Base Load Power Hub (BLPH)

TECHNICAL INTEGRITY VERIFICATION (TIV) Programme

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1 INTRODUCTION

1.1 PROJECT OVERVIEW

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.

Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

1.1.1 Project Location

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.

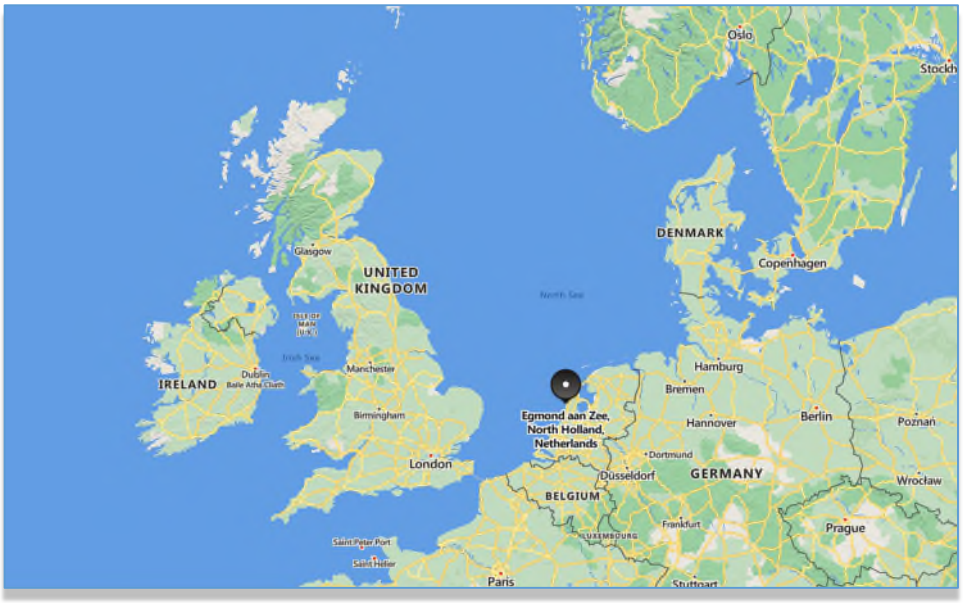


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

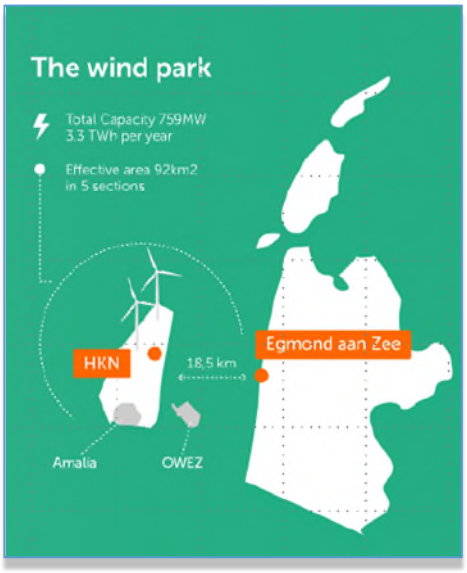


Figure 2 - Wind Park Details

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile located on coordinates E 590719.1, N 5841602.3 is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

1.1.2 Project Concept

All components included in the BLPH will be integrated onshore on a topsides and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

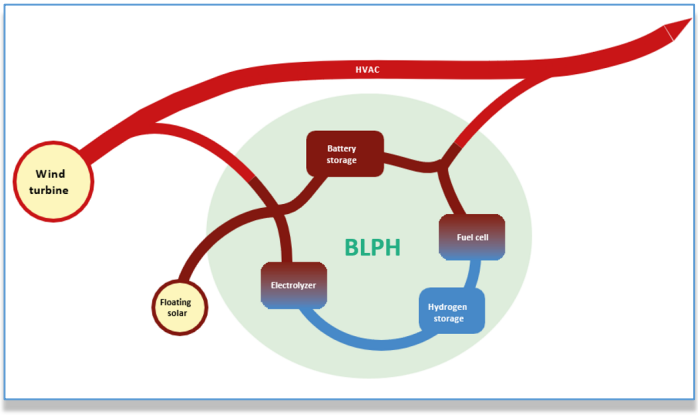


Figure 3 – BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.

