International Association of Oil & Gas Producers

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

JIP33 JOINT INDUSTRY PROGRAMME

Revision history

VERSION	DATE	PURPOSE
1.0	September 2022	First Edition

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).

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 AC 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 (IEC)

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 (IEC)

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 (IEC)

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, IRS, QRS);

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 a BDM having both input and output line-to-line voltages above 1 000 V 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.

NOTE 2 This specification can be used for procurement of HV AC drive systems globally, including in the North American region where IEEE 1566 is more prevalent.

Delete NOTE

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 / disconnector and earthing switch, motor;
  - busbars, wiring, power/control terminals, cable interface;
  - control supply, panel auxiliaries;
  - earthing/grounding.
- Functional requirements:
  - control system, control interface, operator interface, protections and alarms, communication protocol and network interface;
  - reliability and availability;
  - performance including features like voltage dip ride through, active VAr control and implementing active front end.
- Transport, storage and handling.

Add new subclause

1.2 High-voltage AC drive systems included in scope

This specification covers onshore or offshore installations of BDM/CDM 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.

Add new subclause

1.3 Scope boundary

This specification covers the PDS with a BDM having the following characteristics:

- with both the input and output connected to high voltages, i.e. greater than 1 000 V AC with no upper limit;
- aligned with the scope of IEC 61800-2; and
- modified in accordance with Figure 23.

Add new subclause

1.4 Exclusions

The following PDS are excluded from the scope of this specification:

- AC PDS 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 PDS with transformers other than converter transformer at the input side;
- PDS for wind turbine applications;
- PDS for subsea applications;
- low-voltage adjustable speed DC PDS;
- BDM/CDM with cyclo-converter or matrix converter topology.

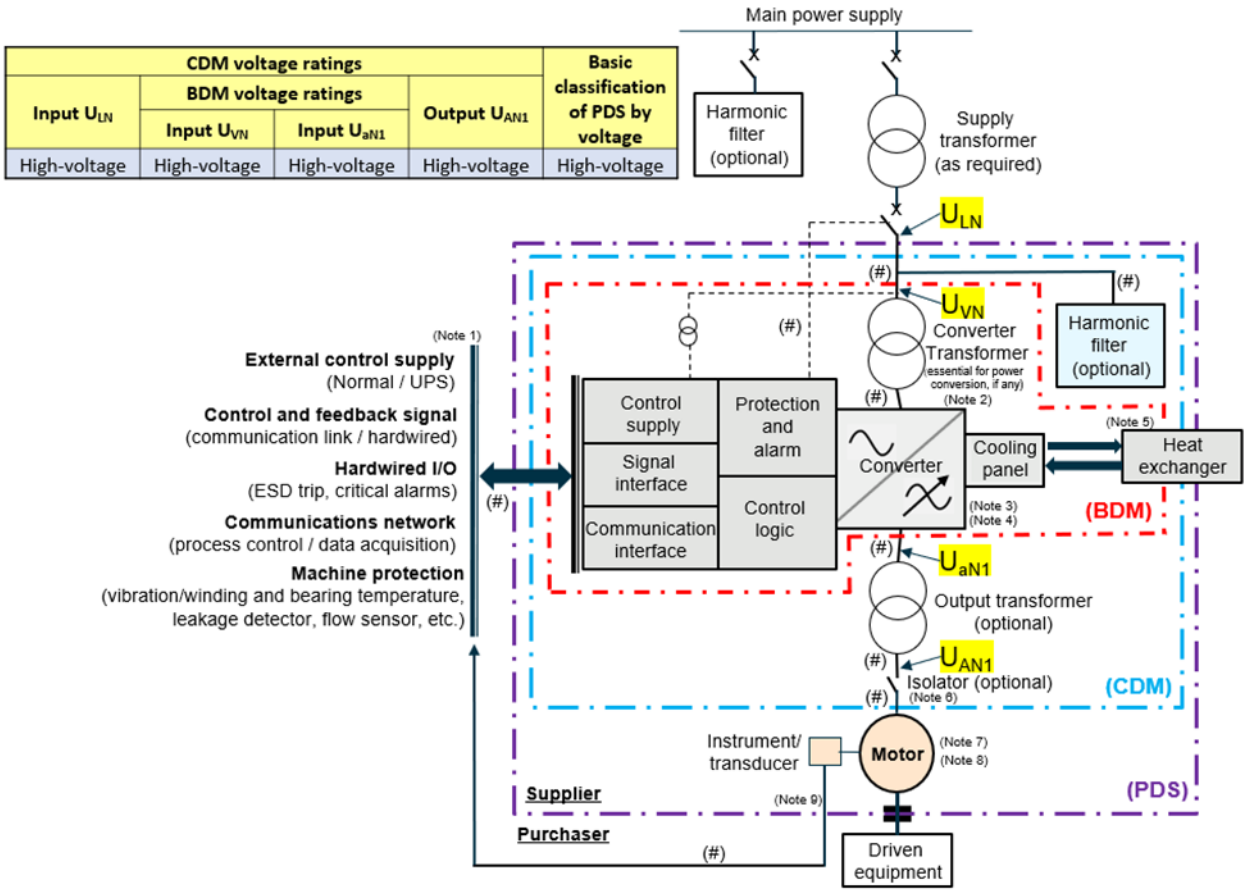
The following components of the PDS are outside the scope of this specification:

- any input transformer upstream of the BDM;
- 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.

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

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

Add new Figure 23



Key

is for interconnecting cables which are typically in customer scope, but may be revised in accordance with project requirements.

Note 1 All interfaces are indicative and may vary in accordance with project requirements.

Note 2 The interface between instruments on transformer and electrical control system is to be considered in accordance with project requirements.

Note 3 Converter may either be air cooled or liquid cooled.

Note 4 Output reactor, du/dt filter, sinewave filter, EMC filter, etc. are considered as part of the BDM.

Note 5 Heat exchanger (water-water) or cooler (water-air) of liquid cooled converter may be either supplier or customer scope.

Note 6 If installed, the output isolator should be electrically interlocked with converter. This unit may be either supplier or customer scope.

Note 7 The interface between motor and converter depends on the type of motor and its associated instrument/transducers.

Note 8 Motor cooling arrangement may be either air-air or water-air.

Note 9 Synchronous motors have an excitation system and associated interfaces with motor and converter.

Figure 23 – Scope boundary diagram

2 Normative references

Add to clause

The following publications are referred to in this document, the procurement data sheet (IOGP S-747D) or the IRS (IOGP S-747L) in such a way that some or all of their content constitutes requirements of this specification.

API Recommended Practice 500, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2*

API Recommended Practice 505, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2*

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)*

ASCE 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*

CSA 22.2 NO 274, *Adjustable speed drives*

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 60721-2-6, *Classification of environmental conditions Part 2: Environmental conditions appearing in nature – Earthquake vibration and shock*

IEC 61000-2-4:2002, *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 61800-3:2017, *Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods*

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 62443-4-2, *Security for industrial automation and control systems - Part 4-2: Technical security requirements for IACS components.*

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*

IEEE 18, *IEEE Standard for Shunt Power Capacitors*

IEEE 519:2014, *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 1566, *IEEE Standard for Performance of Adjustable-Speed AC Drives Rated 375 kW and Larger*

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

IEEE C37.30.1, *IEEE Standard Requirements for AC High-Voltage Air Switches Rated Above 1000V*

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 C57.12.70, *IEEE Standard for Standard Terminal Markings and Connections for 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-704, *Supplementary Specification to IEC 60034-1 High Voltage Three-phase Cage Induction Motors*

IOGP S-720, *Supplementary Specification to IEC 60076-1 Transformers*

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

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*

UL 61800-5-2, *Adjustable Speed Electrical Power Drive Systems - Part 5-2: Safety Requirements - Functional*

Replace Clause 3 title with

3 Terms, definitions and abbreviated terms

Add new subclause 3.0 before first paragraph

3.0 Additional abbreviated terms

For the purposes of this document, the abbreviated terms given in IEC 61800-2 and the following apply.

AHJ	authority having jurisdiction
ESD	emergency shutdown system
HMI	human machine interface
ITP	inspection and test plan
LCS	local control station
LED	light emitting diode
MMS	machine monitoring system
MTBF	mean time between failures
NRTL	nationally recognized testing laboratory
PCS	process control system
PDB	power distribution board
PLC	programmable logic controller
RTD	resistance temperature detector
SAS	safety automation system
SIS	safety instrumented system
UCP	unit control panel
UPS DB	uninterruptable power supply distribution board
VAr	volt-ampere reactive

5 Performance and functionality criteria

5.2 BDM/CDM/PDS characteristics and topology

5.2.4 Cooling topology

5.2.4.1 General

Replace third paragraph with

Safety design of the cooling topology shall be in accordance with IEC 61800-5-1 or UL 347A.

5.2.4.3 Liquid-cooling

Replace first sentence of first paragraph with

Liquid cooling systems shall monitor and control the following parameters:

In first paragraph, replace sixth list item with

prevention of scaling and corrosion.

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

shall

Replace third paragraph with

Safety design of the liquid cooling system shall be in accordance with IEC 61800-5-1 or UL 347A.

5.2.4.4 Heat exchangers

Replace second paragraph with

Safety design of the heat exchanger system shall be in accordance with IEC 61800-5-1 or UL 347A.

5.3 Ratings

5.3.2 Input ratings

5.3.2.2 Input voltage and input frequency

Replace first paragraph with

The rating(s) of the PDS input voltage and input frequency shall be as specified.

Replace first sentence of third paragraph with

Standard voltage values are specified in ANSI C84.1 for installations in North America and IEC 60038 for other installations.

5.3.2.3 Input current

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

shall

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

shall

In first sentence of 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

Delete second sentence of fourth paragraph

5.3.3 Output ratings

5.3.3.1 BDM/CDM continuous operation

Replace first sentence of first paragraph with

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

5.3.3.2 PDS continuous output

In first sentence, replace "should" with

shall

5.3.4 Operating quadrants

5.3.4.1 General

In first sentence, replace "should" with

shall

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 third sentence of fifth paragraph with

Transformers shall comply with either:

- IOGP S-720, IEC 60076 (all parts) and IEC 61378 (all parts); or
- IEEE C57.18.10 and IEEE C57.110.

5.3.6.2.3 Specification and rating

5.3.6.2.3.2 Winding arrangement

Replace first paragraph with

The transformer winding arrangements and connection symbols shall be in accordance with IEC 60076-1 or IEEE C57.12.70.

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 subclause a), replace "should" with

shall

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

shall

5.4.1.4.1.3 Resistive braking (slowdown)

In list subclause a), replace "should" with

shall

In list subclause b), replace "should" with

shall

5.4.2 Fault supervision

5.4.2.2 BDM/CDM/PDS protection interface

Replace third sentence of first paragraph with

This shall include the protections listed in Table 11 for those components which are installed in the BDM/CDM/PDS.

5.4.3 Minimum status indication required

Replace subclause with

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

- mains circuit breaker available;
- mains circuit breaker open;
- mains circuit breaker closed;
- drive ready;
- drive run;
- drive trip;
- drive common alarm;
- output isolator open (if applicable);
- output isolator closed (if applicable).

Table 11 – PDS protection functions

Add rows to Transformer section

Transformer	Alarm	Trip	Remark
Overcurrent	X	X	Only for output transformer
Ground fault	X	(X)	Only for output transformer
Pressure-relief device		X	Oil-type only
Gas relay (sudden pressure rise)	X	(X)	Oil-type only (alternate to Buchholz type)

Add rows to Converter section

Converter	Alarm	Trip	Remark
Overcurrent	X	X	
Under voltage	X	X	
Loss of control supply	X		In case of redundant supply only
Communication watchdog failure	X		
Cooling system changeover failure	X		
Cooling system common alarm	X		For liquid cooled converter only
Short time converter output current limit protection	X		

Add rows to Motor section

Motor	Alarm	Trip	Remark
Overcurrent	X	X	
Phase loss	X	X	
Locked rotor	X	(X)	
Ground fault in stator winding	X	(X)	
Brushless exciter – loss of field	X	X	Synchronous motor only
Brushless exciter – overcurrent	X	X	Synchronous motor only
Brushless exciter – ground fault	X	X	Synchronous motor only
Overtemperature exciter stator winding	X	X	Synchronous motor only

Add new NOTE 3

NOTE 3 Protection functions listed in the table should be achieved via the BDM. If the BDM is not able to achieve a particular protection function, an external device may be required.

Add new NOTE 4

NOTE 4 Alarm and trip events are typically considered independently of each other with unique set-points or thresholds.

5.4.4 I/O devices

5.4.4.1 General

In first paragraph, replace "should" with

shall

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 and IEC 62477-2 or with UL 347A.

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 or UL 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.

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.

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.

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 [c]				
Visual inspection	BDM [d]	Manufacturer's facility	Typically, dimensions, degree of protection, individual marking, accessibility, tag and rating plate, lifting arrangements, indication and HMI functionalities, grounding and padlocking.	Additional visual inspections may be performed as required by the customer / customer's inspector.
Insulation resistance	BDM [d]	Manufacturer's facility	Insulation values of components and devices.	
High-voltage test	BDM [d]	Manufacturer's facility	The circuits to be tested are separately short circuited in accordance with the individual voltage levels: – power circuit(s); – various auxiliary circuit.	This test shall be repeated during factory acceptance test, if specified in inspection and test plan.
Performance/Functional test				
Light load / full current test (typically using a reactor)	BDM	Manufacturer's facility	Current values, converter temperature rise, time duration till the temperature stabilizes.	The duration for a full current test may vary based on the drive topology and converter type.
Start-up condition / sequence and operation	BDM	Manufacturer's facility	Typically, check interlocks (door limit switches, etc.), controls, ramp up/down, schematics, remote access, alarms, trips (overload, overvoltage, ground fault), skip frequency bands, E-stop, communication network, pre-charge of DC link.	Additional interlocks/operations may be performed as required by the customer/customer's inspector.
Protection function test	BDM/CDM/PDS	Manufacturer's facility	Test as listed in Table-11.	
Disturbance ride-through and restart (asymmetrical and symmetrical dips)	BDM	Manufacturer's facility	Ride-through and restart function.	Alternative test methodology may be proposed for customer's approval if the manufacturer cannot comply.
Speed control function	BDM	Manufacturer's facility	Typically, 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, automatic restart and catch on fly/flying restart function.	Final ramp up and ramp down time should be decided prior to commissioning of HV AC drive system.

Table 22 *(continued)*

Test description [a, b]	Test to be performed on	Testing location	Test parameters/measurements	Remarks
Heat run tests	Transformers/ motor	Respective manufacturer's facility	Transformer temperature rise, motor temperature rise, bearing and winding temperatures, bearing and shaft vibrations, etc.	Due to limitations for large ratings in motor factories, this test may be performed during commissioning test with the complete PDS. This test may be part of the load characteristic test during string testing.
Load characteristic (load envelope)	PDS	During commissioning test	Typically, voltage, current and power at terminals of converter transformer input, converter input and motor input, test of current/torque limiting functions, torque capability, power factor, output voltage, output current (RMS).	Certified load points of the machine (pump or compressor) and PDS capability, if possible, may be specified by the manufacturer.
Functionality of all cooling system devices	BDM	Manufacturer's facility	Typically, auto start / auto changeover to standby, replacement of filter/strainer and de-ioniser resin while in operation, leak detection, water conductivity, static pressure, differential pressure, water temperature, simulation of warning/alarms from cooling unit.	
Audible noise	Transformers/ motor	Manufacturer's facility	Noise (dBA) at 1 m distance.	
Torque pulsation (for LCI, CSC drives)	PDS	During commissioning test	Air gap torque pulsations calculated using speed and/or current measurements. Measurement of integer and non-integer harmonics.	This test may be performed during string testing when specified in the ITP.

NOTE 1 The performance tests should be carried out on at least one HV AC drive system of a group of identical systems, within the same purchase order.

NOTE 2 When a string test is specified in the ITP, the location of the test and the test procedure should be agreed between customer and PDS/driven equipment supplier.

[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 any of the above required tests are 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.

[c] Routine tests shall be performed on each element of the PDS according to the respective standards.

[d] The test on the BDM shall not be inclusive of the input transformer unless it is integrated as a part of the BDM.

7 Information and marking requirements

7.1 General

Add to subclause

Name plates shall be 316L stainless steel.

Add to subclause

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

7.2 Marking on product

In first paragraph, replace "should" with

shall

In second paragraph, replace "should" with

shall

In third paragraph, replace "should" with

shall

Add to subclause

Every compartment and door-mounted instruments shall be identified with a permanently engraved laminated identification label.

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.

Add to subclause

When specified, the BDM/CDM shall be "Approved", "Certified", "Identified", or "Listed" and "Labelled" by a NRTL acceptable to the AHJ as mandated under regulatory requirements.

Add to subclause

For North American installations, the BDM/CDM shall be tested to North American standards and marked with "US" for the United States and/or "C" for Canada on the NRTL label.

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

In first paragraph, replace "should" with

shall

In second paragraph, replace "should" with

shall

In third paragraph, replace "should" with

shall

7.4 Information to be supplied or made available

In first paragraph, replace "should" with

shall

In second paragraph, replace "should" with

shall

7.5 Safety and warning

7.5.1 Safety and warning labels

In first paragraph, replace "should" with

shall

Add to subclause

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

Add to subclause

Caution, danger and warning labels shall display information in English and in other specified languages.

Add to subclause

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

7.5.2 Additional safety considerations of a PDS

In third paragraph, replace "should comply with IEC 61800-5-1" with

shall comply with IEC 61800-5-1 or UL 347A

Add new subclause

7.5.3 Caution label

A caution label stating "Unit contains an external voltage source and must be isolated from elsewhere" shall be installed on all compartments that remain energized when the mains supply is de-energized.

Add new clause

8 Construction requirements

8.1 General

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

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.

8.2.1.2

Unless all components in the high-voltage compartments are electrically switched off, isolated and discharged, an interlock shall prevent doors of the high voltage compartments from opening.

8.2.1.3

Door interlocks shall not be provided for low-voltage compartments.

8.2.1.4

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.

8.2.1.5

When the door is open, the low-voltage compartments with live parts that have a voltage above 50V, and that are accessible during operation, shall provide a degree of protection of at least IP20 in accordance with IEC 60529.

8.2.1.6

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

8.2.1.7

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

8.2.1.8

Gland plates shall be non-magnetic.

8.2.1.9

Bolted covers of enclosures shall be removable from the outside.

8.2.1.10

Unpainted hardware of the enclosure shall be of corrosion resistant material or coated with a corrosion resistant material.

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.

8.2.2.2

Hinged enclosure doors shall open at least 90°.

8.2.2.3

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

8.2.3 Internal arc classification

8.2.3.1

An arc-resistant enclosure for high-voltage compartments shall be provided in accordance with IEC 62477-2.

8.2.3.2

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

8.2.3.3

The internal arc classification of the enclosure shall be FL for enclosures installed against a wall and FLR for other installations.

8.2.3.4

The accessibility type shall be 2b, in accordance with IEC 62477-2.

8.2.3.5

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

8.2.3.6

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

8.3 Components

8.3.1 General

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

8.3.2 Converter

8.3.2.1

The power semiconductors or power cells including the power semiconductors shall permit replacement in less than 1 h.

8.3.2.2

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

8.3.3 Cooling

8.3.3.1 General

8.3.3.1.1

Cooling fans essential for continuous operation of BDM/CDM shall have N + 1 redundancy.

8.3.3.1.2

Cooling circuits shall have a redundant pump in hot standby.

8.3.3.1.3

When a working cooling pump fails, transfer of operation to the standby cooling pump shall be initiated automatically.

8.3.3.1.4

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

8.3.3.1.5

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

8.3.3.1.6

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

8.3.3.1.7

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

8.3.3.1.8

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

8.3.3.1.9

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

8.3.3.2 Air cooling

8.3.3.2.1

Operation of air cooling fans shall be monitored.

8.3.3.2.2

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

8.3.3.3 Liquid cooling

8.3.3.3.1

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

8.3.3.3.2

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

8.3.3.3.3

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

8.3.3.3.4

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

8.3.3.3.5

When the secondary cooling medium is sea water, it shall not enter the electrical room.

8.3.3.3.6

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

8.3.3.3.7

Failure of a single sensor shall not initiate a trip of the BDM.

8.3.3.3.8

The liquid cooling system shall allow liquid sampling, topping up of liquid, changing of de-ionizer and water polishing while the BDM/CDM is in operation.

8.3.3.3.9

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

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.

8.3.3.3.11

Condensation within the liquid cooled drive system shall be prevented.

8.3.3.3.12

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

8.3.4 Transformers

8.3.4.1

Power connection terminals of the transformer shall be tinned copper.

8.3.4.2

The minimum insulation thermal class for transformer winding design shall be class F.

8.3.4.3

The temperature rise class of transformer windings shall be one class lower than the designed insulation class.

8.3.5 Capacitors

8.3.5.1

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

8.3.5.2

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

8.3.5.3

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

8.3.5.4

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

8.3.6 Circuit breakers

When an output circuit breaker is installed, the design and testing shall be in accordance with IEC 62271-100 or IEEE C37.04.

8.3.7 Disconnectors and earthing switches

Disconnectors and earthing switches shall be designed and tested in accordance with IEC 62271-102 or IEEE C37.30.1.

8.3.8 Filters

When installed, harmonic filters shall be equipped with earth fault detection.

8.3.9 Motors

8.3.9.1

Induction motors shall be in accordance with IOGP S-704, API Standard 541 or API Standard 547.

8.3.9.2

Synchronous motors shall be in accordance with IEC 60034-1 or API Standard 546.

8.4 Busbars, wiring and terminals

8.4.1 Busbars

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

8.4.2 Wiring

8.4.2.1

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

8.4.2.2

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

8.4.3 Power and control terminals

8.4.3.1

Each wire for external control wiring shall be terminated on an individual terminal.

8.4.3.2

Control terminals shall be labelled in accordance with the wiring diagram.

8.4.4 Cable interface

The separation distance between the gland plate or multi-cable transit and the power terminals within the enclosure shall be in accordance with the recommendation of the power cable termination kit supplier and the minimum bending radius of the power cable.

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.

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.

8.5.1.3

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

8.5.2 Panel auxiliaries

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

8.6 Earthing

8.6.1

A main protective earth shall be provided in all compartments.

8.6.2

The main protective earth shall be extended to both ends for external connections.

8.6.3

The extension of the main protective earth at both ends of the enclosure shall permit connection of earthing cables with a cross sectional area of at least 120 mm² (4/0 AWG).

8.6.4

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

8.6.5

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

Add new clause

9 Functional requirements

9.1 General

9.1.1

The compatibility level for individual harmonic distortion shall be in accordance with the most stringent voltage distortion limit under electromagnetic environment Class 1 from among IEC 61000-2-4:2002, Table 2, Table 3 and 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 that the generation and distribution equipment are designed to operate at such higher limits.

9.1.2

The compatibility level for THD 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 that the generation and distribution equipment are designed to operate at such higher limits.

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.

9.2.1.2

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

9.2.1.3

The converter control system shall record pre-event and post event disturbance data and fault information for trouble shooting and fault diagnosis.

9.2.1.4

The BDM control connected to the HMI shall have a facility to synchronize with the central time server.

9.2.1.5

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

9.2.1.6

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

9.2.1.7

The non-volatile memory shall be manually erasable.

9.2.1.8

The BDM control shall have trend buffers for variables that allow one-shot or multi-shot trending display on the HMI.

9.2.2 Control interface

9.2.2.1

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

9.2.2.2

When the BDM/CDM feeds a synchronous motor, signals exchanged between the PDS and the excitation panel shall be in accordance with Table 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.

9.2.3 Active VAr control

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

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 Documentation for an active infeed converter shows its capability with a complete P-Q diagram for voltages in the range of 0.9 pu to 1.1 pu.

9.2.4 Operator interface

9.2.4.1

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

9.2.4.2

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

9.2.4.3

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

9.2.4.4

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

9.2.4.5

The HMI shall have password protected multiple levels of access in accordance with the following user categories:

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

9.2.4.6

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

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	
Input switchgear – circuit breaker or contactor	Converter	Status feedback	Circuit breaker close (in service), circuit breaker open (in service), circuit breaker ready to close, contactor on, contactor off, circuit breaker open via a leading contact (optional)	Hardwired
PCS or UCP or equipment PLC [b]	Converter	Command	Start (optional), stop, speed setpoint, local/remote selection (optional)	Hardwired / via communication link
Converter	PCS or UCP or equipment PLC	Status feedback	Ready to power up, ready to start (rotation), running, common alarm, common fault, local/remote mode selected (optional), external trip	Hardwired / via communication link
		Measurement/ control feedback	Current, speed, output power (kW/HP), motor running hours	
ESD/SAS/SIS	Input switchgear – circuit breaker or contactor	Command	External trip [c]	Hardwired
Input switchgear – circuit breaker / ESD / SAS / SIS	Converter	Command	Stop (early trip) [d]	Hardwired
CDM components, as applicable (transformer, reactor, output isolator, harmonic filter, cooling unit) [e]	Converter	Interlock	Cover/door interlock (for high-voltage compartments)	Hardwired
		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 gas/surge relay (optional), sudden pressure relay (optional), current (short circuit/earth fault - optional)	
Standalone LCS (if applicable) / driven equipment UCP [f]	Converter	Command	Start (optional), stop, speed increase/decrease (optional), local/remote selection (optional)	Hardwired

Table 23 *(continued)*

From	To	Interface type	Interface signal description [a]	Wiring
Converter	Standalone LCS (if applicable) / driven equipment UCP	Status feedback	Ready to start (optional), run, common fault, local/remote mode selected (optional)	Hardwired
		Measurement/ control feedback	Motor current (optional), motor speed (optional)	
Motor (interface signals depend on the type of motor selected and project requirement)	Converter/SAS/ SIS [g]	Interlock	Purge cycle complete, loss of purge (low-low)	Hardwired
		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, the following interface signals are connected directly:** motor bearing temperature RTD, motor vibration and key phase sensor.	
Motor [h]	MMS (optional) [i]	Measurement/ control feedback	Motor bearing temperature RTD, motor vibration and key phase sensor	Hardwired
MMS (optional)	Converter/SAS/SIS	Command	Trip	Hardwired

[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 the 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.

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

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

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

[f] Provision of LCS or UCP in field and its interface signals shall be based on project control philosophy.

[g] For motor interface signals wiring to converter, SAS or SIS system shall be based on project control philosophy.

[h] The choice of motor type shall be based on project philosophy and hazardous area requirements. The interface signals shall vary in accordance with the motor type.

[i] Where separate machine monitoring system is not envisaged, the interface signals shall 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
Excitation panel	Converter	Interlock	Exciter healthy
		Status feedback	Excitation on/off
Converter	Excitation panel	Command	Excitation start, excitation stop, excitation raise, excitation lower, excitation current (4-20 mA) signal (optional),
		Interlock	Emergency stop push button
Synchronous motor	Converter	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
PDB / UPS DB	Converter	Control source (single phase or DC)	Drive control supply (external)
PDB	Converter	Power source (three phase)	Pre-charge/pre-magnetization circuit, cooling fan circuit, cooling pump
PDB	Converter	Auxiliary source (single phase)	Panel space heater, motor space heater, panel illumination circuit
PDB	Exciter panel	Power source (three phase supply for synchronous motor)	Excitation supply source (for synchronous motor)
PDB	Exciter panel	Auxiliary source (single phase)	Panel space heater, motor space heater, panel illumination circuit

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.

9.2.5.2

The PDS shall have an insulation or ground fault monitoring system covering the entire galvanic circuit.

9.2.6 Communication protocol and network interface

The cyber security requirements for the communication network shall be in accordance with IEC 62443-4-2 or UL 2900-1 and UL 2900-2-2.

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.

9.3.2

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

9.3.3

The BDM/CDM shall have an availability of minimum 99.9 % with MTBF of 10 years causing BDM/CDM outages.

9.3.4

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

9.3.5

The maximum time to repair and make the BDM/CDM available for operation shall not exceed 3 h at the 95 % confidence level.

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 outside the converter.

9.4.2

The BDM shall comply with IEC 61800-3:2017, Table 8 for voltage dips meeting a performance criteria 'B' as per IEC 61800-3:2017, Table 2.

9.4.3

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.

9.4.4

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

9.4.5

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.

9.4.6

The BDM control shall have at least two skip frequency bands that can be configured individually between the operating speed range to rapidly run through the critical speeds.

9.4.7

The BDM/CDM output torque pulsation shall be compatible with the rotor dynamics of the driven equipment train.

9.4.8

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

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.

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.

10.3

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

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.

Bibliography

Add to Bibliography

ANSI C84.1, *American National Standard for Electric Power Systems and Equipment—Voltage Ratings (60Hz)*

ANSI/IEEE Standard C37.2, *Standard for Electrical Power System Device Function Numbers, Acronyms, and Contact Designations*

ISO 9001, *Quality management systems — Requirements*

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