considered a normal event shall be analysed. The occurrence of faults in the protection or internal electrical systems, which do not cause an immediate shutdown and thus can lead to significant fatigue damage, shall be evaluated in DLC 2.2.				P

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Clause	Requirement - Test	Result - Remark	Verdict
	In DLC 2.3 the one-year extreme operating gust needs to be combined with a loss of electrical connection. For passively controlled turbines examples of control system faults are: • faulted furl system (e.g. locked tail) (if the furling system is not demonstrated to be safe life); and • faulted blade pitch system (if the blade pitch system is not demonstrated to be safe life). Evaluate the fatigue case for any single fault of the turbine system for a minimum of 24 h/year.		
7.5.4	Normal shutdown (DLC 3.1 and 3.2)		
	This load case includes all the events resulting in loads on a Wind generator during normal transient situations from a power production situation to a stand-still or idling condition. The number of occurrences shall be estimated based on the control system behaviour. For passively controlled turbines there might not be an automatic shutdown, in those cases the fatigue load case can be ignored. For DLC 3.2, the maximum wind speed is Vout or Vmax,shutdown.		P
7.5.5	Emergency or manual shutdown (DLC 4.1)		
	Loads arising from emergency or manual shutdown shall be considered. The wind speed limitations for the procedures shall be prescribed by the manufacturer in the operations manual. Instead of using Vout the wind speed value specified by the manufacturer shall be used.		P
7.5.6	Extreme wind loading (stand-still or idling or spinning) (DLC 5.1 to 5.2)		
	The rotor of a parked Wind generator, which may be either in a stand-still or idling condition, shall be considered with the extreme wind speed condition. Alternatively this shall be considered for turbines which will have their rotors spinning, like most passively controlled turbines (such as furling). Those conditions shall be either turbulent or quasi-steady with correction for gusts and dynamic response. If significant fatigue damage can occur to some components (e.g. from weight of idling blades), the expected number of hours of non-power production time at each appropriate wind speed shall also be considered. The effects of the loss of the electrical power network or other electrical load (e.g. battery, or dump loads such as resistance heaters or water pumps) on a parked Wind generator shall be taken into account.		P
7.5.7	Parked plus fault conditions (DLC 6.1)		
	Deviations from the normal behaviour of a parked Wind generator, resulting from faults on the electrical network or in the Wind generator, shall require analysis. If any		P

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	fault other than a loss of electrical power network produces deviations from the normal behaviour of the Wind generator in parked situations, the possible consequences shall be the subject of analysis. In DLC 6.1, the fault condition shall be combined with the extreme wind speed model (EWM) with a recurrence period of one year. Those conditions shall be either turbulent or quasi-steady with correction for gusts and dynamic response.		
7.5.8	Transportation, assembly, maintenance and repair (DLC 7.1)		
	The manufacturer shall consider loads on the turbine system caused by the transportation, assembly, installation, and maintenance and repair of the system. Examples of such loads are: • gravity loads on turbine during transportation in other than upright position; • loads caused by special installation tools; • wind loads during installation; • loads introduced by hoisting the turbine onto the foundation; • loads on a tilt up tower during erection; and • loads on a support structure from climbing it.		P
7.5.9	Load calculations		
	Loads as described in 7.3 shall be taken into account for each design load case. Where relevant, the following shall also be taken into account: • wind field perturbations due to the Wind generator itself (wake-induced velocities, tower shadow etc.); • the influence of three dimensional flow on the blade aerodynamic characteristics (e.g., three dimensional stall and aerodynamic tip loss); • unsteady aerodynamic effects; • structural dynamics and the coupling of vibration modes; • aero-elastic effects; and • the behaviour of the control and protection system of the wind turbine.		P
7.6	Load measurements		
	In case the design loads are derived from load measurements, these load measurements should be taken under conditions as close as possible to the load cases described under 7.5. Extrapolation of measured loads shall occur in compliance with IEC/TS 61400-13. Further requirements on load measurements can be found in 13.3 and IEC/TS 61400-13.		P

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Clause	Requirement - Test	Result - Remark	Verdict
	For any of the load cases in 7.4 or 7.5, load measurements can be used instead of calculations as long as the measurements were taken under similar conditions as the load case specifies.		
7.7	Stress calculation		
	Stresses shall be calculated on all important load carrying components. The stresses calculated from the individual forces and moments within a load case have to be combined to find equivalent stresses. The resulting equivalent stresses have to be compared with the design values for material stresses. In the calculation of stresses, account shall be taken of: • stress variations; • stress concentrations; • magnitude and direction of the resulting loads; • component dimensions and material thickness variations; • component surface roughness, surface treatment; • type of loading (bending, tensile, torsion, etc.); and • welding, casting, machining, end grain construction, etc. Table 5 gives guidance for the calculation of equivalent stresses from the unidirectional values.		P

Table 5 – Equivalent stresses

	Circular blade root	Rectangular blade root	Rotor shaft
Axial load	$\sigma_{zB} = \frac{F_{zB}}{A_B}$	$\sigma_{zB} = \frac{F_{zB}}{A_B}$	$\sigma_{x\text{-shaft}} = \frac{F_{x\text{-shaft}}}{A_{shaft}}$
Bending	$\sigma_{MB} = \frac{\sqrt{M_{xB}^2 + M_{yB}^2}}{W_B}$	$\sigma_{MB} = \frac{M_{xB}}{W_{xB}} + \frac{M_{yB}}{W_{yB}}$	$\sigma_{M\text{-shaft}} = \frac{M}{W_{shaft}}$
Shear	Negligible	Negligible	$\tau_{x\text{-shaft}} = \frac{M}{2W_{shaft}}$
Combined (axial + bending)	$\sigma_{eqB} = \sigma_{zB} + \sigma_{MB}$		$\sigma_{eq} = \sqrt{(\sigma_{x\text{-shaft}} + \sigma_{M\text{-shaft}})^2 + 3\tau^2_{M\text{-shaft}}}$

7.8	Safety factors		
7.8.1	Material factors and requirements		
	The material factors given in this subclause 7.8.1 shall be applied to material properties estimated with a 95 % probability with 95 % confidence limits. If the material properties are derived for other survival probabilities the safety factor for materials shall be adjusted (see Annex		P

