ENTSO-E Draft Assessment

Harmonised Document Structure for HVDC Project High Level Specifications

HVDC Project Group, Task Force Supply Chain and Public Procurement, WG Asset Implementation and Management, SDC

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Introduction

Background

A common specification template for HVDC projects would help utilities and manufacturers to reduce their efforts. This specifically addresses the analysis of the specifications and the identification of questions to the utilities.

The main goals of such a common template are to:

1. streamline communication between TSOs and suppliers,
2. accelerate procurement and tendering processes by reducing resources needed to understand the specifications (manufacturers' feedback),
3. improve comparability across projects without prescribing specific asset-level parameters,
4. ensure legal challenges are identified and tackled to ease future project work.

Project Group at ENTSO-E

A project group was installed at ENTSO-E with the key objective to develop a template for the specification of HVDC projects in cooperation between the manufacturers and users. The initiative seeks to promote a shift in mindset and market behaviour among stakeholders.

Status April 2026:

The project group created a draft structure for HVDC project tenders and prepared a draft document following this structure with descriptions of the individual topics. The project group would like to receive some early feedback from manufacturers. Therefore, the draft structure and description is frozen to share outside ENTSO-E, although internal work is continuing and outside comments will be merged with the internal progress later.

For now, the draft is limited to point-to-point HVDC projects as much experience is available. Multi-terminal or other more advanced project types are not explicitly included; many of the topics will be very similar and can be approached in the same way.

Sharing the Draft

With this, the project group shares the draft topic structure and descriptions. The draft uses 18 overarching topics to structure HVDC project tenders. This structure and the sub-structures for each topic may still be changed, if deemed beneficial. Each overarching topic is described on 2-5 pages with an individual sub-structure.

No.	Overarching Topic
1	Instruction to Tenderers
2	Contractual and Commercial
3	Scope of Work
4	Interfaces
5	Management Systems
6	Additional Generic Topics
7	Documentation
8	Digital Collaboration
9	Training
10	Studies
11	Physical Assets
12	AC Connection
13	HVDC System
14	Electric Equipment
15	Maintenance Phase
16	Tests and Commissioning
17	Future Readyness
18	Appendices

Figure: Structure of overarching topics, status April 2026

The topic structure may be subject to modification depending on project needs.

Instructions to Tenderers

Purpose

This chapter defines the procedural and administrative requirements for the procurement of HVDC converter station systems and HVDC Cables. It provides tenderers with the necessary information to prepare and submit compliant, competitive offers. The chapter covers the tender organisation, applicable procurement rules, indicative timeline, and evaluation criteria. TSOs are obliged to follow applicable public procurement law (e.g. EU Directive 2014/25/EU or equivalent national legislation) when contracting HVDC systems.

The tender documents shall be issued in [English / national language] and all tender responses shall be submitted in the same language unless otherwise stated. The TSO reserves the right to request clarifications, to reject any or all tenders, and to annul the procurement process without incurring liability.

This document is used as a structural reference and checklist. In the event of any discrepancies, the technical and contractual requirements defined in the TSO's tender documentation shall prevail.

Main Definitions and Standards

List of main standards that are applicable:

EU Directive 2014/25/EU on procurement by entities operating in the water, energy, transport and postal services sectors (Utilities Directive), or applicable national transposition thereof

IEC 62747: Terminology for voltage-sourced converters (VSC) for HVDC systems

IEC 60146 series: Semiconductor convertors

IEC 60815: Selection and dimensioning of high-voltage insulators for polluted conditions

CIGRE Technical Brochure 590: HVDC Station Availability

Applicable national grid codes and network connection requirements (e.g. EU Network Code on HVDC, Commission Regulation (EU) 2016/1447)

List of Subchapters

Tender Organization (including Public Procurement Law)

- Timeline
- Criteria for Awarding

Contractual and Commercial

Purpose

This chapter defines the minimum contractual and commercial framework for HVDC converter station and Cables procurement. It addresses the allocation of responsibilities between the TSO (Employer) and the Contractor, liability provisions, project milestones and deliverables, payment structures, subcontracting requirements, and consenting obligations. The provisions set out in this chapter reflect a minimum acceptable standard applicable across different TSO procurement models, including multi-contracting and integrated EPC approaches. TSOs should adapt and supplement these provisions in line with their national legal requirements and project-specific circumstances.

Main Definitions and Standards

List of main standards that are applicable (non-exhaustive list below):

FIDIC Books or equivalent EPC contract conditions, as applicable to the procurement model

EU Directive 2014/25/EU (Utilities Procurement Directive) and national transpositions thereof

Applicable national civil and commercial law governing contract formation, liability, and dispute resolution

CIGRE Technical Brochure 590 (HVDC availability definitions); for use in defining performance guarantee and availability provisions

List of Subchapters

- Responsibilities
- Liability
- Project Milestones and Deliverables
- Payments
- Subcontractors
- Consenting

Scope of Work

Purpose

The purpose of this chapter is to define the Scope of Works for the HVDC Converter Stations and associated systems forming part of the HVDC transmission project.

This chapter clearly identifies the works, services, supplies, and obligations to be provided by the Contractor, including engineering, design, manufacturing, factory testing, delivery, installation, site works, testing, commissioning, and handover, as applicable to the defined scope.

The Scope of Works establishes the boundaries of responsibility, interfaces, and limits of supply, and provides a common understanding of the Contractor's obligations necessary to deliver a complete, fully functional, safe, and operational HVDC system in accordance with the Technical Specification, contractual requirements, and applicable standards.

This chapter shall be read and applied in conjunction with all other chapters of the HVDC Technical Specification. In the event of any inconsistency, the requirements of this chapter shall prevail with respect to the definition of scope, unless otherwise explicitly stated.

Main Definitions and Standards

Applicable Standards and Regulations

The works defined within this Scope of Works shall be designed, engineered, manufactured, installed, tested, commissioned, and operated in accordance with the latest applicable editions of all relevant international, European, and national standards, regulations, and codes of practice.

Unless otherwise specified, applicable standards shall include, but not be limited to:

- IEC standards relevant to HVDC converter stations and associated equipment.
- CENELEC and EN standards.
- Applicable grid codes and transmission system operator requirements.
- National laws, regulations, and permitting requirements applicable at the site locations.

The detailed list of applicable standards, together with the rules governing precedence, deviations, and conflict resolution, is provided in Chapter 2: Introduction and Scope of Works.

Where conflicts arise between standards, or between standards and the Technical Specification, the more stringent requirement shall apply unless otherwise agreed in writing by the Employer.

Compliance with Standards

Compliance with the referenced standards and regulations shall be deemed a minimum requirement. The Contractor shall ensure that the Scope of Works includes all measures necessary to achieve full compliance, even where such measures are not explicitly stated in this chapter.

Any proposed deviation from the applicable standards or regulations shall be clearly identified and submitted to the Employer for review and approval prior to implementation.

International and European Standards – HVDC Systems (non-exhaustive)

IEC – High Voltage Direct Current (HVDC):

IEC 61975 – High-voltage direct current (HVDC) systems – Vocabulary.

IEC 62747 – Terminology for HVDC systems.

IEC 62895 – High voltage direct current (HVDC) power transmission – VSC based systems.

IEC TR 63189 – Guidance for specification and design of HVDC converter stations.

Power Electronic Equipment and Converter Technology

IEC 60146 (series) – Semiconductor converters.

IEC 62477-1 – Safety requirements for power electronic converter systems and equipment.

IEC 62501 – Voltage sourced converters (VSC) for HVDC applications.

IEC 61800 (series) – Adjustable speed electrical power drive systems (where applicable).

Insulation, Dielectric and Overvoltage Coordination

IEC 60071-1 / 60071-2 – Insulation coordination.

IEC 60060 (series) – High-voltage test techniques.

IEC 62271-1 – High-voltage switchgear and control gear – Common specifications.

AC Systems and Grid Interface

IEC 61936-1 – Power installations exceeding 1 kV AC.

EN 50522 – Earthing of power installations exceeding 1 kV AC.

IEC 60871 (series) – Shunt capacitors.

IEC 60076 (series) – Power transformers (converter transformers included).

Control, Protection, Automation and Communication

IEC 61850 (series) – Communication networks and systems for power utility automation.

IEC 60255 (series) – Measuring relays and protection equipment.

IEC 60870-5-101 / 104 – Telecontrol protocols (where applicable).

IEC 62351 (series) – Power system management and associated information exchange – Data and communications security.

EMC, Harmonics and Power Quality

IEC 61000 (series) – Electromagnetic compatibility (EMC).

IEC 61000-4-7 / 4-30 – Harmonics and power quality measurement.

IEC 62586 – Power quality measurement instruments.

Health, Safety and Environmental Standards

ISO 45001 – Occupational health and safety management systems.

ISO 14001 – Environmental management systems.

ISO 9001 – Quality management systems.

National Laws and Regulations

The Scope of Works shall comply with:

- Applicable national laws and regulations of the countries where the HVDC Converter Stations and Cables are located.
- Permitting, environmental, construction, fire safety, and occupational safety requirements.
- Applicable transmission system operator (TSO) rules and grid codes.

List of Subchapters

Purpose of the Works and Project Description.

Summary of Key Activities.

Scope Exclusions.

Options.

Description of Subchapters

The details required by the TSO for the tender description are listed in the following.

Purpose of the Works and Project Description

Purpose of the Works

The purpose of the Works is to design, supply, construct, install, transport, test, commission, and hand over a point-to-point High Voltage Direct Current (HVDC) transmission system, intended to enable the controlled transfer of electrical power between two geographically separated AC networks.

The HVDC system shall be designed to provide secure, reliable, and efficient transmission of active and reactive power, while supporting system stability, operational flexibility, and compliance with applicable grid codes and regulatory requirements.

The Works shall result in a complete and fully operational HVDC system, ready for commercial operation, including all associated systems, equipment, services, and documentation necessary to fulfil the functional and performance requirements defined in the Technical Specification.

High-Level Project Description

The Project comprises a point-to-point HVDC transmission link connecting two AC power systems via dedicated HVDC Converter Stations and an HVDC transmission circuit.

At a high level, the Project includes, but is not limited to, the following main elements:

An HVDC transmission system with a rated active power capacity of (___ MW / GW).

An HVDC operating voltage of approximately (±___ kV or ___ kV DC).

A total HVDC route length of approximately (___ km), consisting of (submarine / underground / overhead / mixed) sections, as applicable with expected maximum water depth (m).

Two HVDC Converter Stations, each connected to its respective AC network at a nominal voltage level of (___ kV AC).

Converter technology based on (Voltage Source Converter (VSC) / Line Commutated Converter (LCC)) topology.

Associated auxiliary systems, control and protection systems, communication systems, civil works, and supporting infrastructure.

The HVDC system shall be capable of operating in both power flow directions, enabling import and export of power between the connected AC networks, within the specified operational limits.

Functional Role of the HVDC System

The HVDC system is intended to fulfil the following primary functions:

Transmission of electrical power between the two AC networks with defined capacity and availability.

Independent control of active and reactive power within the technical limits of the system.

Support of AC network stability under normal and disturbed operating conditions.

Operation in defined modes, including (e.g. power transmission, reactive power support, STATCOM mode – if applicable).

Compliance with applicable grid codes, security requirements, and system operator instructions.

Detailed requirements related to operational modes, system configurations, and other HVDC specific technical features are defined in Chapter 13: HVDC System and shall apply accordingly.

Boundaries

This chapter defines the technical, contractual, and physical boundaries of the Scope of Work (SOW).

Its objective is to clearly identify what is included and what is excluded from the Contractor's obligations, and to avoid any ambiguity regarding interfaces, responsibilities, and limits of supply.

This chapter shall be read together with the full Technical Specification, Interface Responsibility Matrix, and Contract Conditions.

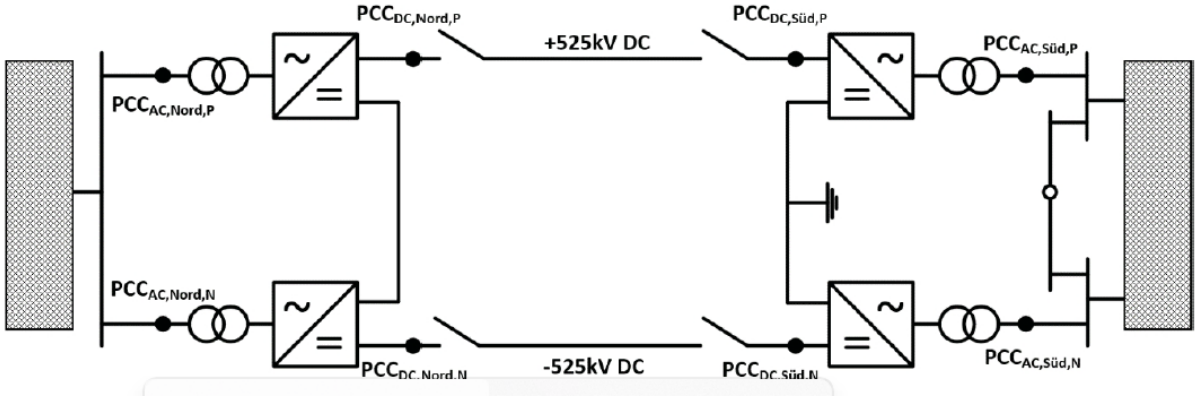

Figure 1 Single line diagram showing scope of work

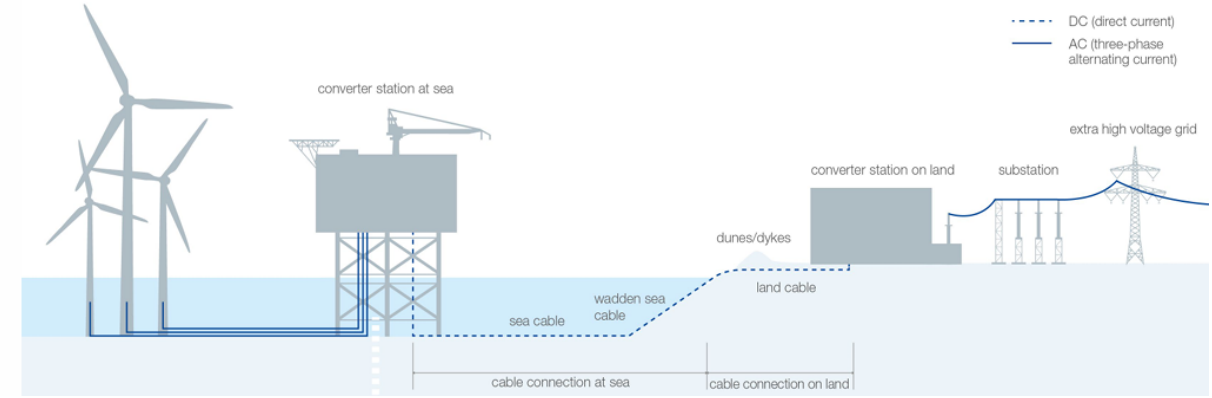

Figure 2 Example drawing to specify the scope of work of the project

Allocation of Responsibilities

The table below defines the allocation of responsibilities between the Employer and the Tenderer for the Scope of Works.