The purpose of the BLPH s to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

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2 PURPOSE

This Technical Integrity Verification (TIV) Programme outlines the strategy for ensuring the operational effectiveness of the Safety Critical Elements (SCE) and adherence to the specified Project Performance Standards (PS) for the BLPH Project.

It outlines the methods by which the Project will confirm SCE functionality and alignment with design requirements.

Specifically, it covers:

- The designated responsibilities for managing and executing the TIV plan.
- The procedures to be followed.
- The key stages where approvals must be obtained from the appropriate personnel or certification bodies.

This comprehensive approach ensures that all Critical Safety Components are verified and that the Project meets its performance objectives.

3 SCOPE

The scope of this TIV Programme is confined to the SCE identified in the document 123A90-DDL-SAF-RE-30003 "Safety Critical ELEMENTS (SCE) and Performance Standard".

This TIV outlines how the hardware barriers, established through the SCE and Performance Standards (PS), will verify that Technical Integrity (TI) has been achieved and validated.

The Programme does not encompass the creation of maintenance tasks or operational procedures necessary to meet the SCE performance standards during the operational phase.

3.1 BOUNDARIES OF THE TIV PROGRAMME

This TIV Programme covers all Safety Critical Elements (SCE) related to the BLPH Project, defining the extent of activities involved from design through commissioning. The programme starts from the initial verification of design compliance and concludes after the commissioning phase verification. Activities outside the operational maintenance and future modifications are not included within this programme scope.

4 REFERENCES AND ABBREVIATIONS

REFERENCES

	Doc. No.	Description
[1]	CW-I-WP4-2023-05	Contract
[2]	CW-I-WP4-2023-05 - SECTION V	Scope Description
[3]	CW-I-WP4-2023-05 - SECTION IX	Quality Management
[4]	CW-I-WP4-2023-05 - SECTION X	Technical Information
[5]	K559-2254-QM-PLN-001	BLPH Technical Integrity Verification Plan

[6]	123A90-DDL-SAF-RE-30003	Safety Critical Elements (SCE) and Performance Standard

Table 1 - Reference Documents

ABBREVIATIONS

COMPANY or Client (CPY):	Crosswind
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project
ALARP	As Low As Reasonably Practicable
ATEX	ATmosphères EXplosibles
BESS	Battery Energy Storage System
BLPH	Base Load Power Hub
CE	Conformité Européenne
DS	Detection Systems
EMC	Electromagnetic Compatibility
EPCM	Engineering, Procurement, and Construction Management
ER	Emergency Response
FAT	Factory Acceptance Test
HKN	Hollandse Kust Noord
HVAC	Heating, Ventilation, and Air Conditioning
IC	Ignition Control
ITP	Inspection and Test Plan
LS	Life Saving
NDT	Non-Destructive Testing
PC	Process Containment
PED	Pressure Equipment Directive
PS	Performance Standard
PSV	Pressure Safety Valve
PV	Pressure Vessel

QC	Quality Control
SCE	Safety Critical Elements
SD	Shutdown System
SI	Structural Integrity
TI	Technical Integrity
TIV	Technical Integrity Verification
TIVR	Technical Integrity Verification Report
TP	Test Procedure
VAT	Verification Activity Tracker
VooW	Van Oord Offshore Wind

Table 2 - Abbreviations

5 RESPONSIBILITIES

The following outlines the key roles and responsibilities in managing TI:

5.1 PROJECT MANAGER

The TIV Programme will be sponsored by the Project Manager.

The Project Manager is accountable for:

- Ensuring that the identified verification activities for their respective stages are completed by the accountable people.
- The overall delivery of the TIV Programme using competent personnel as detailed below.

5.2 PROJECT ENGINEER MANAGER

The Project Engineer Manager is accountable for:

- Identify the SCEs and related PS.
- Ensuring the identification of applicable codes and standards and determining if those standards are "fit for purpose."
- Ensuring that the Design meets the SCE Performance Standards (PS).
- Defining and performing verification activities to confirm that the first level of assurance processes is in place.
- Monitoring the review of engineering deliverables related to TI.
- Maintaining updated the SCE and related PS list.

