International Association of Oil & Gas Producers

SPECIFICATION
S-747J

December 2021

Supplementary Specification to IEC 61800-2 High-voltage AC Drive Systems

NOTE This version (S-747J) of the specification document provides the justification statements for each technical requirement, but is otherwise identical in content to S-747.

JIP33
JOINT INDUSTRY PROGRAMME

Revision history

VERSION	DATE	PURPOSE
0.1	December 2021	Issued for Public Review

Acknowledgements

This IOGP Specification was prepared by a Joint Industry Programme 33 Standardization of Equipment Specifications for Procurement organized by IOGP with support by the World Economic Forum (WEF).

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Foreword

This specification was prepared under Joint Industry Programme 33 (JIP33) "Standardization of Equipment Specifications for Procurement" organized by the International Oil & Gas Producers Association (IOGP) with the support from the World Economic Forum (WEF). Companies from the IOGP membership participated in developing this specification to leverage and improve industry level standardization globally in the oil and gas sector. The work has developed a minimized set of supplementary requirements for procurement, with life cycle cost in mind, resulting in a common and jointly agreed specification, building on recognized industry and international standards.

Recent trends in oil and gas projects have demonstrated substantial budget and schedule overruns. The Oil and Gas Community within the World Economic Forum (WEF) has implemented a Capital Project Complexity (CPC) initiative which seeks to drive a structural reduction in upstream project costs with a focus on industry-wide, non-competitive collaboration and standardization. The CPC vision is to standardize specifications for global procurement for equipment and packages. JIP33 provides the oil and gas sector with the opportunity to move from internally to externally focused standardization initiatives and provide step change benefits in the sector's capital projects performance.

This specification has been developed in consultation with a broad user and supplier base to realize benefits from standardization and achieve significant project and schedule cost reductions.

The JIP33 work groups performed their activities in accordance with IOGP's Competition Law Guidelines (November 2020).

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Introduction

The purpose of this specification is to define a minimum common set of requirements for the procurement of high-voltage AC drive systems in accordance with IEC 61800-2, Edition 3.0, March 2021, Adjustable speed electrical power drive systems – Part 2: General requirements – Rating specifications for adjustable speed AS power drive systems, for application in the petroleum and natural gas industries.

This specification follows a common document structure comprising the four documents as shown below, which together with the purchase order define the overall technical specification for procurement.

JIP33 Specification for Procurement Documents
Supplementary Technical Specification

This specification is to be applied in conjunction with the supporting procurement data sheet, information requirements specification (IRS) and quality requirements specification (QRS) as follows.

IOGP S-747: Supplementary Specification to IEC 61800-2 High-voltage AC Drive Systems

This specification defines the technical requirements for the supply of the equipment and is written as an overlay to IEC 61800-2, following the IEC 61800-2 clause structure. Clauses from IEC 61800-2 not amended by this specification apply as written to the extent applicable to the scope of supply.

Modifications to IEC 61800-2 defined in this specification are identified as *Add* (add to clause or add new clause), *Replace* (part of or entire clause) or *Delete*.

IOGP S-747D: Procurement Data Sheet for High-voltage AC Drive Systems

The procurement data sheet defines application specific requirements, attributes and options specified by the purchaser for the supply of equipment to the technical specification. The procurement data sheet may also include fields for supplier provided information attributes subject to purchaser's technical evaluation. Additional purchaser supplied documents may also be incorporated or referenced in the procurement data sheet to define scope and technical requirements for enquiry and purchase of the equipment.

IOGP S-747L: Information Requirements for High-voltage AC Drive Systems

The IRS defines the information requirements, including contents, format, timing and purpose to be provided by the supplier. It may also define specific conditions which invoke information requirements.

IOGP S-747Q: Quality Requirements for High-voltage AC Drive Systems

The QRS defines quality management system requirements and the proposed extent of purchaser conformity assessment activities for the scope of supply. Purchaser conformity assessment activities are defined through the selection of one of four generic conformity assessment system (CAS) levels on the basis of evaluation of the associated service and supply chain risks. The applicable CAS level is specified by the purchaser in the data sheet or in the purchase order.

The terminology used within this specification and the supporting procurement data sheet, IRS and QRS follows that of IEC 61800-2 and is in accordance with ISO/IEC Directives, Part 2 as appropriate.

The procurement data sheet and IRS are published as editable documents for the purchaser to specify application specific requirements. The supplementary specification and QRS are fixed documents.

The order of precedence (highest authority listed first) of the documents shall be:

a) regulatory requirements;

b) contract documentation (e.g. purchase order);

c) purchaser defined requirements (procurement data sheet, QRS, IRS);

d) this specification;

e) IEC 61800-2.

1 Scope

Replace second paragraph with

This specification amends and supplements IEC 61800-2 and associated parts of IEC 61800 referenced in IEC 61800-2 for the design, manufacture and testing of:

- AC drive systems connected to 50 Hz or 60 Hz input voltages;
- AC drive systems with BDMs having both input and output line-to-line voltages above 1 kV AC, i.e. high voltage;
- AC drive systems with a high-voltage BDM integrated into a CDM, with or without an output transformer, in accordance with Table 5.

Justification

This text indicates the change in scope in comparison with the parent standard and aligns with scope of specification as defined by work group in Framing Proposal (Revision B01, 28 May 2021).

Delete NOTE

Justification

Scope text replaced to align with the framing agreement and supplementary specification.

Add new list item to seventh paragraph

- explosion protection safety requirements are covered by IEC 60079 series related to motors located in potentially explosive atmospheres;

Justification

The additional standard cover safety requirement of motor, which is a part of the PDS.

Add new list item to seventh paragraph

- AC electrical machines used in PDSs – application guide is covered in IEC TS 60034-25.

Justification

The application guide for AC electrical machines used in power drive system is included as a reference standard.

Add new subclause

1.1 Additional scope

This specification covers the following essential minimum requirements related to construction, function and transport/handling of BDM/CDM/PDSs:

- Constructional requirements:
  - — enclosure – design, accessibility and clearances, compartmentalization/sectionalization, internal arc classification;

— components – converter, cooling (air and liquid), transformer, capacitor, circuit breaker / contactor / disconnector and earthing switch, motor;

— busbars, wiring, power/control terminals, cable interface;

— control supply, panel auxiliaries;

— earthing.

- Functional requirements:

  — control system, control interface, encoder interface, operator interface, protections and alarms, communication protocol and network interface;

  — reliability and availability;

  — performance including features like voltage dip ride through, kinetic buffering, active volt-ampere reactive (VAR) control and implementing active front end.

- Transport, storage and handling.

Justification

This text indicates the change in scope in comparison with the parent standard. Aligns with scope of specification as defined by work group in Framing proposal, Revision B01, 21 June 2021.

Add new subclause

1.2 High-voltage AC drive systems included in scope

This specification will cover BDMs/CDMs located:

- indoors in a non-hazardous area feeding motors located in a non-hazardous area;
- indoors in a non-hazardous area feeding motors located in a hazardous area;
- outdoors in a non-hazardous area and within a weatherproof enclosure;
- onshore or offshore.

Justification

This text indicates the change in scope in comparison with the parent standard. Aligns with scope of specification as defined by work group in Framing proposal, Revision B01, 21 June 2021.

Add new subclause

1.3 Scope boundary

This specification covers the PDS including the BDM with either the input, output or both having high voltages, i.e. greater than 1 000 V AC with no upper limit, and is aligned with the scope of IEC 61800-2, but modified in accordance with Figure 23.

Justification

This text indicates the change in scope in comparison with the parent standard. Aligns with scope of specification as defined by work group in Framing proposal, Revision B01, 21 June 2021.

Add new subclause

1.4 Exclusions

The following power drive systems are excluded from the scope of this specification:

- rating specifications for AC power drive systems with BDM terminal voltage at input, output or both below 1 000 V AC, i.e. low voltage;
- BDM units with input terminal voltage as high voltage but fed from a low-voltage supply;
- BDM units with output terminal voltage as high voltage but used to drive low-voltage motors;
- AC power drive systems with input transformer at the BDM input as part of the CDM;
- power drive systems for wind turbine applications;
- rating specifications for low-voltage adjustable speed DC power drive systems;
- BDM/CDM with topology – cyclo-converters and matrix converters.

The following components of PDSs are outside the scope of this specification:

- input transformer, if any, upstream of the PDS;
- high-voltage switchgear and associated devices, i.e., upstream switching device, protection and bypass;
- low-voltage switchgear feeders for BDM/CDM auxiliaries, i.e., upstream feeders and protection devices;
- low-voltage AC motor including sensors and mounted accessories, which are not part of the auxiliaries of BDM/CDM and main motor.

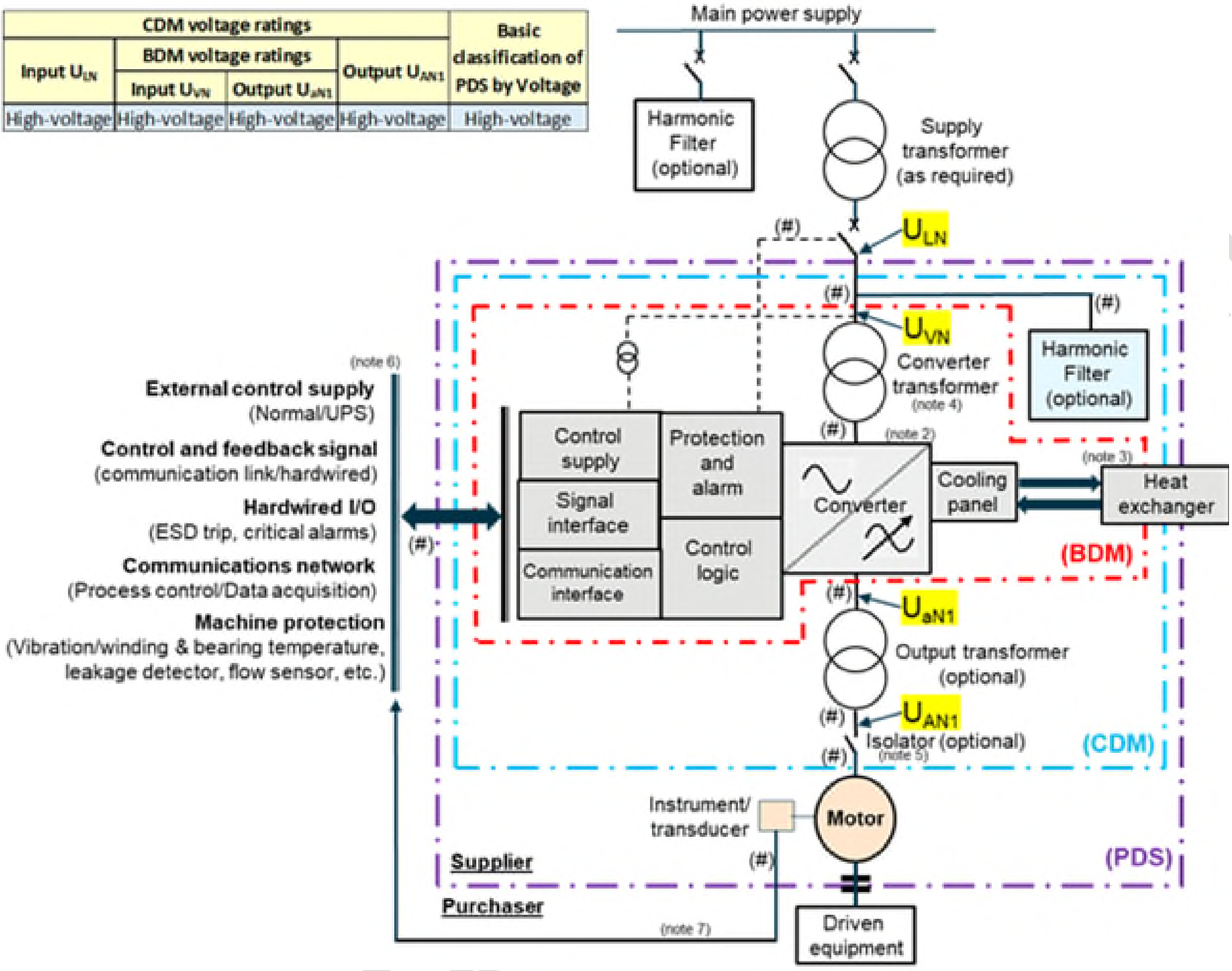
The following components which have interface to the PDS are outside the scope of this specification:

- supply transformer, if any, upstream of the PDS;
- switchgear and switching device protection upstream of the PDS;
- switchgear on the bypass path.

Justification

This text indicates the change in scope in comparison with the parent standard. Aligns with scope of specification as defined by work group in Framing proposal, Revision B01, 21 June 2021.

Add new Figure 23



NOTE 1 (#) indicates interconnecting cables in purchaser scope typically, except agreed differently.

NOTE 2 Converter may either be air cooled or liquid cooled.

NOTE 3 Heat exchanger (water-water) or cooler (water-air) of liquid cooled converter may either be supplier or purchaser scope.

NOTE 4 Motor cooling arrangement shall be either air-air or water-air.

NOTE 5 Output isolator, if installed should be electrically interlocked with converter. This unit may be either supplier or purchaser scope.

NOTE 6 All interfaces are indicative and may be considered as per project requirements.

NOTE 7 The interface between motor and converter will depend on the type of motor and its associated instrument/transducers.

NOTE 8 The interface between instruments on transformer and SCADA will be considered as per project requirements.

NOTE 9 Synchronous motor will have an excitation system and associated interfaces with motor and converter.

Figure 1 — Scope boundary diagram

2 Normative references

Add to clause

API Standard 541, *Form-wound Squirrel Cage Induction Motors—375 kW (500 Horsepower) and Larger*

API Standard 546, *Brushless Synchronous Machines—500 kVA and Larger*

API Standard 547, *General Purpose Form-wound Squirrel Cage Induction Motors—185 kW (250 hp) through 2240 kW (3000 hp)*

CSA 22.2 No. 274-17, *Adjustable speed drives*

IEC 60092 (all parts except 301, 305, 306, 501, 502 and 503), *Electrical installations in ships*

IEC 60417, *Graphical symbols for use on equipment (available at http://www.graphical-symbols.info/equipment)*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 61000-2-4, *Electromagnetic compatibility (EMC) – Part 2-4: Environment – Compatibility levels in industrial plants for low-frequency conducted disturbances*

IEC 61071, *Capacitors for power electronics*

IEC 61378 (all parts), *Converter transformers*

IEC 61892 (all parts), *Mobile and fixed offshore units – Electrical installations*

IEC 62271-100, *High-voltage switchgear and controlgear – Part 100: Alternating-current circuit-breakers*

IEC 62271-102, *High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches*

IEC 62271-106, *High-voltage switchgear and controlgear – Part 106: Alternating current contactors, contactor-based controllers and motor-starters*

IEC 62271-200, *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 62443 (all parts), *Industrial communication networks – Network and system security*

IEC 62477-2, *Safety requirements for power electronic converter systems and equipment – Part 2: Power electronic converters from 1 000 V AC or 1 500 V DC up to 36 kV AC or 54 kV DC*

IEC TS 60034-25, *Rotating electrical machines – Part 25: AC electrical machines used in power drive systems – Application guide*

IEEE 18, *IEEE Standard for Shunt Power Capacitors*

IEEE 519, *IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems*

IEEE 841, *IEEE Standard for Petroleum and Chemical Industry—Premium-Efficiency, Severe-Duty, Totally Enclosed Squirrel Cage Induction Motors from 0.75 kW to 370 kW (1 hp to 500 hp)*

IEEE 1276, *IEEE Guide for the Application of High-Temperature Insulation Materials in Liquid-Immersed Distribution, Power, and Regulating Transformers*

IEEE 1566, *IEEE Standard for Performance of Adjustable-Speed AC Drives Rated 375 kW and Larger*

IEEE 1584, *IEEE Guide for Performing Arc-Flash Hazard Calculations*

IEEE C37.04, *IEEE Standard for Ratings and Requirements for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V*

IEEE C37.20.7, *IEEE Guide for Testing Switchgear Rated Up to 52 kV for Internal Arcing Faults*

IEEE C37.22, *American National Standard Preferred Ratings and Related Required Capabilities for Indoor AC Medium-Voltage Switches Used in Metal-Enclosed Switchgear*

IEEE C57.12.00, *IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers*

IEEE C57.12.01, *IEEE Standard for General Requirements for Dry-Type Distribution and Power Transformers*

IEEE C57.12.90, *IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers*

IEEE C57.12.91, *IEEE Standard Test Code for Dry-Type Distribution and Power Transformers*

IEEE C57.18.10, *IEEE Standard Practices and Requirements for Semiconductor Power Rectifier Transformers*

IEEE C57.110, *IEEE Recommended Practice for Establishing Liquid Immersed and Dry-Type Power and Distribution Transformer Capability when Supplying Nonsinusoidal Load Currents*

IOGP S-560, *Supplementary Requirements to IEC 61439-1 & 2 LV Switchgear & Controlgear*

IOGP S-704, *Supplementary Specification to IEC 60034-1 High Voltage Three-phase Cage Induction Motors*

IOGP S-732, *Supplementary Specification to UL 845 Low Voltage Motor Control Centers*

ISO 7010, *Graphical symbols — Safety colours and safety signs — Registered safety signs*

UL 347, *Standard for Safety – Medium-Voltage AC Contactors, Controllers, and Control Centers*

UL 347A, *UL Standard for Safety – Medium Voltage Power Conversion Equipment*

UL 2900-1, *UL Standard for Safety – Software Cybersecurity for Network-Connectable Products, Part 1: General Requirements*

UL 2900-2-2, *UL LLC – Outline of Investigation for Software Cybersecurity for Network-Connectable Products, Part 2-2: Particular Requirements for Industrial Control Systems*

4 Guidance for specification of BDM/CDM/PDS and methodologies for compliance

4.3 Applicable standards

Add new list item

- Explosion protection safety requirements are covered by IEC 60079 series related to motors located in potentially explosive atmospheres.

Justification

The additional standard cover safety requirement of motor, which is a part of the PDS.

Add new list item

- AC electrical machines used in PDSs – application guide is covered in IEC TS 60034-25.

Justification

The application guide for AC electrical machines used in power drive system is included as a reference standard.

5 Performance and functionality criteria

5.2 BDM/CDM/PDS characteristics and topology

5.2.4 Cooling topology

5.2.4.3 Liquid-cooling

Replace first sentence of first paragraph with

Liquid cooling systems shall monitor and control the following:

Justification

The bullet points listed are parameters vital to the proper operation of a liquid cooling system and needs to be considered as a essential minimum requirement to be monitored and controlled for any liquid cooling system. Accordingly the guidance text in the parent standard is modified to a requirement.

In first sentence of second paragraph, replace "should" with

shall

Justification

The bullet points listed are parameters vital to the proper operation of a liquid cooling system and needs to be considered as a essential minimum requirement to be monitored and controlled for any liquid cooling system. Hence warning and maintenance instructions become importance to achieve the proper functioning of the liquid cooling system. Accordingly the guidance text in the parent standard is modified to a requirement which mandates provision of appropriate warnings and maintenance instructions..

5.3 Ratings

5.3.2 Input ratings

5.3.2.2 Input voltage and input frequency

In first paragraph, replace "should" with

shall

Justification

BDM/CDM/PDS, especially components which form the complete PDS, can be selected based on the ratings of input voltage and input frequency specified by the manufacturer. Hence this form a requirement to facilitate proper selection of BDM/CDM/PDS.

5.3.2.3 Input current

In first sentence of first paragraph, replace "'should" with

shall

Justification

BDM/CDM/PDS, especially components which form the complete PDS, can be selected based on the ratings of input current specified by the manufacturer. Hence this form a requirement to facilitate proper selection of BDM/CDM/PDS.

In second sentence of first paragraph, replace "should" with

shall

Justification

BDM/CDM/PDS, especially components which form the complete PDS, can be selected based on the ratings of input current specified by the manufacturer. Hence this form a requirement to facilitate proper selection of BDM/CDM/PDS.

In fourth paragraph, replace "If the BDM/CDM/PDS is a category C4 equipment as defined by IEC 61800-3, then harmonic current spectrum should" with

The harmonic current spectrum shall

Justification

Category C4 equipment are those with rated voltage equal to or greater than 1000 V, or rated current equal to or greater than 400 A, or those PDS intended for use in complex systems in the second environment as defined by IEC 61800-3. All HV AC drive systems classifies as equipment category C4 and hence this guidance text in the parent standard is modified to a requirement.

Delete second sentence of fourth paragraph

Justification

Category C4 equipment are those with rated voltage equal to or greater than 1000 V, or rated current equal to or greater than 400 A, or those PDS intended for use in complex systems in the second environment as defined by IEC 61800-3. All HV AC drive systems classifies as equipment category C4 and hence this guidance text in the parent standard referring to other BDM/CDM/PDS is not applicable and is deleted.

5.3.3 Output ratings

5.3.3.1 BDM/CDM continuous operation

Replace first sentence of first paragraph with

BDMs/CDMs shall be continuously rated at the specified site conditions to supply the specified motor duty in terms of:

Justification

For proper selection of the BDM/CDM in accordance with the driven equipment, the manufacturer must specify the output ratings.

5.3.3.2 PDS continuous output

In first sentence, replace "should" with

shall

Justification

For proper selection of the BDM/CDM in accordance with the driven equipment, the manufacturer must specify the output ratings.

5.3.4 Operating quadrants

5.3.4.1 General

In first sentence, replace "should" with

shall

Justification

For proper selection of the BDM/CDM in accordance with the operating quadrants, the manufacturer must specify the input and output ratings.

5.3.6 Special ratings related to BDM/CDM/PDS or motor

5.3.6.2 Transformers and reactors

5.3.6.2.1 General

Replace last sentence of fifth paragraph with

Transformers shall comply with IEC 60076 (all parts) and IEC 61378 (all parts), or ANSI/IEEE C57 (12.00, 12.01, 12.90, 12.91. 18.10 and 110).

Justification

Required to ensure that transformers comply with the relevant standards.

5.3.6.2.6 Specific considerations

5.3.6.2.6.4 Shielding between primary and secondary winding

Replace first sentence of first paragraph with

An electrostatic shield shall be provided between the primary and secondary winding to prevent high-voltage transients being transferred to the secondary winding due to capacitive coupling.

Justification

The shield shall prevent transfer of high-voltage transients to the secondary due to capacitive coupling.

In third sentence of first paragraph, replace "should" with

shall

Justification

The dielectric effect of the shield and the increased separation of the windings significantly reduce the inter-capacitance between the windings. The shield in the transformer diverts high frequency noise, which would normally be coupled across the transformer, to the grounds of the circuit in which they occur. A low inductance of the shield connection to earth makes the purpose more effective.

5.4 Performance

5.4.1 Operational

5.4.1.4 Dynamic braking

5.4.1.4.1 Resistive braking

5.4.1.4.1.2 Resistive braking (stop)

In list item a), replace "should" with

shall

Justification

While braking the stored energy in the driven equipment (depending on the load inertia) has to be converted into electrical energy which raises the DC link voltage of the converter. This increased DC link voltage has to be controlled and hence the brake chopper unit triggers and connects/disconnects the resistor across the DC link in bursts. Thus the DC link voltage is maintained within the threshold value. In some cases the drive algorithm has inherent ability to extend the ramp down time for a short duration to control the voltage build up on the DC link. The requirement of braking can be requested at any operating speed (e.g. maximum speed) and hence the chopper unit and braking resistor shall be designed to handle current depending on the converter rating and dissipate the maximum stored energy possible in the driven equipment. An inadequately designed chopper unit and braking resistor can get damaged and cause fire hazard. So as to achieve a correct design, it is important to share the load inertia information of the driven equipment.

In first sentence of list item b), replace "should" with

shall

Justification

While braking the stored energy in the driven equipment (depending on the load inertia) has to be converted into electrical energy which raises the DC link voltage of the converter. This increased DC link voltage has to be controlled and hence the brake chopper unit triggers and connects/disconnects the resistor across the DC link in bursts. Thus the DC link voltage is maintained within the threshold value. In some cases the drive algorithm has inherent ability to extend the ramp down time for a short duration to control the voltage build up on the DC link. The requirement of braking can be requested at any operating speed (e.g. maximum speed) and hence the chopper unit and braking resistor shall be designed to handle current depending on the converter rating and dissipate the maximum stored energy possible in the driven equipment. An inadequately designed chopper unit and braking resistor can get damaged and cause fire hazard. So as to achieve a correct design, it is important to share the load inertia information of the driven equipment.

5.4.1.4.1.3 Resistive braking (slowdown)

In list item a), replace "should" with

shall

Justification

While braking the stored energy in the driven equipment (depending on the load inertia) has to be converted into electrical energy which raises the DC link voltage of the converter. This increased DC link voltage has to be controlled and hence the brake chopper unit triggers and connects/disconnects the resistor across the DC link in bursts. Thus the DC link voltage is maintained within the threshold value. In some cases the drive algorithm has inherent ability to extend the ramp down time for a short duration to control the voltage build up on the DC link. The requirement of braking can be requested at any operating speed (e.g. maximum speed) and hence the chopper unit and braking resistor shall be designed to handle current depending on the converter rating and dissipate the maximum stored energy possible in the driven equipment. An inadequately designed chopper unit and braking resistor can get damaged and cause fire hazard. So as to achieve a correct design, it is important to share the load inertia information of the driven equipment.

In list item b), replace "should" with

shall

Justification

While braking the stored energy in the driven equipment (depending on the load inertia) has to be converted into electrical energy which raises the DC link voltage of the converter. This increased DC link voltage has to be controlled and hence the brake chopper unit triggers and connects/disconnects the resistor across the DC link in bursts. Thus the DC link voltage is maintained within the threshold value. In some cases the drive algorithm has inherent ability to extend the ramp down time for a short duration to control the voltage build up on the DC link. The requirement of braking can be requested at any operating speed (e.g. maximum speed) and hence the chopper unit and braking resistor shall be designed to handle current depending on the converter rating and dissipate the maximum stored energy possible in the driven equipment. An inadequately designed chopper unit and braking resistor can get damaged and cause fire hazard. So as to achieve a correct design, it is important to share the load inertia information of the driven equipment.

5.4.2 Fault supervision

5.4.2.2 BDM/CDM/PDS protection interface

Add to subclause

The BDM/CDM shall detect an internal earth fault in the DC link.

Justification

A DC link fault is a potential source of fire, if it is not detected and isolated promptly. Drive supplier shall have appropriate measures to detect the earth fault in the DC link and provide means for isolating the fault by tripping the supply feeder.

Add to subclause

When an internal earth fault in the DC link is detected, the BDM/CDM shall provide a means of isolating the earth fault.

Justification

A DC link fault is a potential source of fire, if it is not detected and isolated promptly. Drive supplier shall have appropriate measures to detect the earth fault in the DC link and provide means for isolating the fault by tripping the supply feeder.

Table 11 — PDS protection functions

Add rows to Line feeder section

Line feeder	Alarm	Trip	Remark
Earth fault	X	X	

Add rows to Transformer section

Transformer	Alarm	Trip	Remark
Short circuit	X	X	
Earth fault	X	(X)	
Pressure relief valve	X	X	Oil-type only

Add rows to Converter section

Converter	Alarm	Trip	Remark
Short circuit	X	X	Line-Line-Line, Line-Line, Line-Line-Ground
Undervoltage	X		
Underload	X		
Control power trouble	X		
Control unit processor/watchdog failure	X	X	
Cooling system changeover failure	X	(X)	
Short time converter output current limit protection	X		

Add rows to Motor section

Motor	Alarm	Trip	Remark
Short circuit	X	X	
Phase loss	X	X	
Motor stall/jam	X	(X)	
Earth fault in stator winding	X	(X)	
Loss of field	X	X	Synchronous motor only
Exciter current short circuit	X	X	Synchronous motor only
Exciter earth fault	X	X	Synchronous motor only
Overtemperature exciter stator winding	X	X	Synchronous motor only

Add table NOTE 3

NOTE 3 The protection functions listed in this table are achieved via an external protective device or by BDM itself. No external device/component/circuit is required unless the BDM is not able to achieve a particular protection function.

5.4.3 Minimum status indication required

Replace subclause with

The BDM/CDM/PDS shall be equipped with status indication for:

- mains circuit breaker off;
- mains circuit breaker on;
- drive ready;
- drive run;
- drive trip;
- drive common alarm;
- output isolator off (if applicable);
- output isolator on (if applicable).

Justification

The HV AC Drive system is a group of panels with components mostly located inside enclosure. In order to know the drive status few essential minimum parameters can be displayed on the front panel either via indication lamps or via display unit.

5.4.4 I/O devices

5.4.4.1 General

In first paragraph, replace "should" with

shall

Justification

Inputs and outputs for variables and parameters are dependent on the wiring interface considered in the project. Hence the quantity of I/O and type (current, voltage, communication based and sink/source, relay/opto-coupler, etc.) shall be specified to have a proper interfacing with the control system (DCS/PLC).

5.5 General safety

Replace first sentence with

The general safety evaluation of the BDM/CDM/PDS shall be performed in accordance with IEC 61800-5-1 or IEEE 1566.

Justification

The safety evaluation of the BDM/CDM/PDS is covered by the products safety standard IEC 61800-5-1 or IEEE 1566 (for drive installed in North America).

5.6 Functional safety

Replace fourth paragraph with

The functional safety of the BDM/CDM/PDS shall be in accordance with IEC 61800-5-2.

Justification

The functional safety evaluation of the BDM/CDM/PDS is covered by the functional safety standard IEC 61800-5-2.

5.7 EMC

Replace third paragraph with

EM compatibility of the BDM/CDM/PDS shall be in accordance with IEC 61800-3.

Justification

IEC 61800-3 provides EMC requirements and test methods for AC drive system to be complied with.

Replace fourth paragraph with

EM immunity, associated with the functional safety of the BDM/CDM/PDS shall be in accordance with IEC 61800-5-2.

Justification

The functional safety evaluation of the BDM/CDM/PDS including guidance for EM immunity is covered by the functional safety standard IEC 61800-5-2.

5.9 Environmental condition for service, transport and storage

5.9.1 General

Replace first sentence with

Service conditions for operation shall be selected in accordance with IEC 60721 series.

Justification

IEC 60721 (classification of environmental conditions) provides all details related to service conditions and shall be the best guidance standard to be followed by manufacturer. This standard provides an uniform values for aspects related to environmental condition, mechanical installation, operating condition, etc as a reference amongst the manufacturers.

5.9.2 Operation

5.9.2.1 Climatic conditions

5.9.2.1.1 General

Replace first paragraph with

The BDM/CDM/PDS shall comply with the values provided in Table 12 for environmental service condition.

Justification

The environmental service condition for the BDM/CDM/PDS, when stated by the manufacturer helps in selection of the BDM/CDM/PDS as per the intended location of installation and service. This shall ensure that the equipment shall perform as intended in the installed environment.

5.10 Types of load duty profiles

Add to first paragraph

The output current ratings of the BDM/CDM shall comply with motor rated full load current operating in continuous running duty, duty type S1, in accordance with IEC 60034-1.

Justification

The most common duty type for application in oil & gas industry is continuous running duty, duty type S1. Accordingly the output current ratings of the BDM/CDM must comply with motor rated full load current which is operating in continuous running duty.

6 Test

6.5 Standard tests for BDM/CDM/PDS

6.5.1 General

Replace subclause with

Testing of the BDM/CDM/PDS and identified PDS components shall be performed in accordance with Table 22.

Justification

There are few tests which the end user / client would require to be performed on the BDM/CDM/PDS (one or more quantity from the purchase order) and the suggested table 22 identifies the essential minimum routine and performance test requirements to be performed. The table also lists the test location and test parameter/measurement values. Table-6 in the parent standard only identifies visual inspection as part of routine test which is not practical adequate in case of HV AC drive systems.

Add new Table 22

Table 22 — Standard tests for BDM/CDM/PDS

Test description [a, b]	Test to be performed on	Testing location	Test parameters/measurements	Remarks
Routine tests				
Visual inspection	BDM	Manufacturer's facility	Dimensions, mass, degree of protection, individual marking, accessibility, tag and rating plate, lifting arrangements, indication and HMI functionalities, earthing and padlocking, etc.	
Insulation	BDM	Manufacturer's facility	Insulation values of components and devices	
Light load / full current test using a reactor	BDM	Manufacturer's facility	Current values, converter temperature rise, time duration till the temperature stabilizes	Time duration may vary based on the drive topology and converter type
Functional tests				
Start-up sequence and operation	BDM	Manufacturer's facility	Interlocks (door limit switches, etc.), controls, ramp up/down, schematics, remote access, alarms, trips (overload, overvoltage, earth fault), skip frequency bands, E-stop, communication network, etc.	
DC link undervoltage	BDM	Manufacturer's facility	Drive trip below minimum DC link voltage	
Disturbance ride-through and restart	BDM	Manufacturer's facility	Ride-through and restart function	
Speed control function	BDM	Manufacturer's facility	Maximum and minimum speed operation, ramp up / ramp down function, behaviour on loss of speed set point signal (analog/communication link), set point vs, output speed accuracy and linearity, etc.	
Automatic restart/re-acceleration and flying restart capability following a trip at full speed	BDM/CDM/PDS	During string test (location as per purchase order)	Automatic restart and catch on fly/flying restart function	Test if required for intended application
Heat run tests at rated load	CDM/motor	Respective manufacturer's facility	Transformer temperature rise, Motor temperature rise, Bearing temperatures, Shaft vibrations, etc.	
Load characteristic (load envelope)	PDS	During string test (location as per purchase order)	Voltage, current and power at terminals of converter transformer input, converter input and motor input, current unbalance, test of current/torque limiting functions, torque capability, power factor, output voltage waveform, output current waveform, etc.	Test optional per application/rating

Table 22 *(continued)*

Test description [a, b]	Test to be performed on	Testing location	Test parameters/measurements	Remarks
Harmonic distortion (current)	PDS	Field test	Harmonics values up to 40th harmonics in current on the line side and motor side	Test optional
Functionality of all auxiliary devices (cooling system)	BDM (auxiliaries)	Respective manufacturer's facility	Auto start / auto changeover of standby auxiliaries, Replacement of filter and de-ioniser resin bottle in operation, leak detection, water conductivity, static pressure, differential pressure, low flow, water temperature, simulation of warning/alarms from cooling unit	
Bearing insulation	Motor	Motor manufacturer's facility	Shaft voltage, bearing insulation (ohmic value)	
Audible noise	Individual PDS components	Respective manufacturer's facility	Noise (dBA) at 1 m distance	
Torque pulsation	PDS	During string test (location as per purchase order)	Air gap torque pulsations calculated using speed and/or current measurements	Test optional

NOTE The performance tests may be carried out on at least one HV AC drive system of a group of identical systems rated 4 MW and above, within the same purchase order.

[a] The tests in this table shall be conducted for validation of performance and functionality in accordance with the applicable tests specified in Table 6.

[b] When a required test is not listed in Table 6, the test procedures with the relevant acceptance criteria shall be provided by the responsible party, as described in 4.2.

7 Information and marking requirements

7.1 General

Add to subclause

Name plates shall be 316L stainless steel.

Justification

The nameplate shall be lasting and must retain all information marked on it for its entire service life. SS material is durable and does not need any environment protection like painting. Hence SS plate will ensure that it will not rust or deteriorate over the entire service life. Similarly the hardware used for fixing these nameplates shall be of corrosion-resistant material too.

Add to subclause

Name plates shall be affixed with 316L stainless steel rivets or screws.

Justification

The nameplate shall be lasting and must retain all information marked on it for its entire service life. SS material is durable and does not need any environment protection like painting. Hence SS plate will ensure that it will not rust or deteriorate over the entire service life. Similarly the hardware, i.e. screws or rivets, used for fixing these nameplates shall be of SS material too.

7.2 Marking on product

In first paragraph, replace "should" with

shall

Justification

Marking of the minimum required information on the product shall ensure full identification and traceability of the product and the manufacturer.

In second paragraph, replace "should" with

shall

Justification

Marking of the minimum required information on the product shall ensure full identification and traceability of the product and the manufacturer.

In third paragraph, replace "should" with

shall

Justification

Marking of these additional information of PDS shall provide product capability data along with full identification and traceability of the product and the manufacturer.

Add to subclause

Vertical section and door-mounted instruments shall be identified with permanently engraved laminated nameplates.

Justification

Marking of the legend information on the vertical section and door mounted instruments will facilitate cross identification of the panel section and installed components with the relevant documentation (GA drawing and wiring diagrams).

Add to subclause

Internal components, PC boards, devices, protection relays, instruments and terminal blocks shall be identified, in accordance with the wiring diagrams, by permanent labels fixed on the non-removable part of the component or on the structure of the enclosure.

Justification

Marking of the legend information on the internal components and other items will facilitate cross identification of these installed items with the relevant documentation (GA drawing and wiring diagrams).

7.3 Information to be supplied with the PDS or BDM/CDM

In first paragraph, replace "should" with

shall

Justification

These information are important for proper installation, commissioning and operation of the BDM/CDM/PDS.

In second paragraph, replace "should" with

shall

Justification

These information are important for proper installation, commissioning and operation of the BDM/CDM/PDS.

In third paragraph, replace "should" with

shall

Justification

These information are important for proper installation, commissioning and operation of the BDM/CDM/PDS.

7.4 Information to be supplied or made available

In first paragraph, replace "should" with

shall

Justification

These information are important for proper operation and maintenance of the BDM/CDM/PDS.

In second paragraph, replace "should" with

shall

Justification

These information are important for proper operation and maintenance of the BDM/CDM/PDS.

7.5 Safety and warning

7.5.1 Safety and warning labels

In first paragraph, replace "should" with

shall

Justification

These information are important for safe operation of the BDM/CDM/PDS

<u>*Add to subclause*</u>

Caution, danger and warning labels with instructions and graphical symbols shall be in accordance with IEC 60417 or ISO 7010.

Justification

The symbols are commonly accepted one which indicate the hazard pictorially for the personnel to understand the risk involved. Also the caution and warning labels guide then to take necessary precautions to mitigate the hazards. These instructions, in addition to English, can be in other local language depending on the country of installation, as specified in the datasheet.

<u>*Add to subclause*</u>

Caution, danger and warning labels shall display information in English and in the specified language.

Justification

The symbols are commonly accepted one which indicate the hazard pictorially for the personnel to understand the risk involved. Also the caution and warning labels guide then to take necessary precautions to mitigate the hazards. These instructions, in addition to English, can be in other local language depending on the country of installation, as specified in the datasheet. The local language shall help better in understanding the instructions.

<u>*Add to subclause*</u>

Transport and anchoring hardware that needs to be removed when the equipment is installed shall be identified with caution labels or tags.

Justification

Some additional hardware like braces clamps bolts, tie rods, etc are installed in the equipment to protect the components from damage during transportation. These are to be removed after installation to permit proper operation of the components. To identify such hardware, supplier must provide appropriate label and tags to alert the site personnel to remove such hardware after installation.

7.5.2 Additional safety considerations of a PDS

<u>*In third paragraph, replace "should" with*</u>

shall

Justification

The preceding two paragraphs of 7.5.2 adequately justifies the reasons to consider compliance of BDM/CDM/PDS with IEC 61800-5-1 as a requirement.

<u>*Add new clause*</u>

8 Constructional requirements

8.1 General

8.1.1

BDMs shall comply with the emissions and immunity limits in accordance with IEC 61800-3.

Justification

Table 22 to 24 of IEC 61800-3 provides the limits of propagated disturbances (voltage/EMC) which sets a guideline for limiting the disturbance caused by the installation to other networks in the vicinity. These tables are applicable for AC Drive systems which are above 1000 volts and installed in second environment (classified as category C4).

8.1.2

Safety aspects shall be in accordance with IEC 62477-2 or UL 347A or CSA 22.2 NO 274.

Justification

For the HV AC Drives, the safety aspects are in accordance with EC 62477-2
In north American market, following standard are considered:
- UL347A for US
- CSA C22.2 NO 274-17 for Canada

8.2 Enclosure

8.2.1 Design

8.2.1.1

When a high voltage compartment door is not closed and secured, door interlocks shall prohibit the energizing of PDS components.

Justification

It is very important to ensure that under no circumstances shall high voltage exposure occur to any personnel. Hence the interlock will ensure that unless all doors are closed and secured, high voltage power will not be released to the HV AC drive system panel and if any doors are opened while the high voltage compartment is energised, the upstream breaker will trip and prevent high voltage exposure occur to any personnel.

8.2.1.2

When the PDS is energized, high voltage compartment doors shall be prevented from opening.

Justification

It is very important to ensure that under no circumstances shall high voltage exposure occur to any personnel. Hence the interlock will ensure that unless all doors are closed and secured, high voltage power will not be released to the HV AC drive system panel and if any doors are opened while the high voltage compartment is energised, the upstream breaker will trip and prevent high voltage exposure occur to any personnel. To avoid such tripping, it shall not be possible to open the door of high voltage compartments.

8.2.1.3

Unless the high voltage supply is withdrawn with power components in the compartment electrically isolated and discharged or electrically isolated and earthed, the doors of the high voltage compartment shall not open.

Justification

It is very important to ensure that under no circumstances shall high voltage exposure occur to any personnel. Hence the interlock will ensure that unless all doors are closed and secured, high voltage power will not be released to the HV AC drive system panel and if any doors are opened while the high voltage compartment is energised, the upstream breaker will trip and prevent high voltage exposure occur to any personnel. To avoid such tripping, it shall not be possible to open the door of high voltage compartments. After the high voltage input supply is isolated, the high voltage compartment doors of the HV AC drive system shall be prevented from opening unless the compartments are electrically isolated, discharged and/or earthed. (Note earthing switch is optional and considered if specified in the datasheet).

8.2.1.4

Door interlocks shall not be provided for control or cooling compartments that require access for service or maintenance during operation.

Justification

Unlike the high voltage compartment, the control or cooling compartment shall require access for service (setting, checking, etc.) or maintenance (pump / fan / cooling system accessories, etc) during operation. Hence a door interlock would impede these activities when required to be performed during operation. The design shall consider appropriate layout arrangement and avoid door interlocks for such compartments.

8.2.1.5

Compartments without door interlocks shall have no exposed live parts with voltages equal to or greater than 50 V.

Justification

It is very important to ensure that under no circumstances shall high voltage exposure occur to any personnel. Hence the interlock will ensure that unless all doors are closed and secured, high voltage power will not be released to the HV AC drive system panel and if any doors are opened while the high voltage compartment is energised, the upstream breaker will trip and prevent high voltage exposure occur to any personnel. To avoid such tripping, it shall not be possible to open the door of high voltage compartments.Unlike the high voltage compartment, the control or cooling compartment shall require access for service (setting, checking, etc.) or maintenance (pump / fan / cooling system accessories, etc) during operation. Hence a door interlock would impede these activities when required to be performed during operation. The design shall consider appropriate layout arrangement and avoid door interlocks for such compartments. Supplier must ensure that such compartments without door interlocks shall not have any exposed live parts with voltages of 50 volts and greater which can be a source of shock hazard to the personnel working.

8.2.1.6

When the door is open, the low voltage compartments with live parts, accessible during operation, shall provide a degree of protection of at least IP20 in accordance with IEC 60529.

Justification

Unlike the high voltage compartment, the control or cooling compartment (low voltage) shall require access for service (setting, checking, etc.) or maintenance (pump / fan / cooling system accessories, etc) during operation. Hence a door interlock would impede these activities when required to be performed during operation. The design shall consider appropriate layout arrangement and avoid door interlocks for such compartments. Supplier must ensure that such low voltage compartments without door interlocks shall not have any exposed live parts with voltages of 50 volts and greater which can be a source of shock hazard to the personnel working and shall provide a degree of protection of minimum IP20 (touchproof and resistant to dust or objects that are over 12mm in size).

8.2.1.7

When the cover and door are closed, the low voltage compartment shall provide a degree of protection of at least IP21 in accordance with IEC 60529.

Justification

Unlike the high voltage compartment, the control or cooling compartment (low voltage) shall require access for service (setting, checking, etc.) or maintenance (pump / fan / cooling system accessories, etc) during operation. Hence a door interlock would impede these activities when required to be performed during operation. The design shall consider appropriate layout arrangement and avoid door interlocks for such compartments. Supplier must ensure that such low voltage compartments without door interlocks shall not have any exposed live parts with voltages of 50 volts and greater which can be a source of shock hazard to the personnel working and shall provide a degree of protection of minimum IP20 (touchproof and resistant to dust or objects that are over 12mm in size). Such low voltage compartment shall provide a degree of protection of minimum IP21 when the cover and door are closed.

8.2.1.8

The stray magnetic field of the BDM/CDM components shall not cause vibrations in the enclosure.

Justification

The HV AC drive systems may have magnetic components such as transformers, reactors, etc. which causes electric hum. This is caused due to stray magnetic fields resulting in the enclosure and accessories to vibrate. To minimise the resulting vibration, the enclosure design shall be robust by providing adequate reinforcement with stiffeners to dampen vibration due to these stray magnetic fields.

8.2.1.9

Devices that may cause a trip due to vibration or impact shall not be mounted on the enclosure door.

Justification

Some door mounted devices like push buttons, selector switches, etc. may malfunction due to vibration or impact on the enclosure and cause trip (depending on the wiring of the device within the schematic). Hence if the device is must to be installed on the enclosure door, the selection of such devices shall be tolerant to vibration or impact.

8.2.1.10

Undrilled removable gland plates or multi-cable transits shall be used for cable entry.

Justification

The cable sizes will depend on various factors like drive rating, cable conductor, derating factors, etc. Accordingly the cable entries need to be drilled after the cable sizes are finalised. Hence either undrilled gland plates or multi-cable transits (MCT) as per project requirement must be specified. This selection shall be exercised from the datasheet.

8.2.1.11

Gland plates shall be non-magnetic.

Justification

In case of three core cables, the net magnetic field produced by all the phases due to currents, sum up to zero. But in case of single core cables, the net flux surrounding it does not cancel out. If these flux gets linked with MS (magnetic gland plate), it will induce eddy currents in it. This current results in heating of glands and subsequently failure of cable insulation due to heat. However in case of HV AC drive systems, most of the times, single core cables are used due to the higher current ratings. Hence to reduce options, non-magnetic gland plates is being standardised upon.

8.2.1.12

Bolted covers on the side or rear of enclosures shall be removable from the outside.

Justification

In any rare event of maintenance requirement, if the bolted covers are to be removed, it shall be possible to do so from the outside, rather than having to access it from within the panel.. This shall facilitate for shorter maintenance time and lesser efforts.

8.2.1.13

Unpainted hardware of the enclosure shall be of non-corrosive material or coated with a non-corrosive material.

Justification

Hardware like hinges, brackets, clamps, latches, bolts, nut, washers, etc. shall be of either non-corrosive material or shall be coated with a non-corrosive material to prevent corrosion on the hardware.

8.2.2 Accessibility and clearances

8.2.2.1

The internal layout within the enclosure shall permit servicing or replacement of components and modules from the front.

Justification

The layout design of the components and modules shall be done with the objective to facilitate service, maintenance and repair of items from the front of the enclosure. This is more relevant in location where there is space constraint and no additional space is required around the enclosure for service, maintenance and repairs. This will ensure minimum dismantling, faster restoration and increased availability of the drive system.

8.2.2.2

The arrangement of the components within the enclosure shall permit installation of the enclosure against a wall without need for access from the rear.

Justification

This requirement is not always possible as of now across manufacturer and models, but the intent is to have a standard philosophy to ensure that all drive configuration and topology allow installing the drive system with the rear placed against the wall. This will optimise the space requirement and reduce variants among the drive manufacturer on this aspect.

8.2.2.3

Hinged doors of compartments with power components, isolating switches and breakers shall have a facility for padlocking.

Justification

The drive enclosure has compartment with high voltage power supply source. During maintenance activities on the drive/motor/driven equipment, it shall be possible to implement the LOTO (lock out tag out) procedure. The isolation devices have standard padlocking arrangement and are locked out using a pad lock in open position. However the compartment door also need to be locked out to ensure safety of the maintenance personnel.

8.2.2.4

Hinged doors of enclosures shall open at least 90°.

Justification

Since the earlier requirements mandates access from the front for service and maintenance, it needs unobstructed accessibility by keeping the hinged door wide open. Also the locking arrangement of the door in open position will not impede the maintenance personnel while working. This requirement is now being considered for drive systems installed on floating units, but it is also increasing requested for onshore installations

8.2.2.5

Hinged doors shall have a door stay to secure the door in open position.

Justification

Since the earlier requirements mandates access from the front for service and maintenance, it needs unobstructed accessibility by keeping the hinged door wide open. Also the locking arrangement of the door in open position will not impede the maintenance personnel while working. This requirement is now being considered for drive systems installed on floating units, but it is also increasing requested for onshore installations

8.2.3 Compartmentalization/sectionalization

8.2.3.1

Enclosures shall have the vertical sections segregated in accordance with the voltage levels and the need for access during operation.

Justification

Compartmentalisation according to high voltage and low voltage is important to ensure restricted access, implementing LOTO procedure and permitting access to compartment with auxiliaries like cooling system for maintenance and troubleshooting to ensure that the HV AC drive system remains operational with least downtime. This is achieved by the arrangement of components and systems as per voltage levels and need for access during operation.

8.2.3.2

Components and auxiliaries that need open-door access during operation shall not be mounted inside high-voltage compartments.

Justification

It shall not be possible to open the high voltage compartment due to the door interlock which prevent it from opening doors when drive is energised, hence components and/or auxiliaries that need access during operation shall not be housed in high voltage compartment.

8.2.3.3

The arrangement of compartments shall minimize the interconnecting cables between the compartments.

Justification

The compartments when arranged in a logic sequence as per the power flow shall ensure that back and forth cabling connections are avoided across the components. Hence the component arrangement and internal GA shall be well thought of to achieve this objective.

8.2.4 Internal arc classification

8.2.4.1

An arc-resistant enclosure for high voltage compartments, based on the maximum three-phase short circuit current from the power system source, shall be provided in accordance with IEC 62271-200 or IEEE C37.20.7.

Justification

IEC62271-200 (for Arc Flash Test purpose) is equivalent to the US IEEE C37-20-7 2007 corrigendum 2010-1. Internal arc compliant high voltage compartments provide safety level similar to the high voltage switchgear being installed which forms the minimum requirement now-a-days.

8.2.4.2

The incident power level of an electric arc shall be calculated in accordance with IEEE 1584.

Justification

IEEE 1584 titled ' Guide to performing Arc Flash Calculations' provides a method for determining an arcing fault current, incident energy, arc flash protection boundaries, etc. based on empirical results from numerous tests. This guide is applicable from 0.208 to 15 kV range. The revised standard provides a very detailed procedure to calculate the incident energy and the arc-flash boundary.

8.2.4.3

The arc flash energy calculations for a fault in the electrical network shall include the current contribution from the motors in the network.

Justification

The fault shall result in system voltage dip. This will cause a motors to re-generate and feed the fault increasing the resulting arc energy and the severity, Hence the arc flash energy calculation shall include this component also to evaluate the incident energy correctly.

8.2.4.4

The accessibility type shall be 2b, in accordance with IEC 62477-2:2018, Table AA.1.

Justification

The accessibility type '2b' is for skilled personnel only (no physical boundary) which is appropriate for the BDM/CDM installation in electric room.

8.2.4.5

The internal arc classification of the enclosure shall be AFLTB for enclosures placed against a wall and AFLRTB for other installations.

Justification

An internal arc fault classification (IAC) of a switchgear or enclosure is in accordance with IEC 62271-200. The classification distinguishes as follows:

- *Accessibility:*
  - *A – access for qualified personnel only*
  - *B – public access (meaning a testing under tightened conditions)*
- *Classified accessible sides of the switchgear or enclosure:*
  - *F – Front*
  - *L – Lateral*
  - *R – Rear*
  - *T – Top*
  - *B – Bottom.*

8.2.4.6

The rated arc fault current of the enclosure shall be no less than the cumulative contribution of fault currents from all branches of the system.

Justification

The electrical system may have multiple power sources including generating sources. All these power sources contribute fault current to the fault in the system. Also fault current contribution from motors in the system adds to the fault level. The arc flash energy is a function of the arc fault current, arc duration, enclosure type and the distance from the arc. Thus the cumulative contribution from all branches in the system shall be computed and the enclosure rated arc fault current shall be above this cumulative value to withstand the arc flash energy.

8.2.4.7

The rated arc fault current withstand duration of the enclosure shall be no less than 0.5 s.

Justification

The electrical system may have multiple power sources including generating sources. All these power sources contribute fault current to the fault in the system. Also fault current contribution from motors in the system adds to the fault level. The arc flash energy is a function of the arc fault current, arc duration, enclosure type and the distance from the arc. Thus the cumulative contribution from all branches in the system shall be computed and the enclosure rated arc fault current shall be above this cumulative value to withstand the arc flash energy. The trip time of a protective element is determined from its time-current characteristics and usually set for faster clearing of the fault. Meanwhile the enclosure shall withstand the arc duration.

8.2.4.8

The internal arc classification rating plate information shall be in accordance with IEC 62477-2.

Justification

An enclosure shall be verified by type tests according to IEC 62477-2, Clause AA.5 or shall be assigned the accessibility type 0 or 0+ when not tested by manufacturer. For a IAC panel, a rating plate in accordance with IEC 62477-2, clause AA 7.2 shall be indicated through a nameplate with tested values. This data will provide the information on the internal arc withstand capability, associated protection required (APR), special conditions, etc.

8.2.4.9

When required in accordance with IEC 62477-2, associated protection or special conditions shall be documented.

Justification

An enclosure shall be verified by type tests according to IEC 62477-2, Clause AA.5 or shall be assigned the accessibility type 0 or 0+ when not tested by manufacturer. For a IAC panel, a rating plate in accordance with IEC 62477-2, clause AA 7.2 shall be indicated through a nameplate with tested values. This data will provide the information on the internal arc withstand capability, associated protection required (APR), special conditions (SC), etc. These associated protection required (APR) and special conditions (SC) are indicated as 'yes/no' on the rating plate and the details shall be part of the documentation.

8.3 Components

8.3.1 General

8.3.1.1

Components weighing more than 25 kg shall be provided with lifting or pulling lugs.

Justification

Considering ergonomic issues while handling heavy items, any item weighing more than 25 kgs (industry practice) shall be provided with appropriate lifting/pulling lugs and the access shall be from the front of the enclosure.

8.3.1.2

Main circuit switches, MCBs, MCCBs and contactors shall be in accordance with IOGP S-560 or IOGP S-732.

Justification

These standards address the low voltage switchgear component requirements and have further normative references to IEC and UL standards.

8.3.2 Converter

8.3.2.1

The converter power device or cell arrangement shall permit replacement of the power module or the control printed circuit board in less than 1 h.

Justification

The components like power module or control printed circuit board are more prone to failure than other robust items like transformer, reactor, LV switchgear components, etc. The faster the maintenance and replacement time, the better the mean time to repair (MTTR) value. A lower MTTR value is always aimed for improved reliability and better availability. This will reduce the production loss and financial loss

8.3.2.2

The fault withstand duration of the rectifier section of the converter shall be greater than the mains breaker release time.

Justification

The mains breaker is the interrupting device for any overcurrent/short circuit related issue in the rectifier. The opening of the mains breaker take a definite minimum time till which the rectifier components have to withstand the fault scenario. Hence the supplier shall consider this breaker opening time and design the rectifier such that it will survive the fault duration without any internal failure.

8.3.2.3

The converter control system shall identify and isolate a faulty module.

Justification

Such a feature will ensure that the redundancy is effectively utilised without impacting the reliability of the converter and avoid production loss.

8.3.2.4

When the control system isolates a faulty converter module, the converter shall continue to operate uninterrupted.

Justification

Such a feature will ensure that the redundancy is effectively utilised without impacting the reliability of the converter and avoid production loss.

8.3.3 Cooling

8.3.3.1 General

8.3.3.1.1

Cooling fans shall be redundant.

Justification

For such large capacity drive, cooling is an important factor for reliable operation of the drive. Hence these drives have redundant cooling system (either complete system or components). Forced cooling systems consists of fans and pumps (for air/water cooled systems). The cooling topology (forced air, air-water, water-water) is dependent on manufacturer model/design, capacity of the drive, space availability, etc. Redundancy in cooling fans will ensure improved reliability and availability.

8.3.3.1.2

Cooling circuit pumps shall be redundant.

Justification

For such large capacity drive, cooling is an important factor for reliable operation of the drive. Hence these drives have redundant cooling system (either complete system or components). Forced cooling systems consists of fans and pumps (for air/water cooled systems). The cooling topology (forced air, air-water, water-water) is dependent on manufacturer model/design, capacity of the drive, space availability, etc. Redundancy in cooling pumps will ensure improved reliability and availability.

8.3.3.1.3

When an operational cooling fan or pump fails, transfer of operation to the standby cooling fan or pump shall be initiated automatically.

Justification

To effectively utilise the redundancy of components, the transfer to redundant equipment shall be automatic upon detection of failure of the working equipment.

8.3.3.1.4

When automatic transfer is initiated due to a fault of a working fan or pump, the control system shall generate an alarm.

Justification

Any transfer from the working equipment to the standby (redundant) equipment in the event of a failure shall generate an alarm to alert/notify the occurrence of the event.

8.3.3.1.5

The control system shall have a feature for periodic transfer of operation between working and standby cooling fans and pumps.

Justification

It is a good practice to operate the main and standby equipment alternately. This equipment transfer shall ensure readiness of the standby equipment, balanced wear & tear and reliability of the transfer logic.

8.3.3.1.6

Periodic transfer of operation between the working and standby units shall be initiated on elapse of the user-defined run-time interval.

Justification

Periodic transfer interval is set in the control system of the BDM. If the periodic transfer interval is set for a predefined common time, every equipment will have the same run time and the probability of failure/wear-out will be almost similar which would be a risky situation. Hence it is a good proposition to select a 60-40 or 55-45 operation duration for the set of equipment to space the run time and thereby the possible failure/wear-out between them. This will provide sufficient time for the maintenance team to take up maintenance activities on the defective equipment.

8.3.3.1.7

The run-time interval for periodic transfer shall be configurable in the control system individually for each cooling fan and pump.

Justification

Periodic transfer interval is set in the control system of the BDM. If the periodic transfer interval is set for a predefined common time, every equipment will have the same run time and the probability of failure/wear-out will be almost similar which would be a risky situation. Hence it is a good proposition to select a 60-40 or 55-45 operation duration for the set of equipment to space the run time and thereby the possible failure/wear-out between them. This will provide sufficient time for the maintenance team to take up maintenance activities on the defective equipment.

8.3.3.1.8

The control system shall permit manual transfer of operation between working and standby cooling fans and pumps.

Justification

In addition to the automatic transfer during failure and periodic transfer, the provision of manual transfer is also required at times. If any abnormality is observed or in order to perform any maintenance activities on the working equipment, there could arise a need for manual transfer. This feature will help in such situations.

8.3.3.1.9

The BDM/CDM/PDS shall continue to operate uninterrupted during the transfer of operation between the working and standby units.

Justification

The transfer of operation between the working and standby units must be rapid and executed without impacting the cooling effectiveness of the drive system. Any drop in cooling below the safety/design threshold will trigger a trip of the drive system, hence this requirement has to be complied with to ensure continued operation.

8.3.3.1.10

The control system shall initiate an alarm on failure of periodic transfer of operation between the working and standby units.

Justification

The alarm will immediate draw attention to the abnormality and necessary actions can be initiated to prevent drive tripping.

8.3.3.1.11

The cooling system shall be designed for the heat losses of the BDM/CDM at rated output for the specified ambient temperature.

Justification

The cooling system shall be capable of removing the heat generated within the BDM/CDM at the rated output even when the HVAC system has failed (designed to perform at maximum ambient temperature). This shall ensure that the BDM/CDM performance remains unaffected by the external climatic disturbances and improves the drive system reliability.

8.3.3.1.12

A fault in the cooling system shall prevent the start of the BDM/CDM.

Justification

The interlock will ensure that the drive does not start with a defective cooling system and cause an intermediate breakdown. The system shall monitor the healthiness as part of starting logic to ensure the drive reliability is maintained and avoid a failure due to the auxiliary systems.

8.3.3.2 Air cooling

8.3.3.2.1

Air-cooling fans shall be equipped with a monitoring facility.

Justification

Operation of cooling fans are monitored either by air flow, thermal trip, status of protection device, etc. In any case a failure of cooling fan shall alert the maintenance staff of an abnormality.

8.3.3.2.2

Failure of an air-cooling fan shall generate an alarm without shutting down the BDM/CDM.

Justification

Cooling systems are very critical for operation of such large power drives and considering fan redundancy, failure of a single fan shall not cause shutdown of the drive rather should generate an alarm to alert the occurrence of an abnormal event within the drive. This will alert the maintenance staff to take necessary action to manage the situation effectively.

8.3.3.3 Liquid cooling

8.3.3.3.1

Low-voltage three-phase motors for liquid cooling pumps and fans shall conform to IEC 60034 or IEEE 841.

Justification

Standard related to three phase induction motors used for auxiliaries in HV AC drive systems shall follow IEC 60034 for rest of world and IEEE 841 for North America.

8.3.3.3.2

Check valves shall not be used for isolation purposes in the liquid cooling circuit.

Justification

Check valves though inexpensive does not provide internal status of the valve and hence not suitable for isolation purpose. Since there is no external manual control to know the valve status, it cannot be relied upon. Though there are multiple types of check valves, it still has limitation in its installation configurations.

8.3.3.3.3

Piping and tubing in the liquid cooling circuit shall have a service life of at least 20 years

Justification

Piping and tubing material are mostly metallic or of long lasting material and hence can have a service life of at least 20 years. Hoses, gaskets, seals, etc. need to be replaced periodically during maintenance cycle.

8.3.3.3.4

External pipe connections shall be provided with mating flanges, gaskets and fixing hardware.

Justification

Though the metric and imperial system shall be identified in the datasheet, it is better to ensure that the appropriate mating flanges, gasket and hardware are supplied by the manufacturer for proper interface.

8.3.3.3.5

When the cooling medium is sea water, heat exchangers and valves shall be designed for an open ventilated area or outdoor installation.

Justification

Sea water is saline and hence corrosive. The exchanger may need descaling/cleaning and hence better to be located outdoors or in an open ventilated area, i.e. outside electrical rooms. The outdoor conditions are part of datasheet and vary from project to project which the supplier shall comply with.

8.3.3.3.6

The liquid cooling system shall be provided with instruments for protection and measurement of conductivity, pressure, temperature, liquid level and leakage.

Justification

The probe & sensors are the primary devices in the cooling circuit which detects any abnormality. The control system accordingly triggers an alarm or trip based on the severity of the abnormality as per the defined logic. Thus these probes and sensors are important for maintaining the healthiness of the cooling system.

8.3.3.3.7

The liquid cooling system shall permit replacement of consumables while the BDM/CDM is in operation.

Justification

The maintenance of components (fans and pumps) and replacement of consumables are important to keep the cooling system healthy and support continuous drive operation. Such activities needs to be performed while the drive remains in operation as drive shutdown for cooling system maintenance is not a realistic proposition. Redundancy and proper safety is considered to execute this activity to ensure that the drive operation remains unhampered.

8.3.3.3.8

The liquid cooling system shall allow liquid sampling, topping up, changing of de-ionizer, filter replacement, water polishing, etc. while continuing the liquid flow in the BDM.

Justification

The maintenance of components (fans and pumps) and replacement of consumables are important to keep the cooling system healthy and support continuous drive operation. Such activities needs to be performed while the drive remains in operation as drive shutdown for cooling system maintenance is not a realistic proposition. Redundancy and proper safety is considered to execute these activities to ensure that the drive operation remains unhampered.

8.3.3.3.9

The liquid cooling system shall permit maintenance of the standby fan and pump while the BDM/CDM is in operation.

Justification

The maintenance of components (fans and pumps) and replacement of consumables are important to keep the cooling system healthy and support continuous drive operation. Such activities needs to be performed while the drive remains in operation as drive shutdown for cooling system maintenance is not a realistic proposition. Redundancy and proper safety is considered to execute this activity to ensure that the drive operation remains unhampered.

8.3.3.3.10

With the mains supply disconnected and isolated, the power semi-conductor devices shall be replaceable without draining the cooling medium from the liquid cooled converter.

Justification

The design of the cooling system shall not demand drain out of the cooling medium for replacement of a power device while the drive is disconnected and isolated. In order to keep the MTTR value low, such design consideration shall be of utmost importance.

8.3.3.3.11

Dew formation within the liquid cooled drive system shall be prevented.

Justification

There could be a possibility of dew formation due to failure of HVAC system of the building or due to other factors which is detrimental to the safety and operation of the drive system. Hence dew formation shall be prevented for occurring within the drive under any situation.

8.3.3.3.12

BDM/CDM compartments with cooling medium pipes shall have a means of containing leaks.

Justification

The occurrence of leakage of cooling medium is a possibility and needs mitigation plan to be considered to handle the situation. Hence a drip/leak containment pan shall be provided in each compartment of the BDM/CDM where the cooling pipes are run. These pans will restrict the spillage further and contain the leak within the pan. Additionally sensors/probes for leak detector, liquid level, etc. shall detect the abnormality and raise alarm to take immediate corrective and preventive actions.

8.3.3.3.13

The liquid cooling system shall monitor the reservoir or make-up tank for evaporation or leakage of the cooling medium.

Justification

The provision of level detector is one way which detects the loss of liquid in the circuit either due to evaporation or leakages. This alerts the maintenance team to take with necessary corrective and/or preventive action to maintain the drive system in operation and prevent a failure.

8.3.4 Transformers

8.3.4.1

Transformers shall comply with one or more of the following standards

- IEC 61378-1;
- IEC 60076-1, 2, 3, 5, 7, 10, 11, 12 and 14;
- IEEE C57.12.00, 12.01, 12.90, 12.91, 18.10 and 110;
- IEEE 1276.

Justification

Transformers may be included in the HV AC drive system as converter transformer, output transformer, etc. These transformer can be either liquid immersed or dry type as per project requirement. The HV AC drive systems could be supplied to various regions of the world and hence could follow one or more of the mentioned standards. The standard being complied based on the region of installation shall be specified by the supplier.

8.3.4.2

Transformers shall have resistance temperature detectors, two per winding and one on the core.

Justification

The transformer winding and core temperature needs to be monitored to ensure that the temperatures do not exceed the designed values. Any increase beyond the high threshold values shall generate alarm to alert about the occurrence of abnormality to initiate necessary action to prevent a severe failure and further increase beyond the high high threshold values shall trip the drive.

8.3.4.3

The resistance temperature detectors on the windings and core of the transformer shall be located to detect the hottest temperature.

Justification

The transformer winding and core temperature needs to be monitored to ensure that the temperatures do not exceed the designed values. Any increase beyond the set threshold values shall generate alarm to alert about the occurrence of abnormality to initiate necessary action to prevent a severe failure. The location of the RTDs will be such that it senses the highest temperature of the winding and the core.

8.3.4.4

When pre-magnetization is required, the pre-magnetization transformer and disconnectors shall be installed in the same compartment as the converter transformer.

Justification

The pre-magnetisation is related to the converter transformer and access to one or the other need both the components to be de-energised. Hence it is convenient to install both these components within the same compartment. The size of the pre-magnetisation transformer being small can be accommodated in the same compartment.

8.3.4.5

Power connection terminals of the transformer shall be tinned copper.

Justification

Copper has higher conductivity with relatively high tensile strength, thermal-conductivity, and thermal-expansion properties. Copper also has lower electrical resistance, lower power loss, lower voltage drop and higher ampacity. This makes it an ideal choice for terminals which forms a junction with connecting busbar or cables.

8.3.5 Capacitors

8.3.5.1

Capacitors shall be tested in accordance with IEC 61071 or IEEE 18.

Justification

IEC 61071 covers a wide range of capacitor technologies for various applications and capacitors used up to 15 kHz. The standard also covers safety, quality and test requirements for capacitors. IEEE 18 standard deals with power capacitors rated 216 V or higher, 2.5 kvar or more, and designed for shunt connection to alternating-current transmission and distribution systems operating at a nominal frequency of 50 Hz or 60 Hz.

8.3.5.2

Electrolytic capacitors shall not be used in the power section of the converter, input or output filters, DC link or snubber circuits.

Justification

The electrolytic capacitors have disadvantage of having large leakage currents, value tolerances, equivalent series resistance and a limited lifetime which effects the performance and reliability of the drive system and not to be considered for power section of the converter.

8.3.5.3

The line filter capacitors shall have a continuous operation voltage rating of 110 % of the network rated voltage.

Justification

The usual threshold for input line overvoltage is just up to110% beyond which the input side overvoltage protection will trip. Hence the line filter capacitors must withstand up to the 110% of the network rated voltage.

8.3.5.4

DC link capacitors shall have a continuous operation voltage rating of 125 % of the maximum DC link voltage.

Justification

The usual threshold for DC link overvoltage protection is just up to125% beyond which the drive will trip unless other mitigation measures like braking resistor or automatic front end is not provided. Hence the DC link capacitors must withstand up to the 125% of the maximum DC link voltage.

8.3.5.5

Power capacitors shall have a service life of at least 15 years.

Justification

Typically the power capacitors exhibits a minimum service life of about 15 years. There are multiple factors impacting the service life and every drive will be facing different adverse scenario during its service life. Accordingly the performance towards the end of service life might not be consistent for all capacitors. However as a requirement the service life shall be as a minimum at least 15 years.

8.3.5.6

The service life of power capacitors shall take account of the temperature inside the enclosure, the peak voltage stress, ripple currents and harmonic currents.

Justification

Typically the power capacitors exhibits a minimum service life of about 15 years. However there are multiple factors impacting the service life and every drive will be facing different adverse scenario during its service life. Accordingly the performance towards the end of service life might not be consistent for all capacitors. Hence as a requirement the service life shall be as a minimum at least 10 years.

8.3.6 Circuit breakers

Circuit breakers shall be designed and tested in accordance with IEC 62271-100 or IEEE C37.04.

Justification

The standard covers three-phase AC circuit-breakers suitable for indoor or outdoor installations for system voltages above 1 000 V, 50 Hz and/or 60 Hz.

8.3.7 Contactors

Contactors shall be designed and tested in accordance with IEC 62271-106 or UL 347.

Justification

The standard covers AC contactors suitable for indoor installations for system voltages above 1 000 V, 50 Hz and/or 60 Hz. The standard also covers requirements for outdoor installations where the equipment is housed in an
additional protective enclosure.

8.3.8 Disconnectors and earthing switches

Disconnectors and earthing switches shall be designed and tested in accordance with IEC 62271-102 or IEEE C37.22.

Justification

The standard covers AC disconnectors and earthing switches (including operating devices and auxiliary equipment) suitable for indoor and outdoor installations for system voltages above 1 000 V, 50 Hz and/or 60 Hz. IEEE C37.22standard covers American National Standard Preferred Ratings and Related Required Capabilities for Indoor AC Medium-Voltage Switches Used in Metal-Enclosed Switchgear.

8.3.9 Filters

When a harmonic filter is installed, earth fault detection and voltage measurement shall be performed using a voltage transformer.

Justification

Filters can be connected either to a dedicated filter winding or a common Harmonic filter with a NER located in neutral. In order to protect the filter against earth faults a voltage transformer is installed at the star point of the filter winding which measure zero voltage if ok. However, for a large drive (typically LCI) the entire transformer is floating – no earthing at all, the drive is floating and has a dedicated Bender earth monitoring system.

8.3.10 Motors

Motors shall comply with IOGP S-704 or API Standard 541 or API Standard 547 or API Standard 546.

Justification

IOGP S-704 is an overlay for parent standard IEC 60034 and has to be read in conjunction with 60034. Hence IEC 60034 is applicable in all respect, except where modified by IOGP S-704. These standards covers the requirements related to design, safety, rating, performance, tests, etc. of rotating electrical machines (induction and synchronous motor). API STD 541, API STD 547 and API STD 546 covers the requirements of form wound squirrel cage induction motor, general purpose induction motor and synchronous motor.

8.4 Busbars, wiring and terminals

8.4.1 Busbars

Copper busbar joints and termination ends shall be tin-plated.

Justification

Copper is a popular choice for busbars because of its conductive and mechanical properties. However\, copper has a tendency of oxidise over time. This oxide causes less conduction. A coating of tin oxide acts as a shield and inhibits corrosion on the copper surface. and maintains a good electrical contact and thereby conductivity.

8.4.2 Wiring

8.4.2.1

The insulation material of internal wires shall be low halogen, flame retardant and have a low smoke index.

Justification

Low halogen is a material classification typically used for wire insulation or cable sheath. Low smoke zero halogen (LSZH) is composed of thermoplastic compounds that emit lesser smoke and no/low halogen when exposed to high heat source. In the event of fire this material undergoes an endothermic chemical reaction which absorbs heat energy and releases steam when the compound reaches a certain temperature. The steam disrupts combustion of the evolved gases and helps to extinguish the flame.

8.4.2.2

Wiring ends on terminals shall be labelled with wire marker ferrules in accordance with the wiring diagram.

Justification

The identification of wiring connection is an important step in ensuring that the MTTR (mean time to repair) is minimised. Proper identification of wires, connectors, terminals, etc. help in restoring the wiring after replacement of components, PCBs, etc without human error. The material of marker/identification ferrule is of insulating material since it is in close proximity to the live terminals.

8.4.2.3

Wiring for external connections shall be routed to individual terminals on a front accessible terminal block.

Justification

It is good engineering practice to bring the external interface connection to a single location and assign terminals for the same. This ensures that the external cabling does not interfere with the internal wiring of the UPS and such terminals are located close to the front side of the cable entry location.

8.4.3 Power and control terminals

8.4.3.1

Control terminals shall have a single wire termination.

Justification

A proper planning of control terminals is important prior to wiring in a panel. Normally it would be appropriate to assign one termination (wiring end) per end of the terminal which helps in easy identification / labelling of the circuit and prevent loose connection. Systematic wiring in panel facilitates faster troubleshooting and ensuring that the MTTR (mean time to repair) is minimised.

8.4.3.2

Control terminals shall be labelled in accordance with wiring diagram.

Justification

Systematic layout is important for service and operation activities. Normally the terminal are located considering access from front. However specifying the location and accessibility of the control terminals shall standardise this requirement across suppliers and helps in easy access to wiring in panel and also facilitates faster troubleshooting thereby ensuring that the MTTR (mean time to repair) is minimised.

8.4.3.3

Auxiliary power terminals with a voltage greater than 50 V, accessible with the compartment door open shall be shrouded to provide a degree of protection of at least IP20.

Justification

The intent of the requirement is to protect the personnel from hazard of electric shock. In case the cabinet door needs to be opened (excluding the high voltage compartment) for monitoring or service like cooling cabinet, any chance of accidental contact with the live exposed part of any internal components must be prevented. Hence enclosure, shrouds or otherwise protection by barriers must be ensured such that IP 20 (No openings ≥ 12.5 mm or protected against access by finger) shall be ensured.

8.4.4 Cable interface

The separation distance between the gland plate or multi-cable transit and the power terminals within the enclosure shall permit installation of the specified power cables without mechanical stress on the terminals.

Justification

The separation distance between the gland plate and the connection terminals shall be suitable to accommodate the recommended termination length as per cable termination kit manufacturer. This will ensure that the orientation of cable core will not induce any mechanical stress on the cable terminals and cause failure.

8.5 Control supply and panel auxiliaries

8.5.1 Control supply

8.5.1.1

The BDM shall have redundant AC to DC control power units with each unit fed from an independent external AC control power supply.

Justification

The redundant AC to DC control power units shall ensure that failure of any one control power unit (due to either input source or the unit itself) will not affect the BDM operation and control supply availability via the redundant unit will continue. Obviously both unit shall be 100% rated.

8.5.1.2

The output of the AC to DC control power units shall be connected in parallel via blocking diodes prior to further distribution within BDM/CDM.

Justification

The redundant AC to DC control power units shall ensure that failure of any one power supply (due to either input source or the unit itself) will not affect the BDM operation. The output being paralleled shall ensure the availability of control power when the both units operate and from the healthy one when one of them goes faulty. Obviously both unit shall be 100% rated.

8.5.1.3

Protection devices on the input side of the AC to DC control power units shall be provided within the BDM.

Justification

All control and auxiliary supply derived for control and functioning of auxiliaries shall be included within the BDM. The external supply shall be only at one voltage level available from the plant power system and further voltage conversion as required shall be done in the drive itself. Also the protection devices for the control power units shall be part of the BDM.

8.5.2 Panel auxiliaries

BDM/CDM compartments shall have LED lamps for internal illumination controlled by door limit switches.

Justification

Lamps are required for illumination within the panels to aid during trouble shooting and maintenance. These lamps are kept off during operation (with door closed) and hence door limit switch control is provided. LED lamps are more durable.

8.6 Earthing

8.6.1

The electrical safety of HV AC drive systems shall be in accordance with IEC 61800-5-1 or IEEE 1566.

Justification

IEC 61800-5-1 covers the safety requirements related to electrical, thermal and energy hazards. IEEE 1566 covers the safety requirement for drive systems supplied in North America.

8.6.2

A main protective earth of copper material shall be provided in all compartments.

NOTE The main protective earth is normally a tinned copper bar.

Justification

This PE conductor (earth) is required for terminating the earth wires from components within the compartment. The PE conductor may run across the entire enclosure line-up directly linked or connected using jumper cables. NOTE Copper is the conductor of choice due to better conductivity and tinning prevents corrosion on copper.

8.6.3

The main protective earth shall be interconnected between compartments and extended outside the enclosure at both ends for external connections.

Justification

The external earth connection from system earth is connected at both ends of the enclosure to ensure that at least one earth loop remains healthy/connected when the other loop gets loose/disconnected. This provides improved safety and ensures that least resistive path is available for earth fault current.

8.6.4

The extension of the main protective earth at both ends of the enclosure shall permit connection of earthing cables with cross section area of at least 120 mm^2 (4/0 AWG).

Justification

This is the industrial practice. IEEE 1566 standard recommends 200A rating for such connections and 120 sq mm or 4/0 AWG complies to this requirement.

8.6.5

Metal parts of the BDM/CDM shall have electrical continuity and connection to the main protective earth.

Justification

Any leakage current or fault current through these metal parts shall find the least resistive path to earthing and protect human from shock hazard.

8.6.6

Covers, hinged doors, gland plates and multi-cable transits shall have electrical continuity with the metal structure of the enclosure.

Justification

Any leakage current or fault current through these metal parts shall find the least resistive path to earthing and protect human from shock hazard.

8.6.7

High-voltage BDM/CDM components shall have provision for earthing with a 20 mm (0.79 in) earthing ball stud or a fixed earthing switch.

Justification

These provision are required to completely discharge the component and keep it connected to earth to prevent any charge build up due to induction while working on the component.

8.6.8

When provision of an earthing ball stud or fixed earthing switch is not feasible, a portable earthing device shall be supplied.

Justification

These provision are required to completely discharge the component and keep it connected to earth to prevent any charge build up due to induction while working on the component.

Add new clause

9 Functional requirements

9.1 General

9.1.1

Control circuits, signal inputs and signal outputs shall be galvanically isolated from the power circuits in accordance with IEC 61800-5-1 or IEEE 1566.

Justification

IEC 61800-5-1 covers safety requirements and protection against electrical, thermal and energy hazards. Galvanic isolation between power and control circuits are specified. IEEE 1566 covers safety requirements for drive systems supplied in North America.

9.1.2

The compatibility level for total harmonic distortion shall be in accordance with IEC 61000-2-4:2002, Table 5, electromagnetic environment Class 1 and IEEE 519:2014, Table 1.

NOTE 1 Planning level, if defined in national standards or guidelines, is acceptable provided that the planning level is not higher than the compatibility level.

NOTE 2 Where compliance to electromagnetic environment Class 1 value is not practical, Class 2 may be allowed provided the generation and distribution equipment are designed to operate at such higher limits.

Justification

The THD limits for class 1 (5%) as per IEC 61000-2-4, Table 5 matches with the THD limits as per IEEE 519, Table-1 (5%). The offshore installations as per IEC 61892-1 directly points to IEC 61000-2-4 and hence it does not matter whether the installation is onshore or offshore as both consider IEC 61000-2-4 as the base reference standard. However this requirement is not defined for connection directly to grid owner typically for voltage > 132 kV (onshore plants). In IEC TR 61000-3-, it is indicated that 'In some countries, planning levels are defined in national standards or guidelines'. For e.g. Norway has 3% for single harmonics for voltages above 35 kV to 230 kV and 2% above 230 kV as limits for single harmonics. In view of this supportive text shall be added as a NOTE to the requirement. Also IEC 61892-1 indicates that where Class 1 cannot be complied based on study, class 2 may be accepted provided the generation and distribution equipment are designed to operate at such higher limits. This shall also be added as a NOTE.

9.1.3

The compatibility level for individual harmonic distortion shall be in accordance with the most stringent voltage distortion limit under electromagnetic environment Class 1 among IEC 61000-2-4:2002, Table 2, IEC 61000-2-4:2002, Table 3, IEC 61000-2-4:2002, Table 4 and IEEE 519:2014, Table 1 for the specified voltage.

NOTE 1 Planning level, if defined in national standards or guidelines, is acceptable provided that the planning level is not higher than the compatibility level.

NOTE 2 Where compliance to electromagnetic environment Class 1 value is not practical, Class 2 may be allowed provided the generation and distribution equipment are designed to operate at such higher limits.

Justification

The electromagnetic environmental class is specified as class 1 for total harmonic distortion for IEC installations. There are multiple tables for individual harmonics voltage components for odd and even harmonics which does not distinguish between the voltage levels. However, IEEE 519 specifies a single value for a range of voltage and does not distinguish the order of individual harmonics. The offshore installations as per IEC 61892-1 directly points to IEC 61000-2-4 and hence it does not matter whether the installation is onshore or offshore as both consider IEC 61000-2-4 as the base reference standard. However this requirement is not defined for connection directly to grid owner typically for voltage > 132 kV (onshore plants). In IEC TR 61000-3-6, Table-2, NOTE 3, it is indicated that 'In some countries, planning levels are defined in national standards or guidelines'. In view of this supportive text shall be added as a NOTE to the requirement. Also IEC 61892-1 indicates that where Class 1 cannot be complied based on study, class 2 may be accepted provided the generation and distribution equipment are designed to operate at such higher limits. This shall also be added as a NOTE.

9.1.4

For onshore installations, the performance of the BDM/CDM/PDS shall be in accordance with IEC 61800-2 or IEEE 1566.

Justification

IEC 61800-2 provides the guidelines for BDM/CDM/PDS installed in regions other than North America and IEEE 1566 is the standard followed for installations in North America. Additional standards are applicable which covers the requirements related to offshore installations.

9.1.5

For offshore installations, the performance, testing and installation of the BDM/CDM/PDS shall be in accordance with IEC 61800-2 or IEEE 1566, and:

- IEC 61892 (all parts) for mobile and fixed units; or
- IEC 60092 (all parts except 301, 305, 306, 501, 502 and 503) for electrical installations in ships.

Justification

Though the HV AC drive system itself will be secured properly on the base frame, but the vessel or platform itself will experience shakes and vibrations due to turbulence of the waves. The HV AC drive system design for such installations should ensure that all internal assemblies, components and accessories are selected, installed and tested in accordance with the standards applicable for equipment installed on offshore platforms or offshore floating vessels or ships in addition to the parent standard.