As an example, the responsibilities are defined under Table 1.

Table 1 Allocation of Responsibilities (optional when EPCI type contract)

Description	Employer	Tenderer
Project Definition and Boundary Conditions	Define project objectives, functional requirements, and overall system intent	Acknowledge and comply with defined objectives and boundary conditions
HVDC System – Overall Design Concept	Define high-level system requirements and performance targets	Develop detailed HVDC system design in compliance with requirements
HVDC Converter Stations	Define interface requirements and site constraints	Full responsibility for design, supply, installation, testing, and commissioning
HVDC Transmission System (point-to-point link)	Define required capacity, voltage level, and route constraints	Design coordination and system integration within defined parameters

Auxiliary Systems – General	Define functional requirements and operational constraints	Design, supply, installation, integration, and commissioning
– Fire Detection and Fire-Fighting Systems	Review and approve concepts	Design, supply, installation, testing, certification
– HVAC Systems	Review and approve concepts	Design, supply, installation, testing, commissioning
– Power Supply (AC/DC auxiliaries, UPS, batteries)	Define reliability and redundancy requirements	Design, supply, installation, testing
– Earthing and Lightning Protection	Define site constraints	Detailed design and implementation
Control, Protection and Monitoring Systems	Define interface and operational requirements	Full design, configuration, testing, and commissioning
Cybersecurity and Access Control (if applicable)	Define security requirements and policies	Implementation in compliance with requirements
Permits and Approvals – General	Support permitting process as required	Preparation of technical documentation and inputs
– Construction Permits	Obtain or coordinate with authorities (unless stated otherwise)	Provide all necessary technical documentation
– Environmental Permits	Obtain or coordinate	Support with studies and technical data
Engineering and Detailed Design	Review and approve	Full responsibility
Design Reviews and Technical Clarifications	Review, and approve	Prepare, submit, and address comments
Drawings and Documentation Preparation	Review and approve	Prepare and submit
Factory Acceptance Tests (FAT)	Witness and approve	Plan, perform, and document
Civil Works (HVDC Converter Stations)	Define site boundaries and constraints	Detailed design, construction, and completion
Equipment Manufacturing and Supply	—	Full responsibility
Transportation and Delivery	—	Full responsibility
Installation Works	Provide site access	Full responsibility
Site Testing and Commissioning	Witness and approve	Perform and document
System Integration and Functional Testing	Witness and approve	Full responsibility
Training of Employer's Personnel	Nominate personnel	Provide training
As-Built Documentation	Review and archive	Prepare and submit
Handover and Final Acceptance	Grant acceptance	Achieve compliance

Optional Allocation of Responsibilities – Split Scope (Employer Civil Works)

The table 2 shall apply **only where explicitly stated in the Contract**, in cases where the Employer is responsible for the provision of civil works, buildings, and infrastructure, and the Tenderer's scope is limited to the supply and installation of HVDC and main AC equipment.

Table 2 Allocation of Responsibilities – Split Scope Option

Description	Employer	Tenderer
Project Definition and Boundary Conditions	Define overall project requirements, site constraints, and interfaces	Comply with defined boundary conditions
HVDC System – Functional Requirements	Define functional and performance requirements	Detailed design of HVDC equipment within defined requirements
HVDC Converter Equipment (valves, transformers, reactors, filters)	—	Design, manufacture, supply, installation supervision, testing, commissioning
Main AC Equipment (GIS/AIS, transformers, reactors)	—	Design, manufacture, supply, testing, installation supervision
Auxiliary Systems – Functional Definition	Define required functionality and site constraints	Detailed design of auxiliary equipment interfaces
– Fire Detection and Fire-Fighting Systems	Design, supply, installation, certification	Review of interfaces with HVDC equipment
– HVAC Systems	Design, supply, installation	Define heat loads, equipment requirements, and interface data
– Building Services (lighting, drainage, access)**	Design and implementation	Define requirements related to HVDC equipment
Civil Works and Buildings (converter halls, control rooms, foundations)	Full responsibility for design, permits, construction, and completion	Provide equipment loads, layout requirements, and interface data
Civil Works (cable trenches)	Define overall project requirements	Full responsibility for design, permits, construction, and completion
Permits and Approvals – Civil and Building	Define overall project requirements	Support with technical documentation related to HVDC equipment and obtain authorizations
Permits and Approvals – Electrical Works	Support as required	Prepare technical documentation for HVDC and AC equipment
Detailed Engineering – HVDC Equipment	Review and approve	Full responsibility
Detailed Engineering – Civil Works	Define overall project requirements	Full responsibility
Drawing Preparation – Civil and Buildings	Prepare and submit	Review and comment
Drawing Preparation – HVDC and AC Equipment	Review and approve	Prepare and submit
Interface Management (civil ↔ equipment)	Overall coordination	Define interface requirements and constraints
Factory Acceptance Tests (FAT)	Witness and approve	Plan, perform, and document
Transportation and Delivery of Equipment	—	Full responsibility

Installation of HVDC Equipment	Provide access and readiness of buildings	Supervise installation and perform equipment installation
Site Testing and Commissioning (HVDC equipment)	Witness and approve	Perform and document
Integration of Equipment into Buildings	Ensure readiness of infrastructure	Verify compatibility and performance
Training of Employer's Personnel	Nominate personnel	Provide training for supplied equipment
As-Built Documentation (HVDC equipment)	Review and archive	Prepare and submit
Handover and Acceptance (HVDC scope)	Grant acceptance	Achieve compliance

Where this split-scope option applies, the Tenderer shall not be responsible for the design, permitting, construction, or performance of civil works, buildings, or infrastructure, except for defining interface requirements and verifying compatibility with the supplied HVDC and AC equipment.

The allocation of responsibilities described above is indicative and shall be read in conjunction with the full Technical Specification and contractual documents. In the event of discrepancies, the contractual documents shall prevail.

Exclusions and Assumptions

General

This section defines the Exclusions and Assumptions applicable to the Scope of Works.

It identifies activities, systems, and responsibilities that are explicitly not included in the Tenderer's scope, unless otherwise expressly stated in the Contract.

The exclusions defined herein are closely linked to the Interfaces and Limits of Supply and are intended to ensure a clear allocation of responsibilities between the Employer and the Tenderer.

The Contractor Scope of Works shall include all items, activities, services, and obligations necessary to deliver a complete, compliant, and fully operational system in accordance with the Contract requirements.

Exclusions (Examples)

Unless explicitly stated otherwise in the Technical Specification or Contract, the following items could be excluded from the Tenderer's Scope of Works:

- Civil Works and Infrastructure (where Employer-provided).
- Design, permitting, and construction of buildings, foundations, and infrastructure for HVDC equipment installation.
- Earthworks, piling, drainage, roads, fencing, and external site infrastructure.
- Permanent buildings including converter halls, control rooms, auxiliary buildings, and architectural works.
- Utilities and services external to the HVDC equipment boundary.

(Note: This exclusion applies where civil works are defined as the Employer's responsibility.)

- Permits and Statutory Approvals.

Acquisition of construction permits, environmental permits, land use approvals, and similar statutory approvals, except where explicitly assigned to the Tenderer.

Liaison with authorities related to civil works, land acquisition, or third-party infrastructure.

- Third-Party Systems and External Networks.
- Works related to external AC networks beyond the defined interface points.
- Modifications or reinforcements of third-party infrastructure not explicitly included in the Scope of Works.
- Third-party telecommunication systems, external SCADA platforms, or data centres beyond defined interfaces.
- Site Preparation and Readiness
    - Site clearance, demolition, and remediation works.
    - Provision of permanent access roads and construction logistics infrastructure.

- Provision of completed and weather-tight buildings prior to HVDC equipment installation.

- Owner's Operational Systems.

Employer's internal operational procedures, asset management systems, and business IT systems.

Long-term operational staffing and organizational arrangements.

Assumptions

The Scope of Works is based on the following assumptions, which form an integral part of the Tenderer's obligations:

a) Interface Assumptions

All interface points between the Tenderer's scope and the Employer's scope are clearly defined and provided in accordance with the Technical Specification.

The Employer-provided infrastructure shall be completed, accessible, and fit for installation of HVDC equipment at the agreed milestones.

b) Information Provided by the Employer

All data, requirements, and boundary conditions provided by the Employer are assumed to be accurate and complete for the purposes of design.

c) Coordination Assumptions

The Employer or Employer's Representative shall coordinate interfaces between multiple contractors where applicable. Contractors are required to participate in coordination meetings, either remotely or in person, and to provide all information requested by the involved parties.

Relationship to Interfaces and Limits of Supply

The exclusions and assumptions defined in this section shall be read together with the Interfaces and Limits of Supply defined in Section 4.4.

In the event of ambiguity, the interface definition shall take precedence in determining responsibility. This precedence shall apply irrespective of assumptions or exclusions stated elsewhere in the Technical Specification.

Interface Responsibility Matrix – HVDC Project

Legend:

R – Responsible (full execution, design, supply, installation, testing).

S – Support / coordination / data provision.

I – Informed / interface coordination only.

As an example:

The following table 3 (RSI matrices) could define the contractual allocation of responsibilities at all system and physical interfaces and shall be binding.

Table 3 Example of RSI matrix for the contractual allocation of responsibilities.

Interface / Scope Item	CS Contractor	Cable Contractor	TSO / Employer
Overall system integration (HVDC link)	R	S	I
HVDC system studies (EMT, RMS, control interactions)	R	S	I
AC system studies (grid code compliance, PCC)	R	I	S

DC system studies (incl. cable-converter interaction)	R	S	I
Converter station main equipment (valves, transformers, DC yard)	R	I	I
Converter station auxiliary systems (cooling, HVAC, fire, LV, telecom)	R	I	I
Converter station civil works (if EPC/LSTK)	R	I	I
Subsea and land HVDC cables (supply & installation)	I	R	I
Cable route surveys & cable installation studies	I	R	I
DC cable terminations at converter station	R (station side)	R (cable side)	I
Interface at DC termination / head clamps	R (lead)	R	I
Control & protection interface (CS ↔ Cable)	R	S	I
SCADA / telecom interface to TSO	R	I	S
AC connection from CS to PCC	R (unless stated otherwise)	I	S
Permits – converter station	R (with POA if required)	I	S
Permits – cable route & installation	I	R	S
Transport to site (CS equipment)	R	I	I
Transport to site (cables)	I	R	I
Construction site HSE (own scope)	R	R	I
Interface HSE coordination	S	S	R
Pre-commissioning (own scope)	R	R	I
System commissioning & energisation	R (lead)	S	I
Trial operation / reliability run	R	S	I
Performance testing (HVDC link)	R (lead)	S	I
As-built documentation (own scope)	R	R	I
Spare parts (own scope)	R	R	I
Long-term service (if contracted)	R	I	I

Where an interface requires joint action, the Converter Station Contractor shall retain overall responsibility for coordination and for achieving system performance compliance.

Optional Interface Responsibility Matrix – Employer-Led Civils & Permits

Assumption:

Employer/TSO executes civil works and holds all permits (directly or via separate civil contracts).

CS and Cable Contractors retain design integration, system performance, and equipment responsibility.

Table 4 Example of RSI Matrix for Optional Interface

Interface / Scope Item	CS Contractor	Cable Contractor	TSO / Employer
Overall HVDC system integration & performance	R	S	I
HVDC system studies (EMT, RMS, controls)	R	S	I
AC system studies / grid code compliance	R	I	S
DC system & cable-converter interaction studies	R	S	I
Converter station primary equipment	R	I	I
Converter station auxiliary systems	R	I	I
Converter station basic design inputs for civils	R	I	I
Detailed civil works design (buildings, foundations)	S	I	R
Execution of civil works (CS site)	I	I	R
Subsea and land HVDC cables (supply & installation)	I	R	I
Cable route surveys & installation engineering	I	R	I
DC cable terminations at converter station	R (station side)	R (cable side)	I
Mechanical & electrical interface at DC terminations	R (lead)	R	I
Control, protection & telecom interfaces (CS ↔ Cable)	R	S	I
SCADA / dispatch interface to TSO	R	I	S
AC connection from CS to PCC (equipment & integration)	R	I	S
AC civil works (trenches, buildings, foundations)	I	I	R
Permits – converter station (all authorities)	S	I	R
Permits – cable route & marine works	I	S	R
Land acquisition & access rights	I	I	R
Transport of CS equipment to site	R	I	I
Transport of HVDC cables	I	R	I
Site HSE – own scope	R	R	R
Overall site HSE coordination	S	S	R
Pre-commissioning (own scope)	R	R	I
System commissioning & energisation	R (lead)	S	I
Trial operation / reliability run	R	S	I
Performance & acceptance testing	R (lead)	S	I
As-built documentation (own scope)	R	R	I
Spare parts (own scope)	R	R	I

The Employer shall be responsible for the execution and permitting of civil works.

The Converter Station Contractor shall remain fully responsible for the adequacy of civil design inputs and for ensuring that the Employer-executed civil works are suitable for the installation, operation, and performance of the HVDC Converter Station.

04 Interface

Purpose

The purpose of this chapter is to define the Contractor's overall system responsibility for the HVDC interconnector interface, including how the interface interacts with adjacent AC systems and existing HVDC links. It specifies the requirements for modelling, interface behaviour, control coordination, validation activities, and related documentation necessary to demonstrate compliance with technical specifications and applicable ENTSO-E HVDC Network Codes.

Main Definitions and Standards

List of main standards and documents that are applicable (non-exhaustive list):

- Relevant ENTSO-E Documentation.
- IEC 61850 – Communication and automation in substations.
- IEC 61970 / 61968 – CIM for system modelling and interfaces.
- IEC 62501 – VSC HVDC systems.
- IEC 62747 – Terminology for HVDC.
- IEC 60255 – Protection system interfaces and control signals.

List of Subchapters

Interface with AC Substation.

Physical.

Control and Protection.

Metering.

Cyber-Security.

Contractor interface.

Third parties.

Description of Subchapters

The details required by the TSO for the tender description are listed in the following.

Interface with AC Substation

General

The Contractor shall be responsible for managing all engineering interfaces and coordinating with the Client to ensure that the converter station equipment and the cables system are fully compatible with the existing Client provided AC substation equipment and associated interfaces. The Parties shall develop a Project Interface Management Procedure. The objective of this procedure is to establish a structured interface management process that ensures the timely identification and resolution of all technical, execution, and organizational interfaces. This document defines the overarching requirements and methodologies for managing both internal and external interfaces throughout the execution of the XXXX Project. The procedure is intended for application at the project level and, where appropriate, within the engineering and procurement functions. It provides a consistent framework through which interfaces can be identified, documented, agreed upon, tracked, and effectively resolved.

Physical

The Client shall be responsible for providing and preparing a connection point to the XXX AC Bay within the XXX substation. List of items should be described and/or provided sketches/drawing of connection point:

- AC Circuit Breakers.
- AC Disconnectors.
- AC Earthing Switches.
- Current Transformers.
- Potential Transformers.
- AC bus differential protection.
- Circuit Breaker failure protection.

The Contractor shall be responsible for confirming, designing, supplying, installing, testing, and commissioning all equipment required to complete the connection between the AC substation and the HVDC converter station.

This scope shall include, but not be limited to:

- Permits.
- Civil works.
- Clamp terminations and fittings.
- Overlapping protection.
- Control and protection equipment.
- Instrument transformers.
- Wiring, and cabling.

This chapter should include essential baseline diagrams and visual representations to provide a clearer understanding of the interface arrangements and their functional relationships.

Control and protection.

The division of responsibilities for all control and protection systems shall be clearly defined. This chapter shall specify which control and protection functions are to be designed, provided, and implemented by the Client, and which shall fall under the Contractor's scope. Appropriate matrix, figures and diagrams shall be included to clearly illustrate the measurement arrangements and interface points.

Metering

This chapter shall describe the locations for installing the required measuring equipment and shall specify the responsibilities for its provision. The Power Quality Monitoring System shall also be described in this chapter, including its purpose, installation locations, required measurement functions, and the allocation of responsibilities between the Client and the Contractor. Appropriate figures and diagrams shall be included to clearly illustrate the measurement arrangements and interface points.

Cyber security

This document outlines the key security assumptions applicable to the substation IT systems (hereinafter referred to as 'the systems') within the framework of the network segmentation project, as well as the security requirements necessary for the successful implementation of the Project. Details of the system should be described in the chapter **14 Electrical Equipment**.

Contractor interface

Contractor interfaces refer to interactions with external entities whose work may influence project execution or scope. Contractor interface requirements must be defined at an early stage of the project to establish tie-in points and determine the schedule and sequence of technical reviews required to secure approvals. Contractor interfaces on site may involve multiple external parties whose activities directly influence project execution. Typical on-site interfaces include, but are not limited to:

- HVDC Cable Contractor (land cable works, cable pulling, terminations).
- Access Road / Infrastructure Contractor.
- AC Substation Contractor.
- Civil Works Contractor (foundations, buildings, trenches, ducts).
- Telecommunication / Fibre-Optic Contractor.

- Auxiliary Power Supply Contractor (AC/DC auxiliary systems, UPS, diesel generators).
- SCADA / Communication Systems Contractor.
- Environmental and Geotechnical Contractors (monitoring, surveys, permits).
- Security Systems Contractor (CCTV, access control).
- Landscaping / Site Restoration Contractor.
- Fire Safety and Detection Systems Contractor.
- Commissioning Support Teams from various vendors.

The Contractor shall manage interfaces in accordance with the agreed Scope of Responsibility Matrix.

Third parties

Third-party interfaces will arise with various regulatory authorities. These interfaces must be identified early and managed effectively to secure the necessary approvals for engineering, procurement, and construction activities to proceed as scheduled.

Third-Party interfaces for the Project include, but are not limited to, the following:

- Utility service providers.
- Municipal authorities and/or landowners.
- Regulatory agencies (e.g., authorities responsible for construction permits and facility approval prior to operation), with specific requirements varying according to national and local regulations.
- Concession holders.

05 Management Systems

Purpose

This chapter outlines how different management systems should be used to create trust on the client's side that the contractor will fulfil the project as agreed. By showing a professional work and management approach, the contractor can create the necessary confidence.

Client and contractor need to agree on the application of the management systems by tailoring processes, inputs, tools, techniques, outputs, and more to manage the concrete project. As contractors often use their own specialized processes and tools, the requirements on management systems from the client should stay generic and not require contractors to follow detailed prescriptions.

Effective project management should help to meet the client's objectives, satisfy stakeholder expectations, increase predictability and chances of success, deliver the right products at the right time, resolve problems and issues, respond to risks in a timely manner, optimize the use of organizational resources, manage constraints, and manage change in a good manner.

Main Definitions and Standards

List of main standards that are applicable (non-exhaustive):

- PMBOK Guide (A Guide to the Project Management Body of Knowledge).
- ISO 21500 family.
- ICB4 – IPMA (Individual Competence Baseline).

List of Subchapters

Management Topics

For the preparation of the tender, the following topic should be elaborated in more detail to specify what is expected of the tenderer during the tender process.

The tenderer shall describe the management systems that will be used to support the execution of the project.

All the following topics should be addressed in the bid. For all topics, a description should be included; optionally, tools and best practices should be included.

Project Integration Management

Includes the processes and activities to identify, define, combine, unify, and coordinate the various processes and project management activities within the Project Management Process Groups.

Project Scope Management

Includes the processes required to ensure the project includes all the work required, and only the work required, to complete the project successfully.

Planning Management

Includes the processes required to bring all aspects of project management together in a complete and consistent project management plan that sets the conditions for all other areas.

Requirements Management

Includes the processes for determining, documenting, and managing stakeholder needs and requirements to meet objectives. It includes the documentation of all agreed and validated project requirements and their changes as well as documentation of the requirement fulfilment to enable progress tracking.

Schedule Management

Includes the processes required to manage the timely completion of the project.

Enrich the Scope of Work with structured, sequenced and connected information to enable calculation of dates considering incorporated progress feedback. The schedule contains work packages, activities, milestones, and their dependencies.

Change Management

Includes the processes for the timely and appropriate identification, evaluation, authorization, implementation, and documentation of changes affecting project scope, schedule, cost, resources, or deliverables. It ensures that all proposed changes are systematically assessed, impacts are clearly understood, and approved modifications are communicated, implemented, and monitored in a controlled manner. It also determines how change-related information is captured, shared, and delivered to relevant stakeholders throughout the project lifecycle.

Information and Documentation Management

Includes the processes for timely and appropriate planning, collection, creation, distribution, storage, retrieval, management, control, monitoring, and ultimate disposition of information regarding project content as described in the Documentation topic. It also determines how information is shared and delivered.

Reporting and Communication Management

Includes the processes for timely and appropriate planning, collection, creation, distribution, storage, retrieval, management, control, monitoring, and ultimate disposition of information regarding project management. It also determines how information is shared and delivered.

Quality Management

Includes the processes for incorporating the organization's quality policy regarding planning, managing, and controlling project and product quality requirements, in order to meet stakeholders' expectations.

Issue Management

Includes the processes for identifying, documenting, controlling, and resolving issues that prevent the project from reaching its objectives.

Risk Management

Includes the processes for conducting risk management planning, identification, analysis, response planning, response implementation, and monitoring risk on a project.

The types of impact of risks on project objectives are to be considered, mainly time, cost and quality impact, but also stakeholders, environment and others. The project risk response strategies are to be aligned with relevant stakeholders.

Stakeholder Management

Includes the processes required to identify the people, groups, or organizations that could impact or be impacted by the project, to analyse stakeholder expectations and their impact on the project, and to develop appropriate management strategies for effectively engaging stakeholders in project decisions and execution.

Includes interface management as listed in the Interfaces topic.

Health, Safety and Environment Management

Includes the processes for a structured approach in the project to ensure that for both people and the environment, their health and safety is always safeguarded from harm. This shall be done in accordance with the HSE topic.

Optionally, ISO 14001 Environmental Management System can be included.

Security Management

Includes the processes required for systematic planning, implementation, and monitoring of measures to protect a project from threats from a technological, physical, informational, and personnel perspective.

Cost Management

Includes the processes involved in planning, estimating, budgeting, financing, funding, managing, and controlling costs so the project can be completed within the approved budget.

Resource Management

Includes the processes to identify, acquire, and manage the resources needed for the successful completion of the project.

Procurement Management

Includes the processes necessary to purchase or acquire products, services, or results needed from outside the project team.

06 Responsible Business Practices

Purpose

The purpose of this chapter is to define the Contractor's overarching responsibilities regarding business practices like Corporate Social Responsibility (CSR), Health, Safety and Environment (HSE), environmental stewardship, and product safety across all project phases. It specifies the requirements for implementing CSR principles, ensuring safe and sustainable working practices, minimizing environmental impacts, and guaranteeing that all supplied products meet applicable safety standards and regulatory obligations. This chapter also establishes expectations for risk management, monitoring, reporting, and continuous improvement activities, as well as the documentation necessary to demonstrate full compliance with contractual obligations, relevant legislation, and applicable international standards.

Main Definitions and Standards

List of main standards that are applicable (non-exhaustive):

- CSR – Corporate Social Responsibility.
- HSE – Health, Safety and Environment.
- LCA – Lifecycle Assessment.
- SWMS – Safe Work Method Statement.
- ERP – Emergency Response Plan.
- MSDS – Material Safety Data Sheet.
- ESPD – European Single Procurement Document.
- PPE – Personal Protective Equipment.

List of main standards that are applicable (non-exhaustive):

- ISO 26000 – Guidance on Social Responsibility.
- UN Global Compact Principles.
- OECD Guidelines for Multinational Enterprises.
- SDGs – UN Sustainable Development Goals.
- ISO 14001 – Environmental Management Systems.
- ISO 14040 / ISO 14044 – Life Cycle Assessment.
- ISO 14064 – Greenhouse Gas Emissions.
- EU Environmental Directives (e.g., Industrial Emissions Directive, Waste Framework Directive, REACH, RoHS).
- ISO 12100 – Safety of Machinery – Risk Assessment.
- ISO 45001 – Occupational Health & Safety Management.
- ISO 45003 – Safety and Psychological Health (if relevant).
- IEC 61508 – Functional Safety.
- CE Marking Regulations (EU).
- Material Safety Data Sheet (MSDS) Requirements.

List of Subchapters

Corporate Social Responsibility.

HSE (Health & Safety).

Environmental considerations.

Product Safety.

Description of Subchapters

The details required by the TSO for the tender description are listed in the following.

Corporate Social Responsibility

Purpose of this Section

This chapter defines the Contractor's obligations related to Corporate Social Responsibility throughout the contract execution. It sets minimum expectations regarding ethical conduct, transparency, labour practices, social impact, and compliance with organizational and international CSR frameworks.

CSR Policy Compliance

The Contractor shall operate in accordance with internationally recognized CSR principles. The Contractor must demonstrate alignment with these principles through internal policies, certifications, or documented governance frameworks.

Ethics, Integrity and Anti-Corruption Requirements

The Contractor requirements should be included:

- Mandatory adherence to the Contracting Entity's Anti-Corruption Policy.
- Requirement to follow the Supplier Code of Ethics.
- Zero-tolerance policy on bribery, fraud, collusion, or conflict of interest.
- Obligation to report suspected misconduct.
- Whistleblower protection provisions.

The Contractor must confirm compliance by signing declarations or providing policy documents.

Socially Responsible Procurement Obligation

The Contractor requirements should include:

- Requirements for socially responsible supply chains.
- Preference or obligation to use suppliers following ethical labour practices.
- Prohibition of forced labour, child labour, and discriminatory practices.
- Requirements regarding equal opportunities and fair working conditions.
- Compliance with national labour laws and EU social directives.

If applicable, Contractors may need to provide supporting evidence (ESPD, certificates, audits).

Human Rights and Labor Practices

The Contractor must ensure that all employees and subcontractors:

- Work under lawful, safe, and fair labour conditions.
- Receive wages and benefits according to legislation.
- Are not subject to discrimination, harassment, or unsafe working conditions.
- Have the right to form or join worker organizations.
- Have access to grievance mechanisms.

Supply chain monitoring requirements can also be included for high-risk product categories.

Transparency and Disclosure Requirements

Tender documents often require the Contractor to:

- Disclose ownership structures.
- Identify politically exposed people (PEPs).
- Declare potential conflicts of interest.
- Confirm no sanctions, legal restrictions, or ethical violations apply.

This is connected to social and national security compliance criteria.

HSE (Health & Safety)

General HSE Obligations

The Contractor must explicitly state that the Contractor is fully responsible for all Health, Safety and Environmental performance during the contract execution.

The Contractor should include:

- Requirement to provide all H&S services for the project.
- Obligation to follow all local HSE laws and internal rules.

Requirement to execute all works in compliance with the Contractor's HSE management system.

HSE Team & Competency Requirements

Include clear personnel qualification requirements:

- Contractor must establish a dedicated HSE team for the entire project.
- Mandatory Health & Safety Manager, reporting directly to the Project Manager.
- All HSE personnel must be licensed/accredited (e.g., OHSAS 1800 or equivalent).

Environmental specialists must also be part of the team (noise, fauna/flora, EMF, etc.).

HSE Management Plan (HSE Plan)

The HSE Plan must cover:

- Project-specific HSE strategy & responsibilities.
- Leadership, commitment, and accountability model.
- Risk assessment methodology.
- Work-site safety rules and controls.
- Emergency response planning.
- Site access and contractor management.
- Incident & accident reporting procedures.
- Environmental protection measures.
- Waste management.
- Monitoring, audit, and inspection requirements.

Safe Work Organization Requirements

This includes requirements such as:

- Contractor obligations before entering sites.
- Work permits.
- Lock-out/tag-out.
- Method statements & risk assessments.
- Personal protective equipment (PPE) requirements.
- Toolbox talks & safety briefings.

Environmental considerations

Purpose of this section

This chapter defines the Contractor's overarching environmental responsibilities that apply to all supplied products, materials, and services, irrespective of project type or location. These requirements ensure compliance with applicable environmental legislation, promote sustainable resource use, and minimize environmental impacts throughout the lifecycle of materials and equipment.

The Contractor shall identify and manage environmental aspects and impacts associated with its activities, products, and services. This includes:

- Conducting internal assessments of environmental aspects, including emissions, waste generation, energy consumption, noise, and chemical usage.
- Implementing preventive measures to minimize impacts and avoid pollution.
- Ensuring continuous adherence to applicable environmental standards and regulations.

Material Compliance Requirements

The Contractor must ensure that all materials, components, and substances provided under the contract comply with EU and national environmental legislation, including but not limited to:

REACH Regulation

All supplied substances, preparations, and articles must comply with Regulation (EC) No 1907/2006 (REACH):

- No use of substances of very high concern (SVHC) above allowed thresholds unless duly declared.
- Safety Data Sheets (SDS) must be provided where applicable.

Contractors must ensure that upstream suppliers comply with registration and authorization obligations.

RoHS and Hazardous Materials Restrictions

Although project-specific exemptions may apply, equipment must avoid the use of hazardous substances wherever feasible. Labels must follow applicable EU directives and chemical hazard classification rules.

Batteries Directive (2006/66/EC)

If equipment includes batteries, the Contractor must ensure compliance with:

- Chemical restrictions (e.g., mercury, cadmium).
- Labelling requirements.
- Collection and recycling obligations.
- Obligations for take-back and environmentally responsible disposal.

Hazardous Substances: Handling, Classification, Labelling and Storage

Requirements include:

- Compliance with CLP (Classification, Labelling and Packaging) Regulation.
- Labelling according to EU hazard pictograms, signal words, and precautionary statements.
- Safe storage practices, including segregation of incompatible materials.
- Spill prevention and emergency procedures.
- Maintaining up-to-date inventories of hazardous substances.
- Ensuring subcontractors follow identical requirements.

Waste Management Obligations

The Contractor shall implement a waste management system covering all waste streams generated during manufacturing, supply, packaging, delivery, and commissioning.

Key requirements:

- Compliance with applicable waste directives and national waste legislation.
- Proper separation, classification, and documentation of waste.
- Use of licensed waste handlers and recyclers.
- Minimization of landfill disposal.
- No uncontrolled disposal of materials, chemicals, oils, or residues.

Compliance with Environmental Regulations

The Contractor must comply with all applicable:

- EIA reporting requirements.
- EU environmental directives.
- National legislation in the country of manufacture and supply.
- International standards for environmental protection.

Packaging Reuse and Reduction

The Contractor shall ensure that packaging materials are minimized and, where possible, reused or easily recyclable.

Requirements:

- Use of recyclable or reusable packaging materials (e.g., wood, cardboard, recyclable plastics).
- Avoidance of unnecessary packaging layers.

- No use of hazardous packaging additives or restricted materials.
- Clear labelling of packaging for proper recycling and reuse.

Product Safety

Purpose

This chapter defines the Contractor's overarching responsibilities for ensuring the safety of all products, systems, technical equipment, and plant supplied under the Contract. It covers the entire lifecycle of supplied products—from design and manufacturing to delivery, installation, commissioning, operation, and decommissioning. These requirements apply across all projects and locations and are intended to ensure conformity with applicable product safety legislation, standards, and risk-management practices.

Technical Plant Safety Requirements

The Contractor shall ensure that all supplied equipment and systems are designed and engineered according to recognized principles of technical plant safety, including but not limited to:

- Prevention of injury, environmental harm, and property damage.
- Minimization of hazards through inherently safe design.
- Selection of materials and components meeting safety, quality, and durability criteria.
- Provision of adequate protection measures, interlocks, fail-safe mechanisms, and monitoring systems.
- Full compliance with applicable EU directives (e.g., Machinery Directive, Low Voltage Directive, EMC Directive) and international standards (ISO/IEC/EN).
- The Contractor shall document design-stage safety considerations within the product documentation and provide evidence on request.

Hazard Identification (HAZID)

The Contractor shall perform a Hazard Identification (HAZID) process for all supplied products and technical systems. This process must include:

- Systematic identification of hazards that may arise during manufacturing, transport, installation, operation, maintenance, and disposal.
- Consideration of mechanical, electrical, thermal, chemical, ergonomic, and software/human-machine-interface (HMI) hazards.
- Documentation of identified hazards in a structured register.
- Outputs from the HAZID must be included in the product safety file or accompanying technical documentation.

Hazard Analysis and Risk Assessment (HARA)

The Contractor shall carry out a Hazard Analysis and Risk Assessment (HARA) according to established methods such as ISO 12100, ISO 31000, or equivalent standards.

The HARA shall:

- Evaluate each identified hazard in terms of severity, probability, and exposure.
- Distinguish between normal operation, foreseeable misuse, and fault conditions.
- Identify safety functions required to reduce risk to acceptable levels.
- Assess the need for additional protective measures, alarms, redundancies, fail-safe architectures, or emergency shutdown mechanisms.
- A summary risk assessment shall be made available to the Employer upon request and shall form part of the contractor's technical documentation package.

Risk Estimation and Evaluation Procedure

The Contractor is responsible for implementing a structured and traceable risk estimation and evaluation procedure, which must include:

- Clear criteria for risk levels (e.g., qualitative or quantitative scales).
- Documentation of initial (pre-mitigation) risk and residual (post-mitigation) risk.
- Use of recognized methodologies such as FMEA, FTA, ETA, or equivalent methods, where appropriate.
- Compliance with the ALARP principle (As Low As Reasonably Practicable) or an equivalent risk-acceptance framework.

- Residual risks must be explicitly communicated to the Employer through labels, instructions, warnings, or operational limitations.

Hierarchy of Hazard Control

The Contractor must apply the internationally recognized hierarchy of controls when reducing hazards, in the following priority order:

- Elimination – Remove the hazard entirely through design changes.
- Substitution – Replace hazardous materials, components, or processes with safer alternatives.
- Engineering Controls – Implement guards, barriers, interlocks, enclosures, redundancy, monitoring, and fail-safe systems.
- Administrative Controls – Provide procedures, warnings, training requirements, manuals, and safe-work instructions.
- Personal Protective Equipment (PPE) – Use PPE only as a last line of defense.
- The Contractor must demonstrate that higher-order controls have been prioritized before relying on administrative controls or PPE.

Documentation

Purpose

This chapter outlines documentation requirements regarding the project.

This topic serves as a starting point for what information is required to guarantee the desired project outcome and use the assets delivered during the project for their purpose. The topic “Digital Collaboration” prescribes how information management needs to be executed during the project to achieve this result.

For a TSO, accurate and complete information on all assets is needed for all decisions and actions regarding these assets, so they can be operated and managed as required by the TSO’s (legal) assignment, strategy, and goals. As stated in ISO 55000, “effective control and governance of assets by organizations is essential to realize value through managing risk and opportunity, in order to achieve the desired balance of cost, risk and performance.”

To assign information to the correct objects, system structuring principles and designation rules from the TSO need to be applied to ensure consistent and accurate delivery of information. At the end of the project, all the information listed in this chapter needs to exist and be verified and validated according to the methodologies listed.

Main Definitions and Standards

List of main standards that are applicable.

List of Subchapters

Documentation Topics

For the preparation of the tender, the following topics should be elaborated in more detail to specify what is expected of the tenderer during the tender process.

The tenderer shall describe how the documentation requirements will be treated to support the execution of the project.

All following topics should be addressed in the bid. For all topics, a description should be included; optionally, tools and best practices should be included.

The Documentation chapter has very strong relations to the chapter 8 Digital Collaboration.

Reference Designation

The designation rules shall be used consistently throughout all documents across the life cycle for labelling and referencing.

The designation rules together with the international and national reference designation standards need to provide:

- *the basic rules and code letters for the designation of objects and associated documentation and diagrams,*
- *specific designation rules to be used for all operational equipment and components,*
- *a preselection for the structuring of systems,*
- *designation blocks that enable the clear identification and localization of component systems,*
- *specification for (physical) labels attached to the physical asset.*

Asset Structure

Includes the generic and technical requirements of the hierarchical structure of technical objects and equipment to realize an asset register for the operation and maintenance phase. Also includes information about which (IT) systems the TSO uses and time and quality requirements for delivery of the information.

Includes definitions of relevant terms (for example, assets, systems, equipment) and the asset structure with different breakdown levels.

Reference Designation Plan

The contractor shall establish a reference designation plan which shall be verified by the TSO.

The plan shall clarify how the contractor will approach and execute the reference designation during the project, including interfaces with other contractors. The plan shall ensure that assets and all related documentation shall be marked/named with the required documentation and reference designation during all phases, i.e. concept, engineering, fabrication, installation, commissioning, operation, inspection, maintenance and modification. The plan shall include how the digital collaboration [LINK to 08] will be implemented.

Asset Register

The contractor shall establish an Asset Register in the CDE. This register is to be considered as a living data container which needs to be continuously updated in the CDE. The asset register shall reflect the status of the engineering process, and a final asset register is required at the end of the project with as-built information.

The asset register shall contain

the complete reference designation set and breakdown including systems and station reference,

location, long term text, document reference and asset data information.

Asset Documentation

Includes the documentation requirements for all asset types of the project related to the four main categories [Chapter 8] for the operation and maintenance phase and beyond.

- What information is required for which asset type?
- What formats are prescribed?
- What quality checks are required? [Chapter 5]

Project-related Documentation

Includes the documentation requirements for all project activities that are not specifically required for the operation and maintenance phase and beyond[1].

- What information is required for which activity?
- What formats are prescribed?
- What quality checks are required? [Chapter 5]

Asset-labelling

Includes the labelling requirements for all asset types of the project. Labels include any kind of tag which needs to be attached to the asset. Tags can be passive, for example a barcode or QR code, and/or smart, using RFID or other technologies to digitally provide machine-readable information.

Digital Collaboration

Purpose

This chapter outlines how digital collaboration shall be used for effective and efficient information management throughout the project as specified in ISO 19650.

This topic serves as a link (the “how”) between the Scope of Work with the related required Documentation as content and input (Information Requirements, the “what”) and the Milestones and

Payments for Deliveries: Information Deliveries are implemented as containers that can be checked and released throughout the course of the project. This transforms an old-fashioned one-time transfer of project information to the client into a continuous, transparent, and coordinated process—with clear workflows, defined responsibilities, and information status that can be tracked at any time.

This topic also prescribes how the digital collaboration between the TSO and multiple contractors [2], that are not subcontractors of or otherwise contractually bound to each other, shall be implemented within the project.

Main Definitions and Standards

List of main standards that are applicable (non-exhaustive):

- ISO 19650.
- Germany: VDI 2552.

Four main categories of information are considered related to this topic:

- BIM models, mainly related to point structures and area structures.
- GIS information, documenting where point and area structures are located.
- Alphanumerical information.
- All other documentation and unstructured data.

BIM models are parameterized planning or as-built models in which components are represented in the correct orientation with accurate geometry and are functionally linked to the system in accordance with performance and lifecycle-phase requirements. Components relevant to equipment item designation (German: Betriebsmittelkennzeichnung”–BMK) are modelled and tagged with the BMK-identifier as an attribute; these BMK-tagged objects, which are asset or at least switch-bay specific, are used to federate with documents as well as with alphanumeric asset information (via ERP-systems) via BIM attributes or as linked attributes.

The core objective of a BIM model is to establish dependencies between all elements (substation or building components, rooms or room elements, dimensions/labels, section lines, etc.).

List of Subchapters

Digital Collaboration Topics

The tenderer shall describe the digital collaboration that will be used to support the execution of the project.

All following topics should be addressed in the bid. For all topics, a description should be included; optionally, tools and best practices should be included.

Digital Collaboration Roles and Processes

This includes:

- The setup of the Common Data Environment (CDE): What are the responsibilities of the contractor and the client?
    - In what format does the TSO deliver the documentation lists?
    - How does the contractor set up the CDE, for example with asset placeholders and document placeholders?
- What is the different statuses used for information/documents, for example as planned/as-built, draft/checked/approved, …?
- HR review and Approval Processes (external relationships, TSO to Contractor).
- Relationship with other contractors at the same level (i.e., each directly under TSO, but not contractually linked, only via the “interfaces” [Chapter 4 Interface].
- Involvement of subcontractors.
- Assignment of rights.
- Deviations/Issues.
- Insolvency of the Contractor and Rights to Documentation [Legal documents].

Digital Collaboration Tooling

The tenderer shall describe the digital collaboration tooling that will be used to support the execution of the project. The tenderer can merge the tooling description with the above description of roles and processes.

Assignment of System Structures and Asset IDs

Most of the asset-related documentation from the project is linked to specific physical assets. The reference designation requirements [Chapter 7 Documentation] shall be used to establish an Asset Register:

- including unique IDs for each asset/system
- including the given system structure

Once assets in the Asset Register are set up, they shall be populated with the related documentation as described for the asset type [Chapter 7 Documentation].

09 Training

Purpose

This chapter discusses the obligations of the contractor regarding training of the Client's personnel. It covers the scope, organization, delivery, and documentation of training required to ensure safe, efficient, and independent operation and maintenance of the HVDC Converter Stations and associated systems.

Main Definitions and Standards

Definitions:

- Client – TSO.
- Contractor – Tender winner.
- Maintenance staff – Personnel responsible for executing maintenance activities, minor configuration works at the converter station.
- Operators – Personnel responsible for the day-to-day operating of the converter stations, typically from the Client's remote operating centre.

List of Subchapters

- General requirements.
- Maintenance and operation training.
- Operator training.
- Configuration training.
- System model training.

Description of Subchapters

The details required by the TSO for the tender description are listed in the following.

General requirements

The aim of training is that the personnel responsible for operating and maintaining the Works shall achieve the level of knowledge and skills that is required for the personnel to be able to take full responsibility for the operation and maintenance of the Works.

- All training shall have applicable hands-on training included.
- Training material must be provided prior the trainings.
- The date, place and training agenda must be arranged with Client not less than two months before the beginning of training.
- Maintenance training must be based on instructions, checklists and must complement them.
- Training language shall be native Client or English, as agreed.

Maintenance and operation training

The scope and content of the Maintenance and Operation Training shall be directly aligned with the Contractor's Scope of Works under the Contract. In cases where the Client is responsible for civil works and/or building services, the training scope and topic list shall be revised accordingly.

HVDC Basics, operating principles.

HMI operation local:

- o Sequencing.
- o Control functions.
- o Interlockings.

Control and Protection including:

- o Hardware and topology of the Control and Protection system.
- o Engineering interface.
- o Debugging and fault investigation.
- o Software installation, license assignment.
- o Replacement of hardware.

Converter station equipment, including:

- o High voltage equipment, including valves.
- o Medium voltage equipment.
- o Auxiliary systems.
- o Cooling system.

Building Services:

- o Climate and HVAC systems.
- o Fire system.
- o Water and drainage systems.
- o Security system.

Site Services:

- o Water systems (including well water).
- o Drainage systems.
- o Sewage Systems.

HVDC Cables equipment:

- o Fault locator.
- o Monitoring Systems.

Operator training

HVDC Basics, operating principles.

HMI operation local.

HMI operation remote.

Sequencing.

Control functions.

Interlockings.

Operational procedures under normal and disturbed conditions.

Configuration training

Shall include, where applicable:

Minor modification of control code.

Simulation of control code and protection settings for testing purposes.

Modification of protection setting values.

Simulation of signal values for testing purposes.

Auxiliary equipment configuration.

System updates.

System model training

Concepts of the models.

Model usage and limitations.

Troubleshooting.

Dynamic simulation.

Studies and models

Purpose

The purpose of this document is to define the Contractor's overall system responsibility for the performance of the HVDC interconnector, including its interaction with surrounding AC systems and existing HVDC links, and to specify the requirements for modelling, simulation studies, control tuning, validation, and documentation necessary to demonstrate compliance with technical specifications and applicable ENTSO-E Documentation

Main Definitions and Standards

List of main standards that are applicable (non exhaustive):

- IEC 62751 "*Determination of power losses in voltage sources converters for HVDC systems*".
- CIGRE technical brochure 391, RFI limits.
- CIGRE Technical brochure 590, Protocol for reporting the operational performance of HVDC transmission systems.
- CIGRE technical brochure 754: AC side harmonics and appropriate harmonic limits for VSC HVDC.
- CIGRE technical brochure 832: Guide for electromagnetic transient studies involving VSC converters.
- CIGRE technical brochure 604, Guide for the development of models for HVDC converters in HVDC grids.
- CIGRE technical brochure 864, Guide to develop Real-Time Simulation models for HVDC operational studies.
- CIGRE technical brochure 909, Guidelines for sub synchronous oscillation studies in power electronic dominated power systems.
- CIGRE technical brochure 958, Guidelines for use of Real-Code in EMT models for HVDC, FACTs and inverter based generators in power systems analysis.

List of Subchapters

- System Studies.
- Performance Studies.
- Plant design Studies.
- Simulation Models:
    - RMS.
    - EMT.
    - Verification of simulation model.

Description of Subchapters

The studies to be carried by out the contractor should be divided into three main subgroups:

- Studies to be carried out for the offer.
- Studies to be carried out during the engineering phase.
- Studies to be carried out before commissioning.

The details required by the TSO for the tender description are listed in the following.

System Studies (Examples of studies listed below)

Input Data

Adequate network data, necessary for the studies, will be provided by the Employer / TSO.

Dynamic Performance Study

The purpose of the Dynamic Performance Study (DPS) is to optimize and verify the performance of critical HVDC control functions, and the performance and response of the HVDC link to dispatch changes and contingency events.

Multi-Infeed Study

A stability study of the HVDC link and the AC system, including all relevant HVDC interconnections and FACTS devices in the Employer's and neighbour's power systems shall be performed.

Emergency Power Control Study

The purpose of this study is to design and demonstrate the capability of the specified emergency power control functions which shall be designed in order to enhance the operational performance of the AC networks during emergency conditions.

Frequency Controller (FC)

Oscillation Damping controller (POD)

Performance Studies

Operational Performance Studies

Determination of Losses

The study shall calculate the total transmission losses and the auxiliary power consumption within the operating range of the HVDC link according to IEC 62751 "*Determination of power losses in voltage sources converters for HVDC systems*".

Inherent Overload Capability

This study shall establish the inherent continuous, short-term and transient overload capability of the equipment which is available over and above the required ratings.

Reliability and Availability Predictions

The study shall demonstrate that the HVDC link is in accordance with the specified availability and reliability as detailed in Contract [ref to Liquidated Damages].

Emission Studies

High Frequency Performance

The study shall demonstrate the conducted and emitted disturbance generated by the HVDC converter installation for high frequencies, covering frequency ranges for Radio Interference.

The radio interference shall, by suitable design of the plant, be limited so as to minimize the risk of radio interference and satisfy the requirements in CIGRE technical brochure 391, limit 2, "Guide for measurement of radio frequency interference from HV and MV substations".

Acoustic Noise Study

Outdoor Noise

The study shall cover the acoustic noise calculation for the converter stations. The study must demonstrate that specified limits are met. Measurements shall be obtained as verification at a later stage.

Indoor Noise

The study shall cover the maximum indoor sound pressure level everywhere in the working areas which may not exceed the following requirements with all supplies in operation.

Plant Design Studies

Station Grounding study

The aim of the design study is to calculate the ground potential rise by determining the fault currents flowing into the earthing system as well as the duration.

Lightning protection study

This study shall be performed to determine the protection of station apparatus and buildings from lightning.

Study on electrical and magnetic field strength

The purpose of the study is for safety of personnel by ensuring that the calculated electric and magnetic field strength for the proposed design of station at ground level is less than the maximum allowed value of field strength.

EMC Strategy Study

A study shall cover the overall EMC strategy for the converter stations.

HVDC Cables Study

Electrical, mechanical, thermal, and electromagnetic field studies to demonstrate compliance of the cable system with environmental, legislative, and physical requirements.

Simulation Models

Dynamic performance (RMS)

Requirements for RMS simulation model that includes relevant representation of the complete HVDC system, including all main circuit equipment, controls and protection. The provided simulation models shall enable the simulation of normal operation during steady-state conditions as well as during system disturbances.

Harmonic performance model

Requirements for Harmonic performance simulation model.

Transient performance (EMT) model

Requirements for transient (EMT) simulation models.

Verification of simulation model

Preliminary models

The preliminary model verification is to satisfy Employer with the quality of the models and to mitigate possible misunderstandings for the provision of the final models, which may cause delay in the finalization of the overall project.

Factory acceptance test (FAT)

Requirements for Verification of FAT results and relevant simulation models.

Site acceptance test (SAT)

Requirements for Verification of SAT results and Final simulation models.

Physical Assets

Purpose

This chapter outlines the requirements related to the design, installation and construction of the Converter Stations.

Main Definitions and Standards

List of main standards that are applicable.

List of Subchapters

- Site specific conditions.
- Technical interfaces.
- Converter Station(s) layout.
- Transmission System Description.
- DC switching station layout, if any.

Description of Subchapters

The details required by the TSO for the tender description are listed in the following.

Site specific conditions

Site

This section details the location and site of the Converter Station(s).

Operating conditions

This section details the operating conditions for Converter Stations(s) including but not limited to:

- Ambient temperature: min and max.
- Rainfall.
- Wind pressure.
- Wind velocity.
- Snow/ice loading.
- Solar radiation.
- Ground strike point density.
- Keraunic level.
- Seismic level.
- Sea water temperature, if any.

Different studies and timelines can also be addressed: hydrological study, geotechnical study, acoustic study, environmental and landscaping integration study, topographic survey, environmental survey, UXO survey etc.

Technical interfaces

Interfaces with Employer

- Interfaces with Employer Remote Control Centre.

- Interface with Employer existing substation.
- Other interfaces with Employer.

Monitoring system, DTS/DAS, metering etc.

Interfaces with OWF and offshore AC grid, if any

- Control and communication interfaces to the OWFs.
- Protection interfaces to the OWFs.
- Emergency power control of OWFs.

Interfaces with HVDC cable

This section describes the interfaces and information exchanges with HVDC cable, including the maximum stresses on the DC cable termination in Converter Station(s):

- Maximum allowable DC TOV.
- Maximum allowable DC short circuit current.
- For information of HVDC Converter Station contractor, information relating to the HVDC cable testing with S/IMP LI and S/IMP SI.

Other interfaces

Interface with DSO, with other third parties etc.

Converter Stations layout

General requirements

Onshore Converter Station layout

Requirements related to the onshore converter station layout including but not limited to:

- The available surface.
- The layout, considering operational constrains and expectations etc..
- The DC cable termination (design, installation, space needed for testing etc.).

Offshore Converter Station layout, if any

Requirements related to the onshore converter station layout including but not limited to:

- The specific layout, if any.
- The layout, considering operational constrains and expectations.
- The DC cable termination (design, installation, space needed for testing.

Transmission System Description

- Requirements related to the system's point of view impacting layout
    - The expected/specified SLD.
    - AC filter.
    - Spare power transformer.
    - Spare equipment.
    - General HV equipment arrangement, e.g. no direct pole to pole fault prevented by the layout.
    - Specific requirements relating to accessibility to HV equipment during operation.

DC switching station layout, if any

This section describes the functional/operational requirements related to the DC switching station layout, applicable for multiterminal HVDC.

The DC switching station can be installed onshore/offshore.

AC Connection

Purpose

This chapter provides the characteristics of existing AC substation and the characteristics required at the connection point when the **HVDC Link** is in operation.

Main Definitions and Standards

List of main standards that are applicable (non-exhaustive):

- IEC 6100-3-6: Electromagnetic compatibility (EMC) – Part 3-6: Limits – Assessment of emission limits for connection of distorting installation to MV, HV and EHV power systems.
- HVDC Grid Code (EU) 2016/1447.
- CIGRE TB 811 DC side harmonics and filtering in HVDC transmission systems.

List of Subchapters

- Existing AC system description.
- AC system performance requirement.

Description of Subchapters

The details required by the TSO for the tender description are listed in the following.

Existing AC system description

AC system voltage and frequency

The nominal voltage and nominal frequency of the AC grid where HVDC converter station will be connected to.

AC short-circuit level

This section provides the short circuit levels (min and max) of the AC grid at the PCC_AC. The Contractors shall guarantee all the required performances within the range of AC short-circuit levels stated in this section.

Background harmonics

This section provides the background harmonics of the AC grid at the PCC_AC.

AC network harmonic impedances

This section provides the existing AC network harmonic impedances.

AC system performance requirement

This section describes the performance requirements of the “HVDC system” in operation at PCC_AC.

Voltage and frequency ranges

The Contractor shall ensure that the converter station shall be capable of staying connected to the network and capable of operating at maximum active and reactive power capacities within the ranges of the network voltage and frequency described in this section.

The mentioned time periods can occur unlimited number of times. If voltage goes beyond the mentioned limits, the converter station shall not trip as long as the inherent capabilities of equipment are not exceeded.

In addition, fault ride though capabilities shall be fulfilled.

HVDC system shall be capable of staying connected to the network and operate at rate-of-change-of-frequency up to value based on the HVDC Grid Code v2.

Power quality and harmonics

For each converter station, the requirements shall be fulfilled for any network conditions, defined in section 4.1, any topology at AC substations and any converter stations operating conditions. The Contractor shall ensure that the total harmonic distortions (current and voltage) and the flicker at the PCC-AC stay within the limits defined in this section.

Flicker

The converter station shall not cause any deterioration in the existing flicker levels.

Current harmonics

Converter Station

The total harmonic currents at PCC-AC after connection of the converter station shall not exceed the limits.

The total distortions at PCC-AC comprise of the background harmonics, the converter station emission, and any amplification of the background harmonics by the converter station impedance.

HVDC Cable

The equivalent harmonic disturbance current (refer to (CIGRE_TB811)), denoted I_{eq}, generated by the converter in the HVDC Cable Link shall not exceed the specified value.

Voltage harmonics

Converter station

Interharmonic level shall not exceed 0.2% from 50Hz until 5000Hz, in compliance with (61000_3_6).

The total voltage harmonics level after the connection of the HVDC system at PCC-AC shall respect following total limits V_{lim_n}

All the performances of the converter station shall be guaranteed for total voltage harmonics level below V_{lim_n}.

HVDC cable

The voltage Total Harmonic Distortion (THD) in the HVDC Cable Link shall not exceed 2% of the nominal DC voltage. Harmonics up to 5 kHz and with a resolution of 1 Hz shall be considered.

Harmonic filtering and damping

This section describes the requirements related to the filtering and damping capability of the HVDC converter stations.

Negative sequence

Each Converter Station shall be able to withstand a maximum negative phase sequence component specified in this section without accelerated aging of the equipment. It shall remain connected and stable in such network conditions.

Each converter station performance shall be guaranteed for a negative phase sequence component described in this section.

Earthing & lightning requirement

This section describes the earthing requirements of the converter station in order to respect the protection strategies of HVDC system's owner.

HVDC System

Purpose

This chapter outlines the requirements related to the HVDC systems.

Main Definitions and Standards

List of main standards that are applicable (non-exhaustive):

- CIGRE TB 590 / CIGRE TB 956: Protocol for Reporting the Operational Performance of HVDC Systems.
- IEC 61803 : Determination of power losses in high-voltage direct current (HVDC) converter stations.
- IEC 62751 Determination of power losses in voltage sources converters for HVDC systems.
- IEC 62747 Terminology for voltage-sourced converters (VSC) for high-voltage direct current (HVDC) systems.
- CIGRE TB 844: Feasibility study for assessment of lab losses measurement of VSC valves.
- IEC 60909-0: Short-circuit currents in three-phase a.c. systems - Part 0: Calculation of currents.
- EU HVDC Grid Code 2016/1447.
- CIGRE TB 391: Guide for measurement of radio frequency interference from HV and MV substations. 2009.
- EN 50647 Basic standard for the evaluation of workers' exposure to electric and magnetic fields from equipment and installations for the production, transmission and distribution of electricity).
- IEC_61786_2 Measurement of DC magnetic, AC magnetic and AC electric fields from 1 Hz to 100 kHz with regard to exposure of human beings - Part 2: Basic standard for measurements.
- CIGRE TB 535: EMC within power plants and substations.
- IEC 61000: Electromagnetic compatibility (EMC).

List of Subchapters

- HVDC system rating.
- Operating modes / Modes of operation / Configurations.
- Performance requirements.
- C&P concepts.
- Electromagnetic compatibility.
- Audible noise level.
- Redundancy.

Description of Subchapters

The details required by the TSO for the tender description are listed in the following.

HVDC system rating

Active power transmission capacity

Requirements related to the active power including the temporary overload if any.

Reactive power capacity

Requirements related to the reactive power.

DC transmission voltage and current range

Requirements related to the:

- Nominal DC voltage.
- Maximum continuous DC voltage (including harmonics, ripples and measurement tolerances).
- Nominal rated current.

Converter Configuration, Control and Operating modes

HVDC station operating modes depending on configuration

Monopole

Symmetrical monopole

Active Power Control.

Reactive power control in Q or U control.

STATCOM Operation.

Frequency Sensitive Mode.

Black Start.

Grid Forming;

Grid Following.

Power Oscillation Damping Control.

Stop Ramp.

Emergency Power Control (not an operating mode, more protection function).

Bipolar

Back-to-Back

Active Power Control.

Reactive Power Control in Q or U control.

Frequency Control.

Damping Control.

Stop Ramp.

Performance requirements

Reliability, Availability, Maintainability and Safety (RAMS)

Requirements related to the lifetime of HVDC system, the availability, the scheduled outage, the forced outage.

Transmission losses

Requirements related to the losses:

- Definition
- Losses assessment
- Losses calculation and verification

Definition of operating modes

This section defines and describes different operating modes required by HVDC system's owner: power transmission, reactive power, …

The requirements related to the transitions between different operating modes will also be addressed (without / with power interruption).

Start-up, shutdown and restart of HVDC systems

Requirements related to the start-up, shutdown and restart of HVDC system.

HVDC system control

This section describes the requirements related to operational control of HVDC system.

Active power control

AC voltage and reactive power control

Frequency control

STATCOM mode.

HVDC dynamic performances

This section describes the requirements related to dynamic behaviour of HVDC system.

Fault ride through capability (FRT)

The converter station shall have the ride through capabilities described in this section, even during transitions as stated in 4.2.3.

Moreover, the converter station shall be able to withstand reclosing on permanent faults, symmetrical or asymmetrical faults close to the converter station in AC network.

Under Voltage Fault Ride Through (UVRT)

Over Voltage Fault Ride Through (OVRT)

Grid code compliance.

Distinction between onshore/offshore.

Voltage support

Requirements related to the support function of HVDC to the variation of AC voltage i.e fast injection of reactive power

Active power recovery after fault clearance

Sub-synchronous oscillation damping

SSTI damping

Active damping (for harmonics)

Disturbances

This section describes the requirements related to the behaviour of HVDC system in cases of disturbances:

- Energization of nearby HV equipment
- Voltage drops
- Load rejections
- Power step variations

Advance functionalities

Grid forming

Black start

Others …

Electromagnetic compatibility

Radio Frequency Interference (RFI)

The radio interference due to the presence of HVDC Link shall be limited. The limits described in this section shall be respected.

Electromagnetic emissions and electrostatic field limits (EMF)

Electromagnetic emissions and electrostatic fields caused by the HVDC Link shall be limited, so personnel may not be harmed. The limits described in this section shall be applied for electric and magnetic fields.

Emission and immunity inside and near the converter station.

The Contractor has the full responsibility for the desired and error free operation of all equipment within the converter stations under all normal and abnormal conditions in the converter stations thus also during electromagnetic disturbances.

Audible noise level

The noise emission to the environment cannot exceed the specified requirements at any time during construction and operation. Hence, the most critical operation modes throughout the complete operating range must be considered.

During construction

The Contractor is responsible for respecting possible restrictions from local or State authorities regarding noise emission during construction which may apply to the administrative area in which the converter station is built.

During operation

The limitation of audible noise levels is described in this section.

Indoor

Outdoor

Redundancy

This subchapter describes which equipment should be redundant.

Electric Equipment

Purpose

This chapter outlines the requirements related to high voltage equipment, the control and protection equipment, the telecommunication & cyber security, the auxiliary services.

Main Definitions and Standards

List of main standards that are applicable (non-exhaustive):

- IEC 60071-1 Insulation co-ordination - Part 1: Definitions, principles and rules.
- IEC 60071-5 Insulation coordination – Part 5: Procedures for high-voltage direct current (HVDC) converter stations.
- IEC 60815-1 Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Part 1: Definitions, information and general principles.
- IEC 60815-2 Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Part 2: Ceramic and glass insulators for a.c. systems.
- IEC 60815-3 Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Part 3: Polymer insulators for a.c. systems.
- IEC 60815-4 Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Part 4: Insulators for d.c. systems.
- IEC 61869 Instrument transformers.
- IEC 62271 High-voltage switchgear and controlgear.
- IEC 62501 Voltage sourced converter (VSC) valves for high-voltage direct current (HV/DC) power transmission - Electrical testing.
- IEC TR 61000-3-6 Electromagnetic compatibility (EMC) - Part 3-6: Limits - Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems.

List of Subchapters

- High voltage equipment.
- C&P system.
- Telecommunication and cyber security.
- Auxiliary systems.

Description of Subchapters

The details required by the TSO for the tender description are listed in the following.

Insulation coordination

This section describes the requirements regarding insulation coordination within HVDC converter station including:

- Coordination studies according to IEC 60071-11.
- Required withstand levels.
- Required clearance distances.

High voltage equipment – Primary system

General requirements

This section describes the general requirements for high voltage equipment (primary equipment) including:

- General test requirements
- Corrosion protection level
- …

Converter transformers

Requirements related to converter transformers.

Auxiliary supply transformers

Requirements related to auxiliary supply transformers.

Gas Insulated Switchgear

Requirements related to Gas Insulated Switchgear.

AC/DC equipment

Requirements related to AC/DC equipment.

Resistors, Inductances and Capacitors

Requirements related to RLC equipment.

Valves

Requirements related to valves including valve cooling.

Dynamic Braking System (if applicable)

Requirements related to Dynamic Braking System.

Other equipment

C&P system – Secondary system

This section describes the requirements related to C&P system of HVDC system.

General requirements of C&P system

- Redundancy.
- Control cabinet.

Control requirements

- HMI requirements.
- Control requirements:
  - Control location
  - Local control
  - Station HMI
  - Remote control centres
  - Control authority
  - Time synchronization
  - Signals
  - Interlocks & other protective mechanisms
  - Transient Fault Recorder (TFR) and Fault Locator (FL)
  - Remote access
  - Alarms and events
  - …

Protection requirements

The Contractor shall provide all protection systems necessary to ensure complete protection of all equipment within the scope of the HVDC system.

The protection system shall have the following characteristics: redundancy, diversity, speed, selectivity, no under- or over-functioning.

Faults and faulty components within the HVDC system shall be recognized and cleared so that all components are protected, the stability of the transmission grid and the HVDC system is always ensured and for every grid status.

The design of the protection systems shall ensure that the whole HVDC system operates safely even in case of telecommunication loss between converter stations.

The protection concept and protection study shall be developed by the Contractor and shall be approved by the HVDC system's owner. It shall be possible to test the protection system regularly. The Contractor shall develop a test concept for the protection system and hand it over to the system's owner.

It shall be possible to perform maintenance or change the parameters on one set of redundant protections while the other sets remain in service, and the transmission power shall not be disturbed.

If filters are used, they shall be protected in a separate protection zone and shall be able to be switched off selectively.

Detailed requirements.

Fault clearing time

Protection of AC equipment

Other protection requirements

Protection setting and selectivity

C&P Testing

Replica

Requirements related to replica.

Telecommunication & cybersecurity

Auxiliary systems

Auxiliary power supply

HVA/C

Fire protection

Maintenance Phase

Purpose

This Chapter defines the key principles, obligations, and considerations to be incorporated into the final Contract governing the Maintenance Phase of the Works. The intent is to ensure long-term operational reliability, asset availability, and predictable lifecycle costs, while enabling a risk-based and performance-oriented maintenance approach.

Main Definitions and Standards

Unless otherwise defined elsewhere in the Contract, the following abbreviations shall have the meanings set out below:

- Client / Employer – The contracting entity procuring the Works under this Contract.
- Contract – The agreement entered into between the Client and the Contractor, including all Contract Documents.
- Contractor – The legal entity responsible for execution of the Works on an EPC or EPCI basis under the Contract.
- EPC – Engineering, Procurement and Construction.
- EPCI – Engineering, Procurement, Construction and Installation.
- Effective Date – The date on which the Contract comes into full legal effect, as defined in the Contract.
- Good Industry Practice – Has the meaning given in Clause 2.5.
- LTMA – Long-Term Maintenance Agreement, meaning a contractual arrangement entered into after, or in parallel with, the main Contract, governing long-term maintenance services, spare parts support, defined reaction times, and other services necessary to ensure long-term operational reliability of the System.
- Manufacturer – The original manufacturer of equipment or components forming part of the Works.
- Site – The location(s) where the Works are to be executed or installed, as defined in the Contract.
- System – The complete and fully integrated system forming the subject of the Works, including all equipment, components, interfaces, and auxiliary systems.
- Works – All engineering, procurement, construction, installation, testing, commissioning, and related activities to be performed by the Contractor under the Contract.
- Additional definitions and abbreviations may be introduced in other parts of the Contract and shall apply throughout the Contract.

The Contractor shall design, manufacture, supply, construct, install, test, commission, operate (where applicable), and maintain the Works in accordance with the latest editions, as of the Effective Date, of all applicable:

- International standards (including but not limited to IEC and ISO standards);
- European standards (EN);
- Applicable grid codes, network codes, and transmission system operator requirements.
- National laws, regulations, and statutory requirements of the country(ies) where the Site is located.
- Permits, consents, and approvals issued by relevant authorities.
- Generally accepted good industry practice.
- Where national requirements impose more stringent obligations than international or European standards, the national requirements shall prevail.

“Good Industry Practice” shall mean the degree of skill, diligence, prudence, foresight, and operating practice that would reasonably be expected from a competent and experienced contractor engaged in the design, construction, and maintenance of similar high-voltage transmission and energy infrastructure projects under comparable conditions.

Compliance with Good Industry Practice shall be deemed a minimum requirement and shall apply where specific standards or requirements are not explicitly defined in the Contract.

List of Subchapters

Description of Subchapters

Maintenance activities, spare parts availability, and LTMA services shall be planned and executed so as to support compliance with the availability and performance requirements defined in the Contract.

Regular Maintenance

The Contractor shall be responsible for the planning and execution of all regular maintenance activities as required to maintain the System in accordance with the Contract, applicable standards, and good industry practice. In particular, the Contractor shall:

- Perform routine, preventive, and corrective maintenance in accordance with the Manufacturer’s recommendations, approved maintenance manuals, and applicable international standards.
- Prepare and implement detailed maintenance plans, including inspection intervals, servicing activities, and calibration requirements, subject to the Client’s review.
- Coordinate all maintenance activities with the Client to ensure that agreed system availability, outage windows, and operational constraints are strictly respected.
- Provide suitably qualified, trained, and certified personnel for the execution of maintenance activities.
- Maintain complete and up-to-date maintenance documentation, including records of inspections, interventions, findings, and corrective actions.
- The Contractor shall ensure that regular maintenance activities do not result in unplanned outages or degradation of system performance beyond the limits defined in the Contract.

Condition Indicators to Support Risk-Based Maintenance

The Contractor shall implement and maintain condition monitoring arrangements enabling risk-based maintenance of the System. Without limitation, the Contractor shall:

- Define and monitor relevant condition indicators for critical system components, including thermal, electrical, mechanical, environmental, and performance-related parameters.
- Establish threshold values, alarm levels, and trend criteria enabling early detection of degradation, abnormal operation, or incipient failures.
- Provide and maintain all necessary monitoring systems, sensors, diagnostics, and testing arrangements required to collect and evaluate condition data.
- Regularly analyse condition data and provide formal reports to the Client, including recommendations for maintenance actions and risk mitigation measures.
- Integrate condition-based information into maintenance planning and execution.
- Failure to adequately monitor, analyse, or report condition indicators shall not relieve the Contractor of its obligations under the Contract, including warranty, availability, or performance obligations.

Spare Parts Strategy

This Subchapter defines the contractual principles governing the identification, storage, availability, ownership, and management of spare parts necessary to ensure reliable operation and maintainability of the System throughout its operational lifetime.

General Obligations

The Contractor shall develop, implement, and maintain a comprehensive Spare Parts Strategy sufficient to support all maintenance, repair, and restoration activities required under the Contract. The Spare Parts

Strategy shall ensure that spare parts are available in a timely manner so as not to compromise system availability, performance guarantees, safety, or other obligations of the Contractor. Unless otherwise expressly agreed, the Contractor shall bear the risk of unavailability of spare parts required to fulfil its contractual obligations.

Classification of Spare Parts

The Contractor shall identify and classify spare parts, as a minimum, into the following categories:

- Critical Spare Parts – Components whose failure would result in system unavailability, significant reduction of transmission capacity, or safety risks.
- Strategic Spare Parts – Components with long manufacturing or delivery lead times, the unavailability of which may significantly extend outage duration.
- Consumable Spare Parts – Components subject to regular replacement during routine maintenance.

The classification shall be subject to the Client's review and approval and shall be regularly updated to reflect operational experience and obsolescence risks.

Storage and Warehouse Arrangements

The Spare Parts Strategy shall clearly define storage locations and responsibilities, which may include:

- Spare parts stored in the Client's warehouse;
- Spare parts stored in the Contractor's warehouse;
- Spare parts stored in the supplier's or Manufacturer's warehouse;
- A combination of the above.

The Client shall have the right to audit spare parts inventories, stock levels, and storage conditions at the Contractor's or supplier's warehouse upon reasonable notice.

For each storage arrangement, the Contract shall define:

- Ownership of spare parts.
- Minimum stock levels.
- Storage, preservation, and environmental conditions.
- Responsibilities for inspection, shelf-life control, and replacement of degraded or expired spare parts.
- Access rights and delivery times to Site.

Replenishment and Use of Spare Parts

The Contractor shall establish procedures for:

- Use of spare parts during maintenance, repair, or failure events.
- Replenishment of used spare parts within defined time limits.
- Traceability of spare parts, including identification, documentation, and quality records.

Unless otherwise agreed, spare parts used to remedy defects, failures, or non-compliances for which the Contractor is responsible shall be replaced by the Contractor at no additional cost to the Client. Replenishment timeframes for critical spare parts shall be consistent with the reaction times defined in the Contract or applicable LTMA.

Non-Corrosion Guarantee

This Subchapter defines the contractual requirements and guarantees relating to corrosion protection of the Works and is intended to ensure long-term durability, safety, and functional performance of the System under the specified environmental and operational conditions.

Scope of Non-Corrosion Guarantee

The Contractor shall provide a non-corrosion guarantee for all materials, components, structures, and equipment forming part of the Works, including but not limited to steel structures, enclosures, fasteners, interfaces, and auxiliary systems.

The non-corrosion guarantee shall cover corrosion phenomena which may adversely affect:

- Structural integrity.
- Functional performance.
- Safety of operation.
- Compliance with applicable standards and design life requirements.

Guarantee Period and Conditions

The non-corrosion guarantee shall apply for the period specified in the Contract, commencing from the date of Provisional Acceptance or Taking-Over of the Works, unless stated otherwise.

The guarantee shall apply under the environmental, climatic, and operational conditions specified in the Contract, provided that the Works are operated and maintained in accordance with the Contractor's manuals and Good Industry Practice.

Normal wear and superficial cosmetic degradation that does not affect functional performance or structural integrity shall not be deemed a breach of the non-corrosion guarantee, unless expressly stated otherwise in the Contract. Any exclusions to the non-corrosion guarantee shall be expressly listed in the Contract.

Corrosion Protection Measures

The Contractor shall be fully responsible for the selection, design, and implementation of all corrosion protection measures required to meet the non-corrosion guarantee.

Such measures shall include, as applicable:

- Appropriate material selection.
- Protective coating systems.
- Cathodic protection systems, where required.
- Design measures preventing water accumulation, galvanic corrosion, and aggressive environmental exposure.

All corrosion protection systems shall comply with applicable standards, approved technical specifications, and Good Industry Practice. The corrosion protection system shall be designed for the environmental corrosion class applicable to the Site in accordance with the specified standards.

Inspection, Verification and Acceptance

The Contractor shall define and implement inspection and verification procedures to demonstrate compliance with the non-corrosion guarantee.

These procedures shall include:

Visual inspections and measurements;

Relevant testing or sampling, where applicable;

Documentation of coatings, materials, and protection systems.

The Client shall have the right to witness inspections and to require additional verification where reasonable grounds exist to suspect non-compliance. Such inspection rights shall apply during the entire non-corrosion guarantee period.

Remedies and Responsibilities

If corrosion exceeding the permissible limits defined in the Contract is identified during the guarantee period, the Contractor shall, at no additional cost to the Client:

Investigate the root cause of the corrosion;

Propose and implement corrective and remedial measures;

Restore the affected components to full compliance with the Contract requirements.

Any remedial works carried out under the non-corrosion guarantee shall not reduce or limit the remaining guarantee period for the affected components

Relationship with Other Warranties

The non-corrosion guarantee shall apply without prejudice to, and in addition to, any other warranties, guarantees, or performance obligations of the Contractor under the Contract.

No limitation of liability, warranty period, or exclusion clause shall be interpreted so as to diminish the Contractor's obligations under this Subchapter, unless expressly stated otherwise in the Contract.

Long-Term Maintenance Agreement (LTMA)

This Subchapter defines the contractual principles governing the option for a Long-Term Maintenance Agreement (LTMA), intended to ensure sustained operational reliability, availability, and technical support of the System beyond the standard warranty and defect liability periods.

LTMA Concept and Optionality

The Contract shall provide for the option for the Client to enter into a Long-Term Maintenance Agreement (LTMA) with the Contractor or an affiliated entity.

The LTMA shall be:

- Optional and entered into at the Client's sole discretion.
- Separate from, but technically and contractually aligned with, the main EPC/EPCI Contract.
- Structured to commence after expiry of the applicable warranty and defect liability periods, unless otherwise agreed.
- The LTMA is typically concluded as a separate contract with the original Manufacturer of the System or with the Manufacturer's dedicated maintenance or service organisation, in order to ensure continuity of technical expertise, access to proprietary knowledge, and long-term availability of spare parts and support services.
- The contractual term of the LTMA shall be defined based on the expected operational lifetime and criticality of the System and is typically envisaged to be in the range of ten (10) to twenty-five (25) years, unless otherwise agreed by the Parties.

The absence of an LTMA shall not relieve the Contractor of any obligations under the main Contract.

Spare Parts Stock and Logistics

The LTMA shall include provisions for maintaining a defined stock of critical and strategic spare parts at the Contractor's, supplier's, or Manufacturer's warehouse.

Such provisions shall define, as a minimum:

- List and classification of spare parts covered by the LTMA.
- Minimum stock levels and replenishment rules.
- Ownership and financial arrangements for spare parts.
- Storage conditions and preservation requirements.
- Maximum delivery times to Site.

The spare parts arrangements under the LTMA shall be consistent with the Spare Parts Strategy defined in Subchapter 4.3.

Reaction Times and Availability Support

The LTMA shall define guaranteed reaction times corresponding to different categories of events, including but not limited to:

- Critical system failures.
- Partial loss of functionality or capacity.
- Preventive maintenance interventions.
- Technical consultation requests.

Reaction times shall be aligned with the criticality of the System and the availability requirements defined by the Client.

Obsolescence Management and Technical Continuity

The LTMA shall address long-term technical continuity and obsolescence management, including:

- Monitoring of component and spare parts obsolescence.
- Advance notification of risks related to discontinuation of manufacturing or support.
- Proposal of technically equivalent replacements or upgrade solutions.
- Retention and transfer of technical knowledge relevant to the System.

Service Levels, Performance Indicators and Remedies

The LTMA shall define service levels and key performance indicators (KPIs) relevant to the provided services, which may include:

- Compliance with agreed reaction and intervention times.
- Quality and effectiveness of maintenance activities.
- Availability of spare parts and technical support.

The LTMA shall define appropriate remedies or corrective measures in the event of non-compliance with agreed service levels.

Relationship with the Main Contract

The LTMA shall not limit, waive, or otherwise reduce any rights, warranties, or claims arising under the main Contract prior to its commencement.

All technical data, documentation, and operational knowledge developed under the EPC/EPCI Contract shall be made available for the purposes of the LTMA.

Technology Refresh / Mid-Life Upgrade concept

Given the long operational lifetime of the System, the LTMA may provide a framework for supporting technology refresh, mid-life upgrades, and modernization measures, where required to maintain compliance, reliability, or performance.

Such support may include, subject to mutual agreement of the Parties:

- Upgrade or replacement of obsolete components, software, or control systems.
- Adaptation of the System to evolving technical standards, grid code requirements, or cybersecurity requirements.
- Engineering support for integrating upgraded components into the existing System.
- Any technology refresh or upgrade activities shall be treated separately from the original EPC/EPCI obligations and shall be subject to agreed scope, schedule, and commercial terms.

Nothing in this Clause shall obligate the Client to implement any upgrade, nor shall it impose automatic redesign obligations on the Contractor.

Knowledge Transfer and Documentation Continuity

In order to ensure long-term operability of the System and to avoid dependency on a single maintenance provider, the Contract and, where applicable, the LTMA shall include provisions ensuring continuity of technical knowledge and documentation throughout the operational lifetime of the System.

Such provisions shall include, as a minimum:

- Maintenance, operation, and troubleshooting documentation kept up to date to reflect the actual as-operated configuration of the System.
- Availability of configuration data, software versions, parameter settings, and maintenance records relevant to the System.
- Retention and transfer of technical know-how necessary for safe and efficient operation and maintenance of the System.

Where the LTMA expires, terminates, or is not extended, the Contractor, Manufacturer, or maintenance service provider shall provide reasonable cooperation and technical support to enable a smooth transition to the Client or to a successor maintenance provider.

Such cooperation shall include the orderly handover of documentation, data, and knowledge reasonably required to ensure continued operation and maintenance of the System.

16 Tests and Commissioning

General Assumptions

This specification applies to an offshore HVDC link connecting an onshore converter station to an offshore converter station, the latter being connected to an offshore wind power park via a DC submarine cable. The commissioning activities described herein are structured accordingly.

Should the project layout differ from this configuration- for instance, in the case of a back-to-back converter, a multi-terminal link, or an onshore-only interconnector - this document shall be adapted to reflect the actual scope and architecture before use.

General Warnings and Editorial Notes

The following warnings apply to the interpretation and use of this document:

Parallel equipment: Where two or more identical items of equipment are installed and operate in parallel (e.g. Converter 1 and Converter 2), the test specifications shall explicitly state whether functional testing or equipment testing is required. In this document, the general rule is that **all functions shall be tested on all individual items of equipment**. Any exception to this rule shall be explicitly justified and agreed upon by the Employer.

Quantified parameters: All numerical values, thresholds, durations, and performance targets appearing in this document are indicative. They shall be reviewed and adapted to the specific project before this document is issued for construction or commissioning. No value shall be left as a placeholder at the time of contract signature.

Template placeholders: Sections or paragraphs enclosed in curly braces {...} are editorial instructions to the drafter. They shall be replaced with project-specific content before the document is finalised. No {...} placeholder shall remain in the issued version of this document.

Standards & Reference documents

Introductory note

Commissioning includes all the following stages:

i. Pre-Commissioning Tests,
ii. Station Subsystem Tests,
iii. Station System Tests,
iv. Interconnector System Tests,
v. Trial Operation.

Definitions

LV Energisation: it is the 1st energisation of any permanent equipment located onboard the OSS using a 230/400 V power supply. This LV Energisation date and process shall be agreed between the Employer and the Contractor. LV Energisation shall be performed onshore at the yard.

Pre-Commissioning Tests: independent electrical, mechanical tests and simple functional tests performed on all equipment as per (CIGRE_TB697).

Subsystem tests: tests to prove correct interconnection and interactions of individual items of equipment within a functional group (or subsystem) and to verify that these items operate and interact correctly as per (CIGRE_TB697).

Station System Tests: the testing of the Converter Station in operation starting with the first energisation of the equipment and ending with the terminal tests, including all possible and relevant tests excluding the active power transmission related tests except those possible with round power tests for the bipolar technology.

Interconnector System Tests: the testing of the complete HVDC Link in operation with the total system in operation with both active and reactive power transfer.

Trial Operation: a period of time after commissioning for the Employer to check the performance and availability of the HVDC Link by in normal operating conditions under the supervision of the Contractor.

Test Operations has the meaning ascribed to this term in the Contract definition.

General requirements

Key rules

The tests specified within this document are not exhaustive. The Contractor shall be responsible for carrying out all tests necessary to prove the fulfilment of the Employer's requirements. If, from the Contractor's point of view, additional tests are necessary, the Contractor shall point this out to the Employer.

Parameters and dynamic performance that have been determined in studies and off-site tests (e.g. the HVDC Control and Protection Factory System Test) shall, where possible, be verified during Commissioning tests. All proposed Station and Interconnector System Tests shall be simulated and successfully completed in the factory test field prior to being implemented on site.

Commissioning activities shall be led and carried out by the Contractor with cooperation and coordination with the Employer, the Producer and Cable Contractor and operating staff for all works in accordance with the Commissioning Tests.

Tests shall at a minimum comply with the requirements made in (CIGRE_TB697) in particular those stated in the list of tests, the test purposes, the test preconditions, the test procedure, and test acceptance criteria as well as the requirements listed in this specification. Any proposed deviations or derogations from these requirements shall be proposed by the Contractor to the Employer for review. Final review and acceptance of these proposals remain with the Employer.

Contractor's Equipment and services

{in this section indicate the services that must be done or supplied by the contractor: tools, nautical means if any, lifting equipment, radio equipment, catering...}

Operations prior to pre-commissioning

{insert here anything you estimate must be done before starting pre-commissioning}

Pre-Commissioning of Onshore Converter Station and Offshore Substation at Yard dockyard

General

Pre-Commissioning Tests shall be carried out by the Contractor to ensure that the equipment has sustained no damage in transit, has been properly installed on-site, and at the yard, is safe to energize, load or start-up, and will perform and operate as designed.

The spare parts necessary for the Commissioning Period are delivered and properly stored.

Onshore Converter Station Pre-Commissioning Tests

Pre-commissioning shall cover electrical tests and simple functional tests performed on a single installed item of equipment or plant. The tests shall align with manufacturers recommendations, international and national standards, tests described in the specifications for each equipment and (CIGRE_TB697).

Offshore Substation Pre-Commissioning Tests at the yard

Offshore Converter Station Pre-Commissioning Tests shall include but not be limited to the activities described in paragraph 4.3. Offshore station pre-commissioning shall also ensure that any diagrams and drawings necessary for Commissioning are in the correct revision.

{insert safety procedures deemed necessary}

Regarding the Offshore Converter Platform, following scope should be covered as a minimum during the Offshore Substation Pre-Commissioning:

- Auxiliary system

Handling equipment/HVAC/Fire fighting/DGs/Fuel system/Fresh/Grey water systems Navaids/PAGA/CCTV/Weather station/Access control/Mitigation systems/Anode Monitoring.

- LV Systems

UPS AC&DC Chargers/LV main & Emergency SWB & distribution/Lighting/Power Sockets.

Acceptance

{insert the documents that are necessary after acceptance and the associated conditions}

Station Sub-System tests of Onshore Converter Station and Offshore Substation at Yard

General

The Contractor shall test all the components of the subsystems in its scope of supply. Each sub-system shall be tested independently to prove that it works correctly together as a functional unit or sub-system.

Prerequisites

No Station Sub-System Testing shall proceed until the following criteria are met:

a. The Contractor has provided any training, including training materials, which are required for the relevant Employer's Personnel who may be on site to witness and support the Contractor's Personnel with the tests, or the Contractor's Personnel who will participate in the tests.
b. Tests Deliverables as per have been issued by Contractor and accepted by Employer.
c. The Station Sub-System Tests package has been delivered to Employer for the relevant Onshore or Offshore Converter Station. It shall include the following documents at status required below.

{insert the documents that are necessary as prerequisites}

Onshore Station Subsystem Test

In addition to the requirements of (CIGRE_TB697), the Onshore Station Subsystem tests shall include functional test of communication with Offshore Wind Farm if the OWF has installed its cubicles.

Onshore Station Subsystem tests relying on telecommunication equipment supplied and/or installed by the Cable Contractor shall be the last Subsystem tests to be performed, as the related equipment needs to be commissioned by Cable Contractor prior to these tests.

{insert the documents that are necessary after the tests and the associated conditions}

Offshore Substation Subsystem Test at the yard

Offshore Station Subsystem tests are undertaken at the yard with a constant LV supply, attained after the LV Energisation. Prior to the first LV energisation, the Contractor shall have completed all pre-commissioning and have all necessary associated certificates. The Contractor shall also provide a LV Energisation plan to be reviewed by the Employer. This plan details the date and the process of LV energisation including any safety procedures that shall be implemented afterwards.

{insert the tests scope}

{insert safety procedures deemed necessary}

Acceptance

Onshore Station Subsystem tests certificates

{insert the documents that are necessary after the tests and the associated conditions}

Offshore Substation Subsystem tests at Yard

{insert the documents that are necessary after the tests and the associated conditions}

OSS transport, installation and hook up

{insert the requirements and the associated conditions}

Offshore Substation Pre-Commissioning test at sea

General

This stage defines the situation where the OSS has been transported to and installed at the final Offshore Substation Site with array power cable as well as export power cables not being connected. The Contractor shall carry out all the remaining testing of the pre-commissioning phase.

Prerequisite

{insert the prerequisites and the associated conditions}

Content

Acceptance

{insert the documents that are necessary after acceptance and the associated conditions}

Offshore Substation subsystem tests at sea

General

This stage defines the situation where the OSS has been transported to and installed at the final Offshore Substation Site with array power cable as well as export power cables not being connected. In this sub-stage final tests and inspections take place before the grid connection is established, and the wind turbine generators are set into operation.

Prerequisites

Content Sampling of end-to-end test (Percentage to be agreed between parties depending on Onshore and at yard commissioning Punch List status) shall be carried out.

Acceptance

{insert the documents that are necessary after acceptance and the associated conditions}

Onshore and Offshore Station System Tests

General

The Station System Tests contain the following categories as per (CIGRE_TB697):

a. High voltage energisation tests,
b. Terminal tests.

c. Operation and Integration tests

The offshore platform energisation and terminal tests shall be arranged by the Contractor in coordination with the Employer and the Producer.

Prerequisites

No station system tests shall proceed involving any part of the works until the following criteria are met:

Onshore Converter Station

Offshore Converter Station

Common Onshore/Offshore Converter Station

{insert also the documents that are necessary as prerequisite}

Content

All operation and integration tests as per CIGRE_TB697) shall be performed.

{insert all additional content or project specific content}

Acceptance

{insert the documents that are necessary after acceptance and the associated conditions}

Interconnector system tests

General

During the Interconnector System Tests, the Contractor shall cooperate with all involved parties (Cable Contractor, Producer, Employer) in accordance with the commissioning protocol and procedures.

The Interconnector System Tests contain the following categories as per are (CIGRE_TB697):

a. Transmission Tests
b. Operation and Integration Tests
c. Power Quality and Interference tests:

I. AC Network and remote generation interaction tests
II. For interconnections that include an OSS, the AC network interaction Tests, covers both AC network interactions tests and Producer interactions,

Prerequisites

Content

For HVDC converters using bipolar technology, all functions to be tested shall be tested on all equipment. That means each Function is tested on Converter1 and on Converter 2.

Operation and Integration Tests

All Operation and Integration Tests as per *(CIGRE_TB697)* shall be performed.

Transmission tests

{paragraph below as example}

- For performance and PQ characteristic verifications with high power transmission, active power shall be higher than 0.95pu of Guaranteed Active Power Link Capacity during a continuous period of one hour.
- For heat-run tests, active power shall be higher than 0.95pu of Guaranteed Active Power Link Capacity during a continuous period of minimum 12 hours.
- Transmission tests shall be performed considering all the operating configurations of the HVDC Link.

AC Network and remote generation interaction tests

Interconnector System Tests: Power Quality, Interference, Noise and Losses Tests

Power Quality Tests

They comprise Flicker measurement and Harmonics performance verification

Audible Noise Tests

Interference Tests

Tests shall follow section 11.3 of (CIGRE_TB697).

EMF Tests

Acceptance

Trial Operation

General

Trial Operation involves the Cable Contractor, the Contractor and the Producer. As such, they shall coordinate their tasks.

Trial Operation acts as evidence that the HVDC Link functions in a fault-free manner under the specified parameters. During this phase, the HVDC Link is electrically linked to both Onshore & Offshore AC Networks.

The Employer may perform tests during Trial operation, respecting the Operation manual.

Prerequisites

Operational constraints

The Employer's operating procedures shall be followed regarding switching, power dispatching and access to high voltage areas.

Content

The Contractor must achieve a Trial Period profile.

Acceptance

Organisation and acceptance of Tests Operations

This section gives the general requirements for the various phases of the Tests Operations.

General

The Employer or the Contractor shall be entitled to order the cessation of any tests if damage to the Works or connected Transmission Systems or personal injury are likely to result from continuation.

Tests shall at a minimum comply with the requirements made in (CIGRE_TB697) in particular those stated in the list of tests, the test purposes, the test preconditions, the test procedure, and test acceptance criteria as well as the requirements listed in this specification. Any proposed deviations or derogations from these requirements shall be proposed by the Contractor to the Employer for review. Final review and acceptance of these proposals remain with the Employer.

The Contractor shall perform the tests indicated in the performance checking sheets (B21a_ii) and meet the test acceptance criteria. For the avoidance of doubt, successful completion of these tests set out in these performance checking sheets does not constitute achievement of the commissioning tests. The performance checking sheets tests cases are only a complement to the full test plan and test procedures defined by the Contractor and accepted by the Employer.

The Employer will, within five (5) Business Days of receipt of the Test Report of each test stage:

a. give notice to the Contractor in writing that the tests of the test stage have been passed with no comment.
b. give notice to the Contractor in writing that the test stage has been rejected if the Employer considers that the test have failed according to ITP.

Employers Safety Rules

{insert your local safety rule}

Energy for Tests operations

Identification of Punch List items

Scheduling

Failure on Tests

The Contractor shall report to the Employer immediately if any of the Tests is failed.

If any of the tests or part of the Test fails to pass the acceptance criteria to the satisfaction of the Employer, the cause shall be investigated by the Contractor and reported to the Employer. Furthermore, the failure shall be rectified. The test shall be repeated and or adapted as required.

All modifications impacting the control and protections system of the HVDC Link to resolve any failure of thereof, these modifications shall be replicated on the replica(s) and the documentation shall be amended to reflect the modifications.

System studies

Equipment Failure

Tests Deliverables

Commissioning Protocol

A commissioning protocol shall be mutually written and signed by the Contractor, the Cable Contractor, and the Employer. This protocol will be submitted before the Commissioning.

{insert commissioning protocol details}

Inspection Test Plan (ITP)

Test Schedule

The Test Schedule identifies the timing, sequence and duration of the individual tests identified in the Inspection Test Plan. The Test Schedule is first submitted prior to the commencement of the Test phase and shall be updated regularly along with any associated test procedures from this date up until the end of the Commissioning.

During the entire commissioning period including pre-commissioning, sub system, system and interconnector tests, the Contractor shall provide an up-to-date Test Schedule with a seven day lookahead of the precise day to day activies that will be performed.

Test Procedures

Test Records

Test Reports

Appendix I: Abbreviations and Acronyms

AC	Alternative Current
CB	Circuit breakers
CROSS	Centres Régionaux Opérationnels de Surveillance et de Sauvetage (French MRCC)
CSP	Commissioning Switching Programme
DC	Direct Current
EMF	Electro-magnetic fields
ERS	Employer Requirement Specifications
FAT	Factory Acceptance Test
HMI	Human Machine Interfaces
HSE	Health, Safety and Environment
HV	High Voltage > 50 kV
HVAC	Heating, Ventilating and Air Conditioning
IAC	Inter Array Cable
ITP	Inspection and Test Plan
LV	Low Voltage < 1 kV
PCC	Point of Common Coupling
OSS	Offshore Substation
OTDR	Optical Time Domain Reflectometry
OWF	Offshore Wind Farm
QA	Quality Assurance
QC	Quality Control

SCADA	Supervisory Control And Data Acquisition
SER	Sequence of events Recorder
TFR	Transient Fault Recorder
TSO	Transmission System Operator

Future Readiness

Purpose

This chapter outlines how HVDC systems tendered should be designed and implemented to ensure that they can operate as intended for the required time frame and be updated and upgraded with reasonable effort to support additional functions that are not yet fully anticipated.

In general, this chapter considers how (point-to-point) HVDC systems can be made ready for scenarios of:

- Multi-terminal.
- Multi-operator.
- Multi-vendor.

Appendices

Purpose

Main Definitions and Standards

List of main standards that are applicable.

List of Subchapters

Description of Subchapters

The details required by the TSO for the tender description are listed in the following.

Topic A

Topic B