5.3 PROJECT QUALITY MANAGER

The Project Quality Manager is typically the owner of the TIV Plan, and he supports the Project Manager.

The Project Quality Manager is accountable for:

- Developing, implementing, and maintaining management system processes and arrangements for establishing and assuring TI.
- Coordinating the planning and execution of internal audits/reviews of TI arrangements.
- Managing interface and coordination with the Engineering, Procurement, and Construction Management (EPCM) on TI-related activities, in accordance with the project-specific TIV Plan.

5.4 CONSTRUCTION MANAGER

The Construction Manager is responsible for:

- Managing the TIV Programme during the construction stage.
- Ensuring construction activities comply with the TIV Plan.

5.5 COMMISSIONING MANAGER

The Commissioning Manager is responsible for:

- Managing the TIV Programme during the commissioning stage.
- Including SCE functional requirements in the Commissioning Procedures.
- Ensuring commissioning activities comply with the TIV Programme and that commissioning procedures are completed.

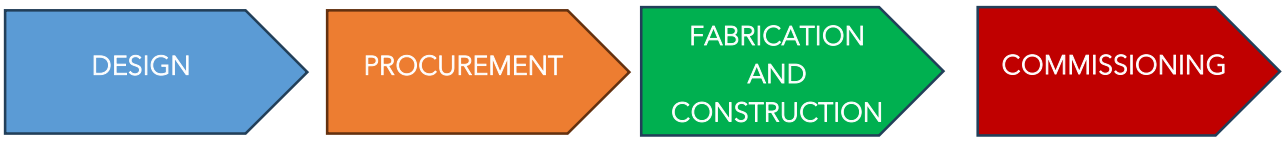
6 TECHNICAL INTEGRITY MANAGEMENT

6.1 GENERAL PRINCIPLES

Technical integrity refers to a condition under which the risk of failure, given specific operating conditions, is reduced to a tolerable level and minimized to as low as reasonably practicable (ALARP).

This condition ensures personnel safety, protection of the environment, and preservation of asset value. Achieving Technical Integrity Verification (TIV) involves establishing, delivering, and maintaining these integrity attributes throughout the project's lifecycle.

Technical integrity is established and maintained through the following phases of the project:



6.2 TECHNICAL INTEGRITY VERIFICATION

Technical Integrity Verification (TIV) is the process of demonstrating design and construction integrity.

It consists of four essential parts:

1. Identifying Safety Critical Elements (SCEs)
   - Purpose: To identify all components and systems critical to the safety protection of the facility.
   - Method: Conduct a thorough facility analysis to determine which elements are crucial for maintaining safe and environmentally sound operations.
2. Developing Performance Standards (PSs)
   - Purpose: To establish clear criteria for the functionality, reliability/availability, survivability, and dependencies of each SCE.
   - Components:
     - Functionality: Define the specific functions that each SCE must perform.
     - Reliability/Availability: Set standards for how often the SCE should be operational and available for use.
     - Survivability: Determine the conditions under which the SCE must remain operational, including during adverse events.
     - Dependencies: Identify other systems or elements that the SCE relies on to function properly.
3. Developing the Validation and Verification Scheme
   - Purpose: To create a framework for ensuring that the Performance Standards (PSs) for the SCEs are achieved and can be maintained over time.
   - Components:
     - Validation: Confirm that the SCEs meet the required PSs during initial design and installation.
     - Verification: Regularly check that the SCEs continue to meet the PSs throughout the facility's lifecycle.
   - Activities: Define specific tests, inspections, and assessments needed to validate and verify SCEs.
4. Executing, and Documenting Verification Activities
   - Purpose: To systematically carry out the activities required to verify that SCEs meet their PSs.
   - Steps:
     - Executing: Perform the planned activities, such as inspections, tests, and reviews.
     - Documenting: Record the results of verification activities, ensuring transparency and traceability.

- Coordination: Ensure proper communication and notification to the verification party to allow for technical and logistical preparations before each activity begins.