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	E). For strengths, these can be on either a stress or a strain basis. The following factors shall be considered when determining the material properties: a) materials and material configurations representative of the full-scale structure; b) manufacturing method of the test samples that are typical of the full scale structure; c) static, fatigue, and spectrum loading testing (including rate effects); d) environmental effects (e.g. UV degradation, humidity, temperature, corrosion etc.); and, e) geometry effects as they affect material properties (e.g. material orientation for injection moulded blades, ply drops in composites and wood, material orientation from forging of metals, etc.). Table 6 lists the partial safety factors for materials that shall be used for fatigue and ultimate strength analysis. When the five factors above have been adequately considered the minimum partial safety factors for materials may be used. This situation is termed “full characterisation” and may include those cases where recognised material codes are available (e.g. ISO). If material properties are based solely upon coupon testing and do not consider the above factors, the maximum material factor shall be used. This situation is termed “minimal characterisation”. In reference to item d) above: • The environmental effects on the load carrying structure of fibre reinforced plastic materials (e.g. material degradation/aging of due to UV radiation, humidity, embrittlement, etc.) of structural components shall be considered by an additional material factor of 1,35 on static strength analysis only. This factor can be reduced if representative tests show lower degradation effects. Fibre reinforced plastic materials include all fibre-reinforced (e.g. by glass or carbon) plastic materials (e.g. epoxy, polyester, vinylester). • The strength reduction (both for ultimate and fatigue strength) of fibre reinforced plastics due to material temperatures higher than controlled room temperature (see 6.5) shall be considered by a material factor of 1,1. This factor can be set to 1,0 if the coupon tests are executed at the highest (extreme) temperature the Wind generator is designed for, i.e. 50 °C unless a higher figure is stated in the design conditions. • The environmental effect of corrosion shall be excluded by adequate means of corrosion protection over the lifetime of the wind turbine. Annex F provides guidelines for determining the appropriate factors depending upon the amount and type		

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	of material testing that has been completed.		

Table 6 – Partial safety factors for materials

Material characterisation	Fatigue strength, γ_m	Ultimate strength, γ_m
Full characterisation	1,25[a]	1,1
Minimal characterisation	10,0[b]	3,0

[a] Factor is applied to the measured fatigue strength of the material. [b] Factor is applied to the measured ultimate strength of the material.

7.8.2	Partial safety factor for loads		
	The partial safety factor accounts for the uncertainty in the load estimation process and thus is different for each load determination method. Table 7 gives the load factors to be used for each method. A simulation model has been verified with limited full-scale measurements; therefore the partial safety factor for loads is lowest for this load determination method. Lower safety factors for ultimate loads may be applied for well-known loads, such as gravity loads.		P

Table 7 – Partial safety factors for loads

Load determination method (see 5.2)	Fatigue loads, γ_f	Ultimate loads, γ_f
1. Simplified equations	1,0	3,0
2. Simulation model	1,0	1,35
3. Full scale load measurement	1,0	3,0

7.9	Limit state analysis		
7.9.1	Ultimate strength analysis		P
7.9.2	Fatigue failure		
	The fatigue damage from all fatigue load cases shall be combined. The fatigue damage shall be estimated using an appropriate fatigue damage calculation. For example, in the case of Miner's rule, the limit state is reached when the accumulated damage exceeds 1. So the accumulated damage within the lifetime of a turbine shall be less than or equal to 1: ni is the counted number of fatigue cycles in bin i of the characteristic load spectrum, including all relevant load cases; si is the stress (or strain) level associated with the counted cycles in bin i, including the effects of both mean and cyclic range; N(.) is the number of cycles to failure as a function of the stress (or strain) indicated by the argument (i.e. the characteristic S-N curve); and γ f, γm are the appropriate safety factor for loads and materials respectively. The influence of the mean stress shall be considered if it is not already addressed by the analysis method. In case the simplified load model (7.4) is used, the		P

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	ranges of load case A normal operation (7.4.2) shall be applied for the number of fatigue cycles given in Equation (48). where Td is the design life of the turbine in seconds. If no S-N curve is available, Equation (46) shall be used with the ultimate strength as the characteristic material strength and the fatigue loads to calculate the design stress. The partial safety factor for fatigue and minimal characterisation from Table 6 (γm=10,0) shall then be used.		
7.9.3	Critical deflection analysis		
	It shall be verified that no deflections affecting the Wind generator's safety occur in the design load cases. One of the most important considerations is to verify that no mechanical interference between the blade and tower can occur. No part of the blade shall hit the tower under any of the design load cases. The maximum predicted tip deflection multiplied by the appropriate partial load factor shall not exceed the no-load clearance between the blade and the tower. The tip deflection analysis shall be based on the most severe bending moment distribution assumed for any of the design load cases. In the case of design loads determined by the simplified load model (7.4), the corresponding distribution of load along the blade span can be obtained by consideration of the equations provided in Annex F. Partial load safety factors shall be applied. NOTE For example, if the design loads are based on load case H and the rotor is parked, then Equation (F.34) implies that the out of plane drag loads will vary in proportion to the blade chord. If the design loads are based on load case H and the rotor is spinning for this load case, then Equation (F.35) assumes a linear load distribution that is a maximum at the blade tip and zero at the blade root.		P
8	Protection and shutdown system		
8.1	General		
	The SWT shall be designed in order to keep all parameters within their design limits under all design load cases. This shall be achieved through an active and/or passive protection system included in the design. In particular, there shall be means to prevent the rotational speed design limit nmax from being exceeded. A safe system or procedure shall be provided that is capable of bringing the turbine to a parked condition in all normal external conditions (i.e. those external conditions which are encountered with less than one-year		P