9.1.6

When the requirements in accordance with the International Maritime Organization (IMO), International Association of Classification Societies Ltd. (IACS) or other applicable classification societies contradicts or conflicts with the requirements of IEC or IEEE standards, the more stringent shall be applied.

Justification

The International Maritime Organization (IMO), International Association of Classification Societies Ltd. (IACS) or any other classification societies also provides a list of rules and requirements to be complied by the operator of the vessels. If the design and testing requirements for equipment by such classification societies are more stringent or has any differences as compared to design and testing requirements for equipment installed by various IEC or IEEE standards then the more stringent requirements will govern.

9.2 Control and interface

9.2.1 Control system

9.2.1.1

The converter control system shall diagnose faults, capture transient waveforms and, monitor and record events.

Justification

The control system has a processor unit which monitor various parameters and analyse the data to diagnose fault, store the waveform, monitor and record events to be displayed as required. This capability helps in displaying status and operating parameters and troubleshooting.

9.2.1.2

The converter control system shall have capability to record disturbance and fault information triggered by a fault condition.

Justification

The instance of a fault is the trigger to capture a lot of pre-fault and post-fault information required for the analysis and trouble shooting. This duration shall be configurable so that the required data can be captured for analysis. Generally the pre-fault duration is quite less than the post -fault duration.

9.2.1.3

The duration of recording the disturbance and fault information shall be a configurable time window from -500 ms to +2000 ms from the instance of the trigger.

Justification

The instance of a fault is the trigger to capture a lot of pre-fault and post-fault information required for the analysis and trouble shooting. This duration shall be configurable so that the required data can be captured for analysis. Generally the pre-fault duration is quite less than the post -fault duration.

9.2.2 Control interface

9.2.2.1

Signals exchanged amongst PDS components and between PDS components and interfacing equipment shall be in accordance with Table 23.

Justification

There could be multiple interface and signal to cater to project requirement. Due to multiple converter topology, cooling topology and configuration requirements (AFE, braking, etc.) the drive design becomes altogether bespoke. In order to establish some standardisation, an essential minimum interface signals are listed for consideration during procurement process. The purchaser can define the applicable signal mentioned as optional.

9.2.2.2

When a synchronous motor is the driver, signals exchanged between the PDS and the excitation panel shall be in accordance with Table 24.

Justification

Synchronous motor has additional equipment in the form of excitation panel for the operation and control of synchronous motor. This signal exchange in covered separately in table 24. For complete PDS signal exchange with synchronous motor as driver, refer to table 23 and 24.

9.2.2.3

The control, power and auxiliary power interfaces between the PDS and external power supplies shall be in accordance with Table 25.

Justification

The PDS has various control, power and auxiliary power interfaces for drive controls, pre-charge/pre-magnetisation, cooling systems, excitation supply, space heater and panel illuminations.

9.2.3 Active VAr control

9.2.3.1

Active infeed converters shall provide reactive power support to the grid power, both leading and lagging, if specified.

NOTE 1 Reactive power support is also known as "Active VAr Control".

NOTE 2 Active VAr control is not possible with LCI drives as the line side power factor is determined by the load.

NOTE 3 An active infeed converter must document its ability with a complete PQ diagram for voltages in the range of 0.9 pu to 1.1 pu.

Justification

Active VAr Control is an additional feature when we have an AFE drive (rectifier parts). This feature use support of capacitive power when larger motors are starting direct on line (DOL), which means there will be less stress on generators or avoid starting an extra generator just for starting larger motors. This feature of AIC when connected to the public grid, can provide grid support (reactive compensation) and replace the need for an SVC (Static Var Compensator) / STATCom (Static. Synchronous Compensator) which are very costly.

9.2.3.2

When the grid power experiences a sudden voltage dip or overvoltage, the reactive power from the active infeed converter shall support the grid voltage.

Justification

Active VAr Control is an additional feature when we have an AFE drive (rectifier parts). This feature of AIC when connected to the public grid, can provide grid support (reactive compensation) and provide support to grid voltage.

9.2.4 Operator interface

9.2.4.1

The HMI shall accept operational input commands, set points and parametrization.

Justification

The HMI is typically touch panel or operator panel with keypad which will provide alphanumeric text and/or graphical interfaces. Input commands (such as start, stop), speed set points and parametrization can be performed from this HMI which is very helpful during commissioning and standalone trials.

9.2.4.2

The HMI shall have a screen for displaying operating status, operating parameter values, alarms, events and fault diagnostics.

Justification

The display of operating status, operating parameter values, alarms, events and fault diagnostics on the screen an essential requirement for monitoring and troubleshooting of the HV AC drive system. Though these information can be accessed from a laptop or a desktop computer, it is essential that the drive has a screen to display the information for the personnel in front of the drive,

9.2.4.3

The HMI shall display information on the cause of a trip, with parameters prior to and subsequent to the trip.

Justification

This information is essential for immediate action as required by the maintenance staff.

9.2.4.4

The HMI shall have a facility to connect and synchronize with the central time server.

Justification

The central time server of the plant provides a common reference to all E&I systems. In case of any event all alarms and trip needs to be recorded with the same reference to study and understand the sequence of events and help in troubleshooting. The HV AC drive systems must also have facility to get connected and synchronise with the central time server so that the time stamps do align with other event being recorded.

Add new Table 23

Table 23 — PDS interface signals

From	To	Interface type	Interface signal description [a]	Wiring
Converter	Input switchgear - circuit breaker or contactor	Command	Close, open/trip	Hardwired
		Interlock	Emergency stop (on converter) push button contacts wired to closing and tripping circuits of circuit breaker or contactor coil	
		Status feedback	-	
		Measurement/control feedback	-	
Input switchgear - circuit breaker or contactor	Converter	Command	-	Hardwired
		Interlock	-	
		Status feedback	Circuit breaker close (in service), circuit breaker open (in service), circuit breaker ready to close, contactor on, contactor off	
		Measurement/control feedback	-	
PCS (process control system) or UCP (unit control panel) or equipment PLC [b]	Converter	Command	Start (optional), stop, speed setpoint, local/remote selection (optional)	Hardwired / via communication link
		Interlock	-	
		Status feedback	-	
		Measurement/control feedback	-	
Converter	PCS (process control system) or UCP (unit control panel) or equipment PLC	Command	-	Hardwired / via communication link
		Interlock	-	
		Status feedback	Ready to power up, ready to start (rotation), running, common alarm, common fault, local/remote mode selected (optional), external trip	
		Measurement/control feedback	Current, speed, output power (kW/HP), motor running hours	
ESD/SAS/SIS (emergency shutdown system/ safety automation system / safety integrated system)	Input switchgear - circuit breaker or contactor	Command	Trip [c]	Hardwired
		Interlock	-	
		Status feedback	-	
		Measurement/control feedback	-	
ESD/SAS/SIS (emergency shutdown system/ safety automation system / safety integrated system)	Converter	Command	Trip [d]	Hardwired
		Interlock	-	
		Status feedback	-	
		Measurement/control feedback	-	

Table 23 *(continued)*

From	To	Interface type	Interface signal description [a]	Wiring
Converter	ESD/SAS/SIS (emergency shutdown system/ safety automation system / safety integrated system)	Command	-	-
		Interlock	-	
		Status feedback	-	
		Measurement/control feedback	-	
CDM components, as applicable (transformer, reactor, output isolator, harmonic filter, cooling unit) [e]	Converter	Command	-	Hardwired
		Interlock	Cover/door interlock (for high voltage compartments)	
		Status feedback	Transformer/reactor cooling fan fault, output isolator close/open, cooling medium low flow (optional), cooling medium high temperature, cooling medium low level, cooling medium fan trip, cooling medium pump trip, conductivity (high and high-high)	
		Measurement/control feedback	Transformer/reactor winding temperature RTD (optional), transformer/reactor oil temperature RTD (optional), transformer/reactor oil level (optional), transformer/reactor core temperature (optional), Buchholz relay – gas/surge (optional), sudden pressure relay (optional), current (short circuit/earth fault - optional).	
Standalone LCS (local control station in field, if applicable) / driven equipment UCP (unit control panel) [f]	Converter	Command	Start (optional), stop, speed increase/decrease (optional), local/remote selection (optional)	Hardwired
		Interlock	-	
		Status feedback	-	
		Measurement/control feedback	-	
Converter	Standalone LCS (local control station in field, if applicable) / driven equipment UCP (unit control panel)	Command	-	Hardwired
		Interlock	-	
		Status feedback (only to LCP/UCP)	Ready to start (optional), run, common fault, local/remote mode selected (optional)	
		Measurement/control feedback	motor current (optional), motor speed (optional)	

Table 23 *(continued)*

From	To	Interface type	Interface signal description [a]	Wiring
Motor (interface signals depend on the type of motor selected and project requirement) [g]	Converter/SAS/SIS (safety automation system / safety integrated system)[h]	Command	-	Hardwired
		Interlock	Purge cycle complete, loss of purge (low-low)	
		Status feedback	exchanger cooling fan fault (air-air cooled), cooling water flow low (optional), cooling water leakage detected (air-water cooled), motor pressurization low (optional), differential pressure high (optional)	
		Measurement/control feedback	Motor winding temperature (thermistor/RTD), cooler inlet air temperature, cooler outlet air temperature, motor speed via. encoder/pulse tach generator/shaft speed pickup (optional) **In the absence of a separate MMS (machine monitoring system), the following interface signals are connected directly:** motor bearing temperature RTD, motor vibration and key phase sensor.	
Motor	MMS (machine monitoring system) (optional) [i]	Command	-	Hardwired
		Interlock	-	
		Status feedback	-	
		Measurement/control feedback	Motor bearing temperature RTD, motor vibration and key phase sensor	
MMS (machine monitoring system) (optional)	Converter/SAS/SIS (safety automation system / safety integrated system)	Command	Trip	Hardwired
		Interlock	-	
		Status feedback	-	
		Measurement/control feedback	-	

[a] There are multiple methods to implement the control philosophy and alternative methods of controls are also acceptable. Interface signals may be added/deleted based on project control philosophy. However, in absence of any defined control philosophy, these interface signals typically used in most projects constitute the essential minimum considering provision of footnotes e to i.

[b] Equipment PLC may be installed separately or within the driven equipment UCP (unit control panel).

[c] This trip command is to disconnect mains supply during emergency.

[d] This trip command is to initiate early trip of converter during emergency.

[e] The CDM components may vary depending on the topology and so will the interface signals.

[f] Provision of LCS (local control station) or UCP (unit control panel) in field and its interface signals will be based on project control philosophy.

[g] The choice of motor type will be based on project philosophy, ATEX requirements and the interface signals will vary in accordance with the motor type.

[h] Motor interface signals wiring to converter, SAS or SIS system will be based on project control philosophy.

[i] Where separate machine monitoring system is not envisaged, the interface signals will be wired to converter, SAS or SIS system based on the project control philosophy.

Add new Table 24

Table 24 — Synchronous motor interface signals

From	To	Interface type	Description	Wiring
Excitation panel	Converter	Command	-	Hardwired
		Interlock	Exciter healthy	
		Status feedback	Excitation on/off	
		Measurement/control feedback	-	
Converter	Excitation panel	Command	Excitation start, excitation stop, excitation raise, excitation lower, excitation current (4-20 mA) signal (optional),	Hardwired
		Interlock	Emergency stop push button	
		Status feedback	-	
		Measurement/control feedback	-	
Synchronous motor	Converter	Command	-	Hardwired
		Interlock	-	
		Status feedback	-	
		Measurement/control feedback	Speed encoder (optional)	
NOTE Apply this table with Table 23 for complete interface signals of a PDS having a synchronous motor as driver.				

Add new Table 25

Table 25 — Control, power and auxiliary supply interface signals

From	To	Interface type	Description	Wiring
PDB / UPS DB	Converter	Control source (single phase or DC)	Drive control supply (external)	Hardwired
PDB	Converter	Power source (three phase)	Pre-charge/pre-magnetization circuit, cooling fan circuit, cooling pump	Hardwired
PDB	Converter	Auxiliary source (single phase)	Panel space heater, motor space heater, panel illumination circuit	Hardwired
PDB	Exciter panel	Power source (three phase supply for synchronous motor)	Excitation supply source (for synchronous motor)	Hardwired
PDB	Exciter panel	Auxiliary source (single phase)	Panel space heater, motor space heater, panel illumination circuit	Hardwired

9.2.4.5

Alarms, events and fault information shall be time stamped and stored chronologically in the non-volatile memory of the HMI.

Justification

The memory available in the HMI unit shall be such that it shall retain the available event log and other data even in case the power to the unit is completely lost. A non-volatile memory is a type of memory that has the capability to hold saved data even if the power is turned off. This ensures that the data is available when the power is restored and the data can be used for trouble shooting and fault analysis later. In case of an abnormality, all alarms, trip and fault informations when recorded with the same reference shall facilitate the analysis and understand the sequence of events and help in troubleshooting. The HV AC drive systems HMI having facility to get connected and synchronise with the central time server will record the alarms, events and fault information with the time stamps and will facilitate in the troubleshooting.

9.2.4.6

When the storage capacity is full, the non-volatile memory shall be automatically overwritten on a "first-in, first-out" basis.

Justification

The memory available in the HMI unit shall be such that it shall retain the available event log and other data even in case the power to the unit is completely lost. A non-volatile memory is a type of memory that has the capability to hold saved data even if the power is turned off. This ensures that the data is available when the power is restored and the data can be used for trouble shooting and fault analysis later. This memory has a definite storage capability and can store only a specific amount of data. Hence all old data needs to be cleared away to make memory space free for new data. The logic followed for such release of memory space is "First in – First out", i.e. – the oldest data (first input as per the time stamp) is erased the earliest (first input data is erased first as per sequence). This logic ensures that the most recent data are available for use whereas the older data gets replaced and the same memory space is recycled optimally. The entire data stored in the memory can be manually erased, if required.

9.2.4.7

The non-volatile memory shall be manually erasable.