These four elements are closely linked and provide the mechanism for ensuring that the facilities' design intent is understood and adhered to during the project phase.

7 ASSURANCE AND VERIFICATION PROCESS

7.1 TECHNICAL INTEGRITY WITHIN PROJECT PHASES

7.1.1 Design Phase

During this phase, technical integrity is embedded into the project through design specifications and standards that address safety, environmental, and operational requirements.

Design Integrity is achieved when the following conditions are met:

- Specification of Standards: Performance and specification standards for systems, are clearly defined and documented. This ensures that all components meet the necessary criteria for safety, reliability, and functionality.
- Review of Design Documentation: Conduct a detailed review of the system(s) 's design documentation to confirm that the safety-critical system's design meets the stated performance criteria. This includes verifying that design calculations, drawings, and specifications align with the performance standards and safety requirements.
- Basis for Design Compliance: Review design documentation to confirm it complies with the Basis for Design. Ensure that all design decisions and specifications are consistent with the foundational design principles and objectives established at the project's inception.
- Assessment of Functional Failure Modes: Potential functional failure modes are identified and assessed. This involves analyzing how and why systems might fail and the impact of such failures. Based on this assessment, necessary redesigns or adjustments to the operating and maintenance requirements are made to mitigate identified risks. This proactive approach helps prevent failures and ensures that the asset operates within safe and optimal parameters.

7.1.2 Procurement Phase

The procurement process ensures that all materials and equipment meet the predefined technical specifications and performance standards essential for maintaining technical integrity.

Procurement Integrity is achieved when the following conditions are met:

- Vendor Qualification and Selection: Suppliers and vendors are qualified to ensure they meet the required performance and quality standards. This includes evaluating their track record, technical capabilities, compliance with industry standards, and their ability to deliver within the specified timeframes.
- Specification Compliance: All materials and equipment procured must adhere to the predefined technical specifications and performance standards established during the design phase. This ensures

that every component is fit for purpose and capable of contributing to the overall technical integrity of the project.

- Quality Assurance and Control: Implement quality control (QC) processes throughout the procurement phase. This includes inspecting and testing materials and equipment before acceptance to ensure that they meet the required standards and specifications.
- Witness Factory Acceptance Tests (FATs): Conduct and witness FATs to ensure that the equipment and systems meet the required design and performance standards. This includes functional tests and inspections to verify that the fabricated items are fit for purpose.
- Witness Function Tests and Sign Test Reports: Witness function tests of the equipment to verify that it operates according to the design specifications. Ensure that all test results are documented, and sign off on the test reports to confirm their validity and compliance.
- Witness Inspections and Sign Inspection Reports: Witness inspections of the equipment and materials to ensure they meet the specified quality and safety standards. Sign off on inspection reports to confirm that the inspections were conducted thoroughly and that the results are accurate.
- Documentation and Traceability: Maintain comprehensive documentation and traceability for all procured items. This includes certificates of compliance, test reports, and inspection records. Proper documentation ensures that all materials and equipment can be traced back to their source, facilitating accountability and quality verification.
- Logistics and Handling: Ensure proper logistics and handling procedures are in place to prevent damage or degradation of materials and equipment during transportation and storage. This includes using appropriate packaging, handling equipment, and storage conditions to maintain the integrity of procured items.
- Risk Management: Identify and mitigate procurement-related risks. This includes contingency planning for potential delays, supply chain disruptions, or quality issues. Proactive risk management ensures that any procurement-related challenges do not compromise the overall project integrity.

For procured packages, where relevant, Type Approval, EMC, PED, ATEX, and CE Marking requirements must be met. A Technical Construction File should also be created and maintained for these packages.

7.1.3 Fabrication and Construction Phase

Construction Integrity is a critical phase where the asset is fabricated, installed, and verified to ensure that the design integrity objectives are met prior to handover. Achieving construction integrity involves a comprehensive approach that includes auditing, inspection, testing, witnessing, and examination activities. The following conditions shall be met to ensure construction integrity:

- Compliance with Design Specifications: Ensure that all construction activities adhere to the design specifications and performance standards established during the design and procurement phases. This involves verifying that all materials and equipment installed match the specified requirements.