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	recurrence period) for the design SWT class, unless the system can be shown to be safer in another condition.		
8.2	Functional requirements of the protection system		
	The protection system shall be designed to be fail-safe. It shall be able to protect the SWT from any single failure or fault in a power source, or in any non-safe-life component within the control and protection system. Testing and/or analysis (such as FMEA/FMECA) shall verify the fail-safe behaviour of the system. A failure of the control, power, or protection system shall not allow the turbine to either exceed the nmax rotational speed or go into an unsafe state of operation. The protection system shall be capable of satisfactory operation at all times, irrespective of whether the turbine is under manual or automatic control. Measures shall be taken to prevent the accidental or unauthorized adjustment of the protection system. The service life of safe life components in the protection system shall be well beyond the design lifetime of the Wind generator system, or if they are maintainable components the specified maintenance interval of the component shall not be exceeded. The probability of catastrophic failure of a safe life component in the protection system shall be extremely small during its safe life.		P
8.3	Manual shutdown		
	There shall be a manual shutdown button/switch/lever/etc. and shutdown procedures. The manual shutdown button/switch/lever/etc. shall override the automatic control system and result in a parked turbine for all normal external conditions. After shutdown the turbine shall remain parked until manually returned to operation. NOTE In accordance with Clause 1 “Any of the requirements of this standard may be altered if it can be suitably demonstrated that the safety of the turbine system is not compromised”. The button/switch/lever/etc. shall be accessible by authorised personnel at floor or ground level. This shall be achievable by an ordinary user, within a reasonable time period.		P
8.4	Shutdown for maintenance		
	The manufacturer shall provide a safe method for shutdown of the SWT before performing inspections, service or maintenance. The method shall include specification of the maximum wind and other conditions under which the procedure may be carried out which is termed Vmaint. This Vmaint shall not be less than 10 m/s or 1,4 Vave whichever is the greater.		P

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	The rotor and yaw motion shall be brought to a standstill prior to performing maintenance. Any other mechanical motions (such as tails or pitch mechanisms) shall also be brought to a standstill or be demonstrated to be safe prior to performing maintenance. Provision shall be made for safe return to service. For Wind generators of less than 40 m2 the manufacturer shall provide safe procedures for bringing the turbine to a standstill below Vmaint. The lowering of a small Wind generator of less than 40 m2 on a tilt-up tower is an acceptable procedure to bring the turbine to a standstill. For Wind generators of greater than or equal to 40 m2 the manufacturer shall provide safe means for bringing the turbine to a standstill below Vmaint with a procedure for the use of the means (e.g. a procedure for the safe insertion of a locking device). The lowering of a small Wind generator of greater than or equal to 40 m2 shall not form any part of an acceptable procedure to bring the turbine to a standstill. Maintenance for small Wind generators on tilt-up towers may be performed on the ground. If the maintenance is performed on top of the upright tower, then there shall be a means to prevent rotor and yaw movement and other mechanical motions (such as tails or pitch mechanisms) before the maintenance is performed.		
9	Electrical system		
9.1	General		
	The electrical system of a SWT, and every electrical component used in it such as controllers, generators and the like, shall comply with the applicable portions of Clauses 4 through 15 of IEC 60204-1:2005 and all relevant product standards. When a SWT is connected to an electrical equipment power network, 9.7.3 shall be applied. Every electrical component shall be able to withstand all the design environmental conditions (6.4), as well as the mechanical, chemical and thermal stresses to which the component may be subjected to during operation. Every electrical component selected on the basis of its power characteristics shall be suitable for the duty demanded of the equipment, taking into account design load cases including fault conditions. However, if an electrical component, by design, does not have the properties corresponding to its end use, it may be used on the condition that adequate additional protection is provided as part of the complete electrical system of the SWT.		P
9.2	Protective devices		
	A SWT electrical system shall include suitable devices		P

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	that ensure protection against malfunctioning of both the SWT and the external electrical system, which may lead to an unsafe condition or state. This shall be done in accordance with 7.1 to 7.5 and 7.8 of IEC 60204-1:2005. (Examples of such devices are fuses for over-current protection, thermistors for temperature, etc.). Generally the SWT shall be protected against over voltages (e.g. atmospheric or switching) by surge protective devices (SPD). In case of limited space within a SWT such equipment may be installed in separate cabinets outside of the SWT. The cabinets shall be suitable for the environmental conditions.		
9.3	Disconnect device		
	It shall be possible to disconnect a SWT electrical system from all electrical sources of energy as required for maintenance or testing. This shall be done in accordance with Subclauses 5.3.2 and 5.3.3 of IEC 60204-1:2005. Where lighting or other electrical systems are necessary for safety during maintenance, auxiliary circuits shall be provided with their own disconnect devices, such that these circuits may remain energised while all other circuits are de-energised.		P
9.4	Earthing (grounding) systems		
	The design of a SWT shall include a local earthing (grounding) electrode system to meet the requirements of IEC 60364-5-54. The installation, arrangement, and choice of earthing equipment (earth electrodes, conductors, bars, and main terminals) shall match the application of the SWT for lightning protection. The range of soil conditions for which the earth electrode system is designed shall be stated in the installation documentation. For other soil conditions, there shall be recommendations in the installation documentation as to how they shall be managed.		P
9.5	Lightning protection		
	Guidance for lightning protection of a SWT can be found in document IEC 61400-24. It is not typically necessary for protective measures to extend to the blades and other aerodynamic devices. All turbine protection system circuits that could possibly be affected by lightning and other transient overvoltage conditions shall be protected according to IEC 61643-11. All surge protection devices used on SWTs shall be in compliance with the IEC 61643-11.		P
9.6	Electrical conductors and cables		
	The conductors of a SWT shall be rated for the particular application with respect to the temperature, voltage, current, environmental conditions and exposure to degraders (oil, UV exposure) in accordance with Clause 13 IEC 60204-1:2005.		P

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	Mechanical stresses, including those arising from twisting, to which the conductors may be subjected to during installation and operation, shall be considered. Conductors shall be installed in accordance with Clause 14 of IEC 60204-1:2005. Where there is a probability of rodents or other animals damaging cables, armoured cables or conduits shall be used. Underground cables shall be buried at a suitable depth so that they are not damaged by service vehicles or farm equipment. The limits of the protection shall be designed so that any over-voltage transferred to the electrical component will not exceed the limits established by the component insulation levels.		
9.7	Electrical loads		
9.7.1	General		
	The electrical loads covered in 9.7.2 through 9.7.5 are suitable loads for SWT systems.		P
9.7.2	Battery charging		
	A SWT intended to be used as a battery charging device shall be designed to charge the battery at the current and voltage appropriate for the type recommended in the operation manual. Other considerations are: • battery temperature; • battery expansion; and • conductor size and rating of insulation. The charging circuit shall be capable of withstanding the maximum voltage during a loss of load or when the batteries are fully charged and the voltage is transferred to another use.		P
9.7.3	Electrical power network (grid connected systems)		
9.7.3.1	General		
	A SWT, intended to be connected to the electrical power network, shall comply with the requirements in 9.7.3.2 through 9.7.3.3 and relevant interconnect standards.		P
9.7.3.2	Self-excitation – loss of grid connection		
	Any electrical system that by itself can self-excite the SWT shall be automatically disconnected from the network and remain safely disconnected in the event of loss of network power. If a capacitor bank is connected in parallel with a network-connected SWT (i.e. for power factor correction), a suitable switch is required to disconnect the capacitor bank whenever there is a loss of network power, to avoid self-excitation of the SWT electric generator. Alternatively, if capacitors are fitted, it shall be sufficient to show that the capacitors cannot cause self-		P

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	excitation. Provisions shall be made in order to bleed the capacitors in the event that the capacitor bank cannot be disconnected.		
9.7.3.3	Power conditioning equipment, EMC, harmonics and electrical flicker, and reactive power		
	The electromagnetic compatibility (EMC) of small Wind generator systems is discussed in Annex H. The power conditioning component, such as inverters, power electronic controllers, and static VAR compensators, shall be designed such that harmonic line currents and voltage waveform distortion do not interfere with electrical network protective relaying. Specifically, for network- connected SWT the current harmonics generated by the SWT shall be such that the overall voltage waveform distortion at the network connecting point will not exceed the acceptable upper limit for the electrical network. Any reactive power correction capacity shall similarly not interfere with electrical network protective relaying.		P
9.7.4	Direct connect to electric motors (e.g. water pumping)		
	SWTs that are directly connected to motors can vary in voltage, current and frequency. It shall be demonstrated to operate safely over the whole operating range.		P
9.7.5	Direct resistive load (e.g. heating)		
	SWTs that are directly connected to resistive loads can vary in voltage, current and frequency. It shall be demonstrated to operate safely over the whole operating range. The documentation for a SWT intended for connection to a resistive load, such as a heater, shall specify conductors that are suitable for the current, voltage and temperatures involved.		P
9.8	Local requirements		
	Local electrical codes differ around the world, often because of the different technical details of the local electrical distribution and/or transmission systems. In particular earthing and lightning protective system practices can be incompatible and/or in conflict. It is recommended that documentation of the SWT should be sufficient to provide guidance in such situations.		P
10	Support structure		
10.1	General		
	The support structure is a critical component for the SWT. The support structure carries the loads from the turbine. If the rotor swept area is greater than 2 m2 then the support structure shall be included as part of the SWT system and designed as described in Clause 7.		P

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	It is recommended that any Wind generator and tower that cannot be safely lowered to the ground for maintenance should have a fall arresting system for ascending, descending, and working at the top of the tower.		
10.2	Dynamic requirements		
	An evaluation of the Wind generator system dynamics shall be conducted. By experimentation and/or analysis it shall be shown to be generally free of damaging dynamic or resonant conditions that can affect the structure and/or cause loss of control functions. For further information see Annex I.		P
10.3	Environmental factors		
	The SWT support structure should be able to withstand all the external conditions listed in Clause 6. Particular consideration should be given to installation, operation and maintenance of the SWT under extreme environmental conditions. The manufacturer shall identify the design environmental conditions for the SWT in the installation and operation manuals and design documentation.		P
10.4	Earthing		
	The SWT support structure (including guy wires) shall be appropriately earthed to reduce damage from lightning (see 9.4 and 9.5).		P
10.5	Foundation		
	For turbines with a rotor swept area greater than 2 m2, the manufacturer shall specify the foundation requirements including layout of the foundation, location of guy wires with minimum and maximum guy location recommendations, and guy wire installation requirements as applicable. For turbines with a rotor swept area greater than 2 m2 the manufacturer shall design a sample foundation system for normal soil conditions and design loads. For turbines with a swept area of less than or equal to 2 m2 refer to 11.2.3.2.		P
10.6	Turbine access design loads		
	Consideration shall be given for the design loads arising from normal turbine maintenance including climbing, raising and lowering the tower. These loads shall be consistent with the turbine access procedures specified in the appropriate manuals (for the loads refer to 7.4.11 and/or 7.5.8).		P
11	Documentation requirements		
11.1	General		
	Clause 11 provides requirements for SWT product		P

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	manuals and other product literature.		
11.2	Product manuals		
11.2.1	General		
	The product manuals shall provide a clear description of assembly, installation, operation and erection requirements for the SWT equipment, including the technical specification of the Wind generator. The documentation shall also provide specific information for the maintenance requirements of the SWT. The information shall be provided in one or more manuals for the installer, owner and service personnel. All documentation shall inform the user that the contents are important safety instructions and they should be saved. The documentation shall reference the turbine model, serial and revision number. The documentation shall be available to the user and be written in a language that they can read and understand.		P
11.2.2	Specification		
	The following information shall be provided by the manufacturer: a) manufacturer; b) model; c) general description of main components; d) reference power (W or kW) to be provided only following the completion of tests; e) reference annual energy (kWh/yr); f) rotor diameter (m) (if applicable); g) swept area (m2); h) number of blades; i) upwind or downwind rotor (if applicable); j) VAWT or HAWT or other; k) tower top weight (kg); l) description of protection and shutdown system; m) description of yaw mechanism; n) direction of rotation; o) rotor speed and/or tip speed range (r/min and/or m/s) to be provided only following the completion of tests; p) cut-in wind speed (m/s) to be provided only following the completion of tests; q) cut-out wind speed (m/s); r) extreme wind speed (3-s gust with 50-year recurrence period, m/s); s) SWT class (as designed, and if available as tested) (if it is an S class a precise explanation of the design parameters is required);		P

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	t) power form; u) maximum output power (per definitions, giving the P60 as a minimum); v) maximum output voltage (per definitions, giving the U0,2 as a minimum); w) maximum output current(s) (per definitions, giving the i60 as a minimum); x) declared sound power level at a wind speed of 8 m/s (dB(A)) to be provided only following the completion of tests; y) operating temperature range (°C); z) available support structures; aa) design life (years).		
11.2.3	Installation		
11.2.3.1	General		
	The manufacturer of SWTs shall provide drawings, procedures, specifications, instructions and packing lists for assembly, installation, operation and erection of the SWT. The documentation shall contain details of all loads, weights, lifting tools and procedures necessary for the safe handling and installation of the SWT. If the manufacturer requires that the SWT be installed by trained personnel, a statement to this effect shall appear on the cover of the installation manual: “TO BE INSTALLED BY TRAINED PERSONNEL ONLY”. Requirements for cranes, hoists and lifting equipment, including all slings, hooks and other apparatus required for safe lifting shall be included. Specific lifting points shall be clearly marked in the manual and on the component. Reference shall be made to all special tools, jigs and fixtures and other apparatus required for safe installation. Requirements for pre-service conditioning and proper lubrication of all components shall be clearly stated in the documentation. An electrical interconnection wiring diagram with international markings for electrical machine terminals shall be included in this clause of the manual with sufficient information to select appropriate conductor sizes if wire is to be supplied by the owner/installer. A system wiring diagram shall be provided in either the installation or service portion of the manual(s).		P
11.2.3.2	Support structure		
	For turbines with a swept area of less than or equal to 2 m2 the manufacturer shall supply all information needed by the user to select a suitable support structure for safe turbine operation. This shall include but is not limited to: • details on the mechanical turbine/tower connection;		P

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	• details on the electrical turbine/tower connection; • minimum blade/tower clearance; • maximum allowable tower top deflection; and • maximum tower top loads (stating whether a safety factor has been included, and its magnitude); • a sample support structure design. For turbines with a swept area of more than 2 m2, it is recommended that the above information be supplied. For these turbines the information required by 10.5 shall be provided including drawings of a sample foundation stating assumed soil conditions, operating loads, and access loads.		
11.2.4	Operation		
	The operation document shall include specific procedures for starting the SWT and stopping it in normal external conditions. The manual shall include all appropriate controller settings such as emergency shutdown control set points. The operation document shall also cover a description of the overall system for normal operation and intended applications. The manufacturer shall provide a written manual shutdown procedure including a specification of a wind speed limit and other conditions in which the procedure may safely be carried out. Contact information shall be provided for unscheduled maintenance/customer support.		P
11.2.5	Maintenance and routine inspection		
11.2.5.1	General		
	The manufacturer shall provide documentation for inspection and maintenance of the SWT. This documentation shall provide a clear description of inspection, shutdown procedure, and routine maintenance requirements for the SWT equipment. This documentation shall clearly state and explain Vmaint per 8.4. If the manufacturer requires that the SWT be maintained and serviced by trained personnel, a statement to this effect shall appear on the cover of the maintenance and service manual: “MAINTENANCE AND REPAIRS TO BE PERFORMED BY TRAINED PERSONNEL ONLY”.		P
11.2.5.2	Safety procedures		
	The maintenance document shall include specific shutdown procedures, including but not necessarily limited to instructions of how to: • disengage the load and/or energy sources (see 9.3);		P

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	• stop and secure the rotor; • stop and secure the yaw mechanism; • stop and secure the furling system if appropriate. If the SWT is connected to the utility grid, then a procedure to disconnect the turbine from the utility grid shall be provided. The manufacturer shall provide safety recommendations for climbing towers, including proper climbing equipment and procedures, as applicable.		
11.2.5.3	Routine inspections		
	Manufacturers shall provide an interval for routine inspection of the SWT including tower, drivetrain, controller, and rotor. The manufacturer shall document the components to inspect, that includes but is not limited to: • rotor blades; • worn or twisted droop cables; • guy wire tension; • lubrication leaks; and • fasteners. The manufacturer shall provide a list of equipment and measurements necessary to ensure proper operation and its verification. The manufacturer shall state all values of normal operating ranges, which are critical to the safety of the SWT. (This could include battery voltages, water pump flow rate, inverter voltage, current and frequency, etc.) Manufacturers shall recommend that a logbook be maintained for each SWT. Data that should be included in the logbook are the date, time, and personnel conducting the inspection, any important events, and any corrective action taken or additional information recorded.		P
11.2.5.4	Maintenance		
	The manufacturer shall provide an interval for routine maintenance of the SWT. Routine maintenance is defined as any service or repairs that the manufacturer deems necessary after a period of time to maintain the safe operation of the SWT. Routine maintenance may include but is not limited to: • lubrication; • periodic testing of emergency shutdown/overspeed system; • adjustment/replacement of braking system; • replacement of bearings, brushes/sliprings; and		P

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	• maintenance required on any safe life components that are required for them to meet their design lifetime. If the manufacturer requires that the SWT be shutdown before routine maintenance, a statement to this affect shall be provided in the documentation. " CAUTION – PRIOR TO PERFORMING ROUTINE MAINTENANCE, FOLLOW PROCEDURE FOR THE PROPER SHUTDOWN OF THE Wind generator" Manufacturers shall recommend that all maintenance and repair be recorded in the logbook referenced in 11.2.5.3 and 11.2.5.4.		
11.2.5.5	Troubleshooting		
	The manufacturer shall provide a troubleshooting list of items that can be checked before calling service personnel. Items in the list shall be such that they could be checked by a trained operator but not requiring specialised test equipment or trained service personnel.		P
11.2.5.6	Personnel safety		
	In the installation, operating and maintenance manuals, the manufacturer shall supply all necessary information on personnel safety. Such information may include topics such as: climbing procedures, ladders, anchor points, and the use of personnel safety equipment. The manufacturer shall also specify any wind speed limit for climbing and/or lowering the tower.		P
11.3	Consumer label		
	It is recommended that a consumer label be provided in accordance with Annex M. If this is done the measurement reports used to complete the consumer label shall meet the requirements of ISO/IEC 17025 and relevant standards used to define the test requirements (e.g. IEC 61400-12-1).		P
12	Wind generator markings		
	The following information shall be as a minimum, prominently and legibly displayed on the indelibly marked turbine nameplate: • Wind generator manufacturer and country of manufacture; • model, revision, and serial number; • SWT class; • power form; • maximum output power (per definitions, giving the P60 as a minimum); • maximum output voltage (per definitions, giving the U0,2 as a minimum); Additional information may include:		P

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	• production date; • tower top mass; • design extreme (survival) wind speed (i.e. Ve50); • maximum output current(s) (per definitions, giving the i60 as a minimum); • swept area. II Type testing		
13	Testing		
13.1	General		
	Clause 13 describes the available tests for small Wind generators. In 5.2 an overview is given on which tests are mandatory. The test specimens shall be representative of the design of the Wind generator type/component. Properly calibrated instruments and appropriate sample rates shall be used. For all measurements where wind speed is required, the location of the anemometer and the measurement sector shall be in accordance with the latest edition of the power performance measurement standard, IEC 61400-12-1. The tests shall be documented in a report containing a full description of the test methods used, the test conditions, the specifications of the tested machine and the test results. The description of the test method shall include a detailed description of the measuring procedures, instrumentation, data acquisition, and data analysis. Deviations from the methods as described in this clause shall be documented. The measurement reports shall meet the requirements of ISO/IEC 17025 and relevant standards used to define the test requirements (e.g. IEC 61400-12-1, and IEC/TS 61400-13, and IEC 61400-11).		P
13.2	Tests to verify design data		
13.2.1	General		
	To determine the data required for the simplified load analysis or verify the simulation (aero- elastic model) a test shall be performed to verify or determine the following design data: • design power, Pdesign; • design rotational speed, ndesign; • design shaft torque, Qdesign; and • maximum rotational speed, nmax.		P
13.2.2	Pdesign, ndesign, Vdesign and Qdesign		
	The design wind speed is defined as 1,4 Vave. The		P

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	design power Pdesign and design rotational speed ndesign are then the power level and rotational speed at that wind speed. To determine these parameters wind speed, power production and rotational speed shall be measured at the nominal electrical load. The measured data shall be binned into 0,5 m/s wind speed bins. Each wind speed bin from 1 m/s below Vin up to 2 Vave shall contain at least 10 data points. A data point is based on a 1-min average of samples recorded at a sample rate of at least 0,5 Hz. The design torque shall either be derived from Pdesign and ndesign or may be measured directly. Drive train efficiency, η, shall be assumed to be given by Equation (49) in the absence of any proven, more precise values.		
13.2.3	Maximum yaw rate		
	The maximum yaw rate is defined as the maximum speed of yaw movement of the rotor around the yaw axis. 1) In case of passive yaw turbines with free movement of the rotor around the yaw and/or furl axis this yaw speed can consist of a nacelle frame yaw speed and a component of the furl speed around an axis parallel to the yaw axis. In the case of passive yawing turbines measured values cannot be used in the simple load calculations. Instead the values given by Equation (27) in 7.4.3 shall be used. 2) In the case of active yaw turbines with controlled movement of the rotor around the yaw axis under all conditions measured values should be used in the simple load calculations. 3) In the case of semi-active yaw or damped yaw turbines with partially restrained movement of the rotor around the yaw axis (e.g. through the use of devices to limit rotational velocity or acceleration, such as dampers) then measured values may be used provided that it can be shown that there is an upper limit to the measured values in all operating wind conditions. If this cannot be shown then the values given by Equation (27) in 7.4.3 shall be used. In case the manufacturer wants to measure yaw rate for model validation per points 2 and 3 above the following considerations should be taken into account: • yaw rates are highly influenced by the external conditions; • interpolation or extrapolation could be necessary to derive the maximum yaw rate; and • deriving yaw rates from yaw positions can lead to ambiguous results.		P
13.2.4	Maximum rotational speed		

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	The rotor speed shall be measured during the turbine condition most likely to give the highest rotor speed (e.g. loss of load or wind gust) at wind speeds between 10 m/s and 20 m/s. At least 2 h of data are required of which at least 30 minutes shall be below 15 m/s and 30 minutes shall be above 15 m/s. From these data the maximum rotor speed shall be determined by interpolation or extrapolation to Vref, taking into account any visible slope changes.		P
13.3	Mechanical loads testing		
	The purpose of load measurements can be twofold: to verify design calculations or determine the design loads. The load measurement program shall be based on and consist of measurement load cases that are as close as practically possible to the design load cases defined in 7.5. The measurement load cases shall include all normal and critical operating and fault conditions, braking performance and yaw behaviour. Testing shall be sufficient to characterise typical operational behaviour throughout the design wind speed range. A statistically significant amount of data for relevant wind speeds, allowing extrapolation, shall be collected. Measured data shall at least include loads, meteorological parameters and Wind generator operational data. Loads at critical load path locations in the structure shall be measured. These loads may include blade root bending moments, shaft loads and loads acting on the support structure. Meteorological parameters shall include hub height wind speed and wind direction. Relevant Wind generator operational data including rotor speed, electrical power, yaw position and turbine status shall be measured. In case load measurements are performed to verify the design loads the data shall be analysed in such way that valid comparison with calculated loads is possible. As a minimum the mean, minimum and maximum values, standard deviation of the appropriate load data shall be evaluated and included over the recorded wind speed and turbulence ranges and the relevant data included in the test report. Guidance for test procedures and evaluation of tests may be found in IEC/TS 61400-13.		P
13.4	Duration testing		
13.4.1	General		
	The purpose of the duration test is to investigate: • structural integrity and material degradation (corrosion, cracks, deformations);		P

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	• quality of environmental protection of the Wind generator; and • the dynamic behaviour of the turbine. During the duration test, test procedures shall be implemented to determine if and when the test turbine successfully meets the following test criteria. The Wind generator will have passed the duration test when it has achieved: 1) reliable operation during the test period; 2) at least 6 months of operation; 3) at least 2 500 h of power production in winds of any velocity; 4) at least 250 h of power production in winds of 1,2 Vave and above; 5) at least 25 h of power production in winds of 1,8 Vave and above; and 6) at least 10 min in winds of 2,2 Vave and above but not less than 15,0 m/s during which the turbine shall be in normal operation. Regarding items 5) and 6) above: • if the turbine is designed to be shut down at 1,8 Vave then this can be relaxed from power production to normal operation; • if the turbine is designed to shut down at this wind speed it shall shut down, if the turbine is designed to produce power it shall produce power. If the turbine is an S class turbine, it shall comply with the full criteria expressed above including the minimum 15 m/s requirement. The average turbulence intensity at 15 m/s shall be reported. This turbulence intensity is the average turbulence intensity of all data points with 10-min average wind speeds between 14,5 m/s and 15,5 m/s. The highest instantaneous (3-s gust) wind speed during the test shall be stated in the test report. The turbine behaviour during the duration test shall resemble normal turbine use as much as possible, e.g. battery voltage levels should change to reflect normal charging and discharging of the battery bank for battery charging systems. Small repairs are allowed but shall be reported as described in 13.4.4. Wind speed is defined as the 10-min average of wind speed samples as measured at hub height (10-min periods derived from contiguous measured data as defined in IEC 61400-12-1) with a sampling rate of at least 0,5 Hz. NOTE To convert 1-min data to 10-min data: If there is a need to convert 1-min data to 10-min data.		

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	The 10-min average is simply the average of the 1-min averages. The 10-min minimum and maximum are simply the minimum and maximum of the 1-min measurements respectively. The 10-min standard deviation can be calculated from the 1-min standard deviation with the equation below: σ 10min Simplified: where is the standard deviation; and is the mean value for the given set of data. Power production means that the turbine is producing positive power as measured by the power transducer at the connection to the electrical load. If the 10-min average power is positive (after accounting for any offset value on the power signal) the whole 10-min period shall be counted towards the 2 500 h. 10-min periods shall be counted toward the 250 h and 25 h of power production if the 10-min average wind speed is equal to or above 1,2 Vave or 1,8 Vave respectively. For duration testing winds from all directions can be used towards the hours of power production. The terrain does not have to meet the requirements used for power performance testing (Annex B or IEC 61400-12-1). The anemometer should be located and mounted such that the wind speed it measures is representative of the wind speed at the Wind generator hub height. Caution should be taken to not locate the anemometer in such location that it reads a significantly (5 %) higher wind speed than the turbine sees.		
13.4.2	Reliable operation		
13.4.2.1	General		
	Reliable operation means: • operational time fraction of at least 90 %; • no major failure of the turbine or components in the turbine system; • no significant wear, corrosion, or damage to turbine components; and • no significant degradation of produced power at comparable wind speeds.		P
13.4.2.2	Major failure		
	If the turbine is altered in any way during the test other than to perform scheduled maintenance or for inspections, the test organisation will determine if such an alteration has resulted from a major failure. The test organisation's judgement shall be noted in the test report. A major failure of the Wind generator system		P

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	includes any significant failure of the system components which affect the turbine safety and function such as blades, main shaft, alternator, yaw bearings, support structure, controller or inverter.		
13.4.2.3	Significant wear		
	Significant wear is any wear which, extrapolated to the lifetime of the turbine, would result in unacceptable loss of strength or clearance. Wear, corrosion and damage to components shall be assessed by conducting a detailed inspection of the turbine system shortly after installation and commissioning, documenting any wear, corrosion and damage that was present before the test started and a second detailed inspection at the conclusion of the test. Such a detailed inspection shall be no more intrusive than the size of the turbine, the consequences of failure, and the status of the component warrant.		P
13.4.2.4	Operational time fraction		
	For purposes of this test, operational time fraction is defined as the ratio of time a Wind generator shows its normal designed behaviour to the test time in any evaluation period expressed as a percentage. Normal designed behaviour includes the following (where applicable): • turbine producing power; • automatic start-up and shut-down due to wind speed transitioning across low wind cut-in and high wind cut-out; • idling or parked states at wind speeds under Vin or above Vout; and • extended time between a normal shutdown (not caused by a failure) and a restart of the turbine (e.g. brake cool cycle, retraction of tip brakes). The operational time fraction, O, is given by the following equation: where TT is the total time period under consideration; TN is the time during which the turbine is known to be non-operational; TU is the time during which the turbine status is unknown; and TE is the time that is excluded in the analysis. Note that neither the time during which the turbine status is unknown nor the time that is excluded from the analysis count against or in favour of the operational time fraction. The following conditions shall be considered as turbine faults and shall be part of TN: • any turbine fault condition indicated by the turbine controller that prevent the turbine from operating;		P

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	• any automatic shutdown of the turbine by its controller due to an indicated fault; • manual selection of pause, stop, or test mode that prevents the turbine from operating normally for the purpose of routine maintenance or a perceived fault condition; • turbine inspections conducted in accordance with manufacturer's recommendations; and • downtime due to unwrapping of the droop cable. The following conditions shall be considered as time during which the turbine status is unknown (TU in the equation above): • failure or maintenance of the test institute's data acquisition system; and • lost or unresolvable records of turbine condition. The following conditions shall be excluded from the test time period and be part of TE: • turbine inspections conducted as part of this test that are not recommended by the manufacturer (e.g. inspection of data acquisition system); • any non-operational time that is caused by something other than the turbine or manufacturer; • manual selection of a pause, stop, or test mode that prevents the turbine from operating normally for any purpose other than routine maintenance or a perceived fault condition; • failure of the grid, battery system, inverter or any component external to the turbine system being tested (see below). If these components are considered part of the system this time shall count as TN; and • reduced or no power production due to the turbine control system sensing external conditions outside the designed external conditions. If a turbine fault is present during one of the above situations, caused during normal external conditions, this time shall count as TN. The duration test report shall clearly state which components were considered part of the turbine system and which components were considered as external to the turbine. This statement shall consider: • mechanical interface between the turbine and the ground; • electrical interface between the turbine and the load; and • control interface between the turbine and local and/or remote control devices. In cases where conditions may exist that are not clearly attributable to a turbine fault or an external condition, the		

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	test plan shall define to which category such conditions will be attributed. Examples of such conditions are: • inadvertent actuation of tip brakes or furling; and • confusion of the controller due to voltage transients. The test report shall describe instrumentation and data logging arrangements that allowed for determination and recording of turbine operation status at all times during the duration test.		
13.4.2.5	Power production degradation		
	To check any hidden degradation in the power performance of the turbine the following procedure is part of the duration test. For each month in the duration test the power levels shall be binned by wind speed. For each wind speed a plot shall be made with the binned power levels as a function of time. If there is a trend visible, then investigation shall take place to determine the cause. For battery charging systems, points with comparable state of charge should be plotted. Only data points that are considered normal operation should be used in this analysis. Only data taken within the measurement sector should be used to eliminate potential effects of terrain or obstacles on wind speed readings on the analysis.		P
13.4.3	Dynamic behaviour		
	The dynamic behaviour of the turbine shall be assessed to verify that the system does not exhibit excessive vibration. The dynamic behaviour of the turbine shall be observed under all operating conditions (e.g. loaded, unloaded, furled); and for at least 1 h in total; and in winds from cut-in wind speed up to 1,8 Vave. Special attention should be paid to tower vibrations and resonances, turbine noise, tail movement and yaw behaviour. Observations should be written down in the logbook and be reported in the test report. Assessment by instrumentation is also allowed.		P
13.4.4	Reporting of duration test		
	The duration test report shall contain the following information: a) An identification and description of the specific Wind generator design configuration under test, including: • turbine manufacturer, model name, serial number, production year; • SWT class stated by the manufacturer for the design; • swept area;		P

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	• rotor diameter (if applicable); • hub height and tower type; • description of load (e.g. grid connected, battery charging) including voltage; • control system software versions and set points; • a clear description of the boundaries of the turbine system (both mechanical electrical and control). b) A description of the test site, including: • a map of the test site showing the surrounding area covering a radial distance of 20 Wind generator rotor diameters and indicating the topography, location of the wind turbine, meteorological tower, significant obstacles and other Wind generators. The map shall include an indication of scale; • photographs taken towards all four cardinal positions (North, East, South and West); • a photograph showing the turbine and meteorological tower taken towards the predominant wind direction; • description of site elevation and indication of typical air density; • a plot showing the air temperature during the test period. c) A description of the test equipment: • make, model, serial number of all instruments used; • location of instruments on the meteorological tower; • a copy of the calibration certificate for each instrument; • description of method used to determine the turbine operation status; • description of sample rate. d) Description of data reduction techniques e) A description of the test results: • a description of the start and end date of the test; • a table listing the hours of power production above each wind speed and operation time fraction time components broken down by month (see Annex G); • the average turbulence intensity at 15 m/s; • the highest instantaneous wind speed during the test (maximum observed 3-s gust); • a table listing the hours in each time category used in the calculation of the operational time fraction for each month and the reasons for classification of any time		

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	other than TT; • a plot of the power degradation analysis and if applicable reason(s) for found degradation; • transcripts of observations of dynamic behaviour; • the SWT class for which the duration test has been completed (turbine test class). f) Maintenance/ repairs/modification: • records of any maintenance that was performed to the turbine; • records of any repairs or changes that were made to the turbine. g) Post-test inspection: • any findings of the post-test inspection including photographs. h) Deviations from the standard • any deviations from the requirement in this clause shall be clearly documented in a separate clause. Each deviation shall be supported with the technical rationale and an estimate of its effect on the test results.		
13.5	Mechanical component testing		
13.5.1	General		
	A static blade test is required for all turbines. For all other load carrying components, in case no calculations of a component have been performed in accordance with 7.9, one shall subject that component to a component test. In general the worst combination of design loads including safety factors shall be applied to the component. No damage that may interfere with the safe operation of the turbine may occur (e.g. significant loss of stiffness, plastic deformation, buckling or cracking). In case of purchased components it shall be sufficient to show that the design loads are within the specifications of the component.		P
13.5.2	Blade test		
	The applied load for the static blade test shall be the worst combination of the flap-wise bending moment and the centrifugal force. The blade shall be tested including the blade hub connection. No damage may occur at a test load up to the maximum operating load as predicted by simplified load model, simulation modelling or measurements, including load safety factors. In the case of design loads determined by the simplified load model (7.4), the assumed distribution of load along the blade span can be obtained by consideration of the equations provided in Annex F. A representative number of loading points should be used to distribute loads along the length of the blade		P

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	during the test. The location of the loading points and the magnitude of the loads shall be selected to provide the required blade root bending moment and also provide a bending moment distribution along the blade span that is as close as practicable (equal to or greater than) to the bending moment distribution for the design load case being represented by the test. The blade tip deflection shall not exceed the no-load clearance between the blade and tower or other support structure. Either sufficient deflection margin shall be provided to cover variations in material properties or geometry, or sufficient tests shall be conducted to ascertain the quality of the manufactured blades. NOTE In some cases it can be appropriate to perform tests for more than one load case. For example, a test can be required to represent the bending moments for a parked rotor and second test required to represent the centrifugal loads during maximum rotational speed. It is recommended that the blade be tested to failure to determine the strength margin between the design load and actual blade failure load. In case a blade fatigue test is performed, the test shall meet the requirements of IEC/TS 61400-23.		
13.5.3	Hub test		
	In case a hub test is performed, the hub shall be tested statically by simulating centrifugal force and flap-wise bending on all connection points of the blades. The hub shall be tested including the hub shaft connection. No damage may occur at the design test load (including factors of safety) based on the maximum calculated load.		P
13.5.4	Nacelle frame test		
	In case a nacelle frame test is performed the nacelle frame shall be statically tested by subjecting it to a shaft tilt bending moment, axial rotor force and its own weight. No damage may occur at the design test load (including factors of safety) based on the maximum calculated load.		P
13.5.5	Yaw mechanism test		
	In case a yaw mechanism test is performed, the yaw mechanism shall be tested by applying the loads as described under the nacelle frame test. It shall be shown that the yaw mechanism still works properly.		P
13.5.6	Gearbox test		
	A gearbox test is not required but testing and designing according to the IEC 61400-4 standard is recommended.		P
13.6	Safety and function		
	The purpose of safety and function testing is to verify that the turbine under test displays the behaviour predicted in		P

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	the design and that provisions relating to personnel safety are properly implemented. The safety and function tests shall include the critical functions of the control and protection system that require test verification, as described in the design documentation. These critical functions shall include: 1) power and speed control; 2) yaw system control (wind alignment); 3) loss of load; 4) over speed protection at design wind speed or above; and 5) start-up and shut down above design wind speed. Other items that might be applicable are: 6) excessive vibration protection; 7) battery over- and under-voltage protection; 8) emergency shutdown under normal operation; 9) cable twist; and 10) anti-islanding (for grid connections). Any additional protection system function that may be activated by component failure or other critical events or operational conditions shall also be tested. This testing may include simulation of the critical event or operational condition. For example, SWTs with droop cables designed to automatically disconnect under excessive cable twisting shall be demonstrated to function properly.		
13.7	Environmental testing		
	In case the turbine is designed for external conditions outside the normal external conditions (as given in clause 6), the turbine shall be subjected to tests simulating those conditions. These tests are preferably performed on the whole turbine. In case this is not feasible, these tests shall be conducted on all portions of the system that are affected by this external condition.		P
13.8	Electrical		
	All safety critical electrical subsystems (e.g. generators, control panel, motors, transformers, GFCIs, heaters) of a SWT shall be evaluated and tested to their relevant IEC standards. For example, for generators, the testing should be in compliance with IEC 60034-1, IEC 60034-2 series, IEC 60034-5, and IEC 60034-8.		P

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Photo 1 General Appearance of the EUT



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