Justification

The memory available in the HMI unit shall be such that it shall retain the available event log and other data even in case the power to the unit is completely lost. A non-volatile memory is a type of memory that has the capability to hold saved data even if the power is turned off. This ensures that the data is available when the power is restored and the data can be used for trouble shooting and fault analysis later. This memory has a definite storage capability and can store only a specific amount of data. Hence all old data needs to be cleared away to make memory space free for new data. The logic followed for such release of memory space is "First in – First out", i.e. – the oldest data (first input as per the time stamp) is erased the earliest (first input data is erased first as per sequence). This logic ensures that the most recent data are available for use whereas the older data gets replaced and the same memory space is recycled optimally. The entire data stored in the memory can be manually erased, if required.

9.2.4.8

The HMI shall have trend buffers for variables that allow one-shot or multi-shot trending.

Justification

These are trends for general monitoring of parameters on the HMI display itself while commissioning or troubleshooting. High resolution trends require large amount of data which is uploaded from the drive to a work station or laptop for further processing.

9.2.4.9

Failure of the HMI shall not compromise the operation of the BDM/CDM/PDS.

Justification

The HMI display or any other indicating equipment on the HV AC Drive system does not play any active role in the operation of the drive functioning except that manual commands are transferred from the HMI keypad. Any abnormality in the HMI display unit or the complete failure shall not impact the functioning of drive and the drive shall continue to function with all its capability including protection, except for displaying on HMI and receiving commands from HMI.

9.2.4.10

The HMI shall have password protected multiple levels of access:

- for viewing, by the operator;
- for settings, by trained operating personnel;
- for service, by the manufacturer's personnel.

Justification

The HMI shall be capable for displaying all parameters available from the various control cards within the system. Not all parameters are required for the operator for basic monitoring. There needs to be specific level of expertise and skill to interpret and understand various parameters and values. Such parameters be categorized under multiple access level and shall be locked by means of access password. The passwords control shall ensure that the critical parameters and settings are kept secure and accessed by qualified person only.

9.2.4.11

The HMI shall use plain language text for error messages without the need to look up error codes or decipher the meaning of error messages.

Justification

To aid faster troubleshooting, the HMI shall display the error description as plain language text messages and eliminate the need for referring to the O&M manual for deciphering/understanding the error message. Generally short alphanumeric codes are displayed when the HMI has inadequate display means (too small in size, limited text lines or width, etc.). This requirement needs supplier to provide the error information using plain language text messages.

9.2.4.12

When the HMI and BDM are installed in the same field zone as an IEC 62443 network without a layer 3 firewall in between the HMI and BDM processor unit, the HMI shall have a non-windows operating system.

Justification

The HMI is the hardware or component with a resident software application that enables humans to engage and interact with drive's processor unit. An operating system (OS) is system software initially loaded into the processor of the hardware unit that manages the hardware functioning and correctly interprets the software application. 'Windows' platform is the most predominant OS, but has more vulnerability as compared to other OS. A firewall is essential to protect the OS from cyber threats and malware attacks. Considering increased cyber security threats, a non-windows OS is preferred for the HMI where there is no layer 3 firewall installed between the HMI and the processor unit of BDM.

9.2.5 Protection and alarms

9.2.5.1

The alarm and protection functions shall be displayed on the HMI with a first failure feature.

Justification

Any alarm or protection which gets triggered from the control system shall be displayed on the HMI for information to the operator. However in actual event, a trouble would create a cascading effect and generate multiple alarm which shall get logged as part of the event log. To facilitate the operator or maintenance staff to identify the origin of the trouble, the HMI display logic shall adopt a first failure feature, whereby the first alarm or protection function which got triggered shall be retained on the display whereas all subsequent events shall be available in the event log. All the events shall be stamped with the date and time when the event occurred.

9.2.5.2

When specified, the BDM/CDM/PDS shall permit continued operation with a single earth fault.

Justification

Some power distribution system operate with ungrounded/floating system letting the equipment operate with a single earth fault in the system provided the design of the equipment permits. This provide time for the maintenance to plan and rectify the cause of fault. However the manufacturer should be made aware of such requirement to take appropriate measures in the design.

9.2.6 Communication protocol and network interface

9.2.6.1

The BDM shall have communication hardware compliant with the interface media and protocol as specified for remote monitoring and automation system interface.

Justification

The BDM shall provide hardware with communication functionality for remote connectivity so that the data of the control system can be transferred at any remotely located system and can also receive commands from the automation system. The communication protocol and interface media shall be project specific agreed thru' the datasheet entries.

9.2.6.2

The cyber security requirements for the communication network shall be in accordance with IEC 62443 (all parts) or UL 2900-1 and UL 2900-2-2.

Justification

IEC 62443 is an international series of standards that covers the security risks related to industrial automation and control systems. UL 2900 is North American Standard for Software Cybersecurity for Network-Connectable Products. The communication networks incorporates hardware that are purchased off-the-shelf and support open networking technologies. Such technologies while facilitating increased connectivity, poses an imminent risk for cyber attack against control system hardware and software. Compliance to cyber security requirements for the communication network in accordance with established standards will require the software developer to evaluate and test for vulnerabilities, software bugs and malware and build appropriate barriers and risk controls to ensure a robust design.

9.3 Reliability and availability

9.3.1

The BDM/CDM/PDS shall provide a minimum operation life of 20 years for the specified environmental conditions in accordance with the scheduled maintenance activities recommended by the manufacturer.

Justification

The BDM/CDM/PDS is expected to provide a minimum useful service life of 20 years in the specified environmental conditions. However this also should consider that the manufacturer's recommended maintenance activities be performed as per the maintenance plan. It would be difficult to verify this requirement and hence a document regarding declaration of conformity

9.3.2

The PDS shall operate continuously for 6 years without need for intermediate stop to perform preventive or routine maintenance.

Justification

Most of the operating companies have a turn around period ranging from 4-6 years and drive systems are expected to operate without interruption for this duration. A scheduled maintenance shall be performed during the turn around time which will further extend the period of operation and provide an overall availability of 99.9%.

9.3.3

The BDM including auxiliaries shall have an availability of minimum 99,9 %.

Justification

Most of the operating companies have a turn around period ranging from 4-6 years and drive systems are expected to operate without interruption for this duration. A scheduled maintenance shall be performed during the turn around time which will further extend the period of operation and provide an overall availability of 99.9%.

9.3.4

Failure of a component or sub-component within the BDM/CDM/PDS shall not trigger a cascade failure involving other components.

Justification

The design of the control system and protection features should facilitate a faster detection of the fault as close as possible to the source of fault. The control system should then isolate the faulty component/section and initiate a trip/alarm such that this failure does not result into a cascade failure involving other component or sub-component. This will result in faster troubleshooting and better MTTR figures.

9.4 Performance

9.4.1

The BDM/CDM/PDS shall withstand thermal and dynamic stresses and transient mechanical torques resulting from a short circuit.

Justification

The thermal and dynamic stresses and transient mechanical torques developed during a short circuit are much higher and the BDM/CDM/PDS design should withstand this rare but critical condition. The purchaser data on the maximum short circuit value is key information for the design.

9.4.2

The converter control system shall provide speed regulation within ±1 % of maximum frequency in Volt/Hertz control.

Justification

Almost all of the HV AC drive systems operate in an open loop (Volt/Hertz or V/Hz) control (without speed feedback loop). The speed regulation from no load to full load as a percentage of full load determine the drive control capability in an open loop control mode.

9.4.3

The converter control system shall provide speed regulation within ±0,2 % of maximum frequency in an open loop vector control.

Justification

Almost all of the HV AC drive systems operate in an open loop (Volt/Hertz or V/Hz) control (without speed feedback loop). The second control method is open loop vector control wherein most of the drive control system has the feature to run a auto tune. This auto-tune of the motor is performed to ensure the drive control system has as much motor data as possible. The drive can now calculate the magnetizing current (Id) and the torque producing current (Iq). This results in better torque control and speed regulation, which helps achieve better process control. In short The third control method is using a physical feedback from the encoder mounted on the motor shaft providing a true speed feedback. This arrangement provides a very precise speed regulation.

9.4.4

The converter control system shall provide speed regulation within ±0,02 % of maximum frequency in a closed loop vector control.

Justification

Almost all of the HV AC drive systems operate in an open loop (Volt/Hertz or V/Hz) control (without speed feedback loop). The second control method is open loop vector control wherein most of the drive control system has the feature to run a auto tune. This auto-tune of the motor is performed to ensure the drive control system has as much motor data as possible. The drive can now calculate the magnetizing current (Id) and the torque producing current (Iq). This results in better torque control and speed regulation, which helps achieve better process control. In short The third control method is using a physical feedback from the encoder mounted on the motor shaft providing a true speed feedback. This arrangement provides a very precise speed regulation.

9.4.5

When an input voltage on one or more phases dips to 65 % of the nominal voltage for a duration of no longer than 500 ms, the BDM shall initiate the kinetic buffering feature and sustain the control power through the duration of the voltage dip.

Justification

During a voltage sag, the DC link voltage starts to reduce accordingly. The control voltage also start to reduce which if drops below the threshold will cause the drive to trip. To overcome this drawback, the drive has a feature of kinetic buffering. Kinetic buffering is a feature wherein the BDM regenerate power from load by slightly dropping the speed to keep the control power alive and sustain the control power through the duration of voltage sag.

9.4.6

When the input voltage is restored from a voltage dip to at least 90 % of the nominal voltage, the BDM shall perform a flying restart and re-accelerate to the given set point.

Justification

The BDM has a feature of flying re-start also termed as catch-on fly. This feature needs to be enabled (parameter setting) when required and shall be triggered when there is voltage has been restored and the kinetic buffering has been turned off. During the flying restart the BDM verifies the motor speed at that instant and then compare it with the specified set point. Based on the difference the BDM will increase or decrease the speed of motor to match with the speed as per the set point value. This feature facilitates the BDM to avoid a trip during such temporary supply variations.

9.4.7

When the input voltage is restored from a voltage dip to at least 90 % of the nominal voltage, BDM auxiliary drives if tripped, shall restart and prevent a trip of the BDM/CDM/PDS.

Justification

The operation of auxiliary drive is critical for the operation of HV AC drive system. After the input voltage is restored to at least 90% of the nominal voltage, any auxiliary drive like cooling fan or pumps have tripped should restart to ensure that the HV AC drive system does not trip and cause production loss.

9.4.8

The BDM/CDM/PDS shall have an automatic restart feature with a programmable re-start delay.

NOTE A sustained start command and a healthy control supply are essential to operate this feature, when enabled.

Justification

When the input mains supply experiences a momentary loss of power and the automatic restart function is enabled, the function will take following actions to enable a successful restart - disable under voltage fault, - stop inverter function and cooling to conserve remaining energy. However a sustained start command and a healthy control supply are essential to operate this feature.

9.4.9

The converter control system shall have at least two skip frequency band which can be configured individually between the operating speed range to rapidly run through the critical speeds.

Justification

Skip frequency bands are used to pass thru' the speed range which causes resonance and detrimental to the structural integrity, hence need to be avoided. A minimum of two such frequency bands can be configured in the entire speed range,

9.4.10

The BDM/CDM output voltage and performance shall be compatible with the permissible torque ripple or pulsation for the driven equipment train.

Justification

The switching of BDM generates some ripple / distortion / pulsation on the AC output wave which is a very fundamental and unavoidable phenomenon. The magnitude of the ripple frequency generated on AC output is different for each type and make of the BDM. The ripple frequency at the BDM output produces a ripple component torque in the motor air gap torque. This ripple frequency may occasionally coincides with the natural frequency of the driven equipment causing torsional resonance vibration. This resonant torque when exceeds the withstand capability of the weakest part of the driven equipment train, it will get damaged causing a trip. Hence it is important that the BDM/CDM output voltage and performance shall be compatible with the permissible torque ripple or pulsation for the driven equipment.

9.4.11

The insulation of the BDM/CDM shall be designed to overvoltage category III in accordance with IEC 61800-5-1.

Justification

IEC 61800-5-1 defines the overvoltage category based on the where the equipment is energized from the supply mains network. Since the HV AC drive system is permanently connected in fixed installations (downstream of, and including, the main distribution board), overvoltage category III is applicable.

Add new clause

10 Transport, storage and handling

10.1

When specified, an impact indicator and a data logger with date-time stamping for recording shock, tilt, temperature, humidity and pressure shall be installed on each shipping section prior to shipping.

Justification

The impact indicator and data logger is important when transporting the HV AC Drive system over distances. The intent is to ensure that the shipping sections have not been exposed to undesirable conditions of shock, tilt, temperature, humidity and pressure. The review of the recording with date and time stamp shall disclose whether the shipping sections have been properly transported to the installation site and track the abnormality. This will ensure that the HV AC Drive system shall perform as intended through the service life.

10.2

Transport and anchoring hardware shall be installed to prevent damage due to tilt or inclination of shipping sections when manoeuvring during transportation and installation.

Justification

During the transportation there is always a possibility of jerk, tilt or shake which can adversely impact the internal component and the mounting arrangement leading to some kind of permanent damage to component and/or the mounting. Additional transport and anchoring hardware can mitigate the risk during handling and transportation. However these additional hardware may not be suitable to be left in place due to undesired stress or restriction that may arise during operation of the equipment. Hence such additional transport and anchoring hardware shall be clearly identified physically (with specific colour or tagging) and addressed with instructions for removal in the O&M manual post installation at site.

10.3

Transport and anchoring hardware shall be identified in the instruction manual for removal post-installation.

Justification

During the transportation there is always a possibility of jerk, tilt or shake which can adversely impact the internal component and the mounting arrangement leading to some kind of permanent damage to component and/or the mounting. Additional transport and anchoring hardware can mitigate the risk during handling and transportation. However these additional hardware may not be suitable to be left in place due to undesired stress or restriction that may arise during operation of the equipment. Hence such additional transport and anchoring hardware shall be clearly identified physically (with specific colour or tagging) and addressed with instructions for removal in the O&M manual post installation at site.

10.4

When specified, the packaging shall permit safe connection of an external power supply to the internal space heaters of the enclosure during storage.

Justification

This facility will ensure that the internal condition within the enclosure during storage remains free from condensation and related cascading damages. The provision of external temporary power supply shall be safe to eliminate possible fire risk and electric shock hazards.

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