- Qualified Personnel: Utilize skilled and qualified personnel for all construction tasks. This includes ensuring that all workers and supervisors have the necessary certifications, training, and experience to perform their duties safely and effectively.
- Quality Control and Inspections: Implement quality control (QC) processes and conduct regular inspections throughout the construction phase. This includes on-site inspections, testing, and verification of materials and workmanship to ensure compliance with specified quality standards. Non-conformances shall be identified, recorded, and rectified promptly.
- Documentation and Record-Keeping: Maintain thorough documentation and records of all construction activities. This includes inspection reports, quality control documentation, and any changes or deviations from the original design. Proper documentation ensures traceability and accountability.
- Witnessing and Verification: Ensure that authorized personnel or third-party inspectors witness and verify critical activities. This includes witnessing tests, inspections, and commissioning activities to validate compliance with design specifications and performance standards.
- Auditing: Perform regular audits to verify project requirements and standards compliance. Audits shall assess the effectiveness of quality control processes, adherence to safety protocols, and overall progress against the project plan.
- Coating Procedures and Application Methods: Approve proper coating procedures and application methods to ensure all protective coatings meet the specified standards for corrosion resistance and durability. This includes verifying that surface preparation, coating thickness, and curing processes comply with the design specifications.
- Inspection and Test Plan (ITP): Complete all inspection tasks as defined by the Inspection and Test Plan (ITP). This includes detailed inspections at various stages of fabrication to verify compliance with design specifications, quality standards, and performance criteria.
- Installation of Safety-Critical Systems: Install the safety-critical systems in accordance with the design specifications. Ensure that all components are correctly positioned, aligned, and connected as per the approved design and installation procedures.
- Inspection and Testing of Installed Systems: Inspect and test the safety-critical systems to confirm that they have been installed according to the design. This includes functional testing, pressure testing, and other relevant tests to verify that the systems operate correctly and meet the required performance standards.
- Completion Certificates: Sign off on completion certificates to formally document that all fabrication and installation tasks have been successfully completed and that the systems meet the required standards. This includes obtaining approvals from relevant technical authorities and stakeholders.
- Final Inspection and Handover: Conduct a final inspection to ensure all construction activities are completed, and all systems and components meet the specified standards. Address any remaining issues or punch list items before the formal handover to the operations team.

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7.1.4 Commissioning Phase

Commissioning Integrity is a critical phase that ensures all systems and components are installed, tested, and functioning according to the design specifications before the asset is put into operation. Achieving commissioning integrity involves planning, execution, and verification activities to validate that the asset meets all performance standards. The following conditions shall be met to ensure commissioning integrity:

- Preparation and Planning: Develop a detailed commissioning plan that outlines the scope, objectives, and sequence of commissioning activities. This plan shall include a comprehensive list of tests, inspections, and verification activities required to confirm that systems and components are ready for operation.
- Competent Personnel: Ensure that qualified and experienced personnel are assigned to perform commissioning activities. This includes engineers, technicians, and other specialists with the necessary expertise to perform the commissioning tasks effectively.
- Verification of Installation: Conduct thorough inspections (Mechanical Completion) to verify that all equipment and systems have been installed according to design specifications and manufacturer requirements. This includes checking alignment, connections, and compliance with installation procedures.
- Functional Testing: Perform functional tests on all systems and components to ensure they operate as intended. This includes testing control, safety, and operational systems under various conditions to validate their performance and reliability.
- Performance Testing: Conduct performance tests to ensure that systems and components meet the specified performance standards. This includes stress testing, load testing, and other tests designed to evaluate systems' performance under realistic operating conditions.
- Integration Testing: Conduct integration tests to verify that all systems and components work together seamlessly. This ensures that interfaces between different systems function correctly and that the entire system operates as a cohesive unit.
- Safety and Environmental Checks: Perform safety and environmental checks to ensure that all systems comply with safety regulations and environmental standards. This includes verifying that safety devices and systems are operational, environmental controls are in place, and functioning correctly.
- Witnessing and Verification: Ensure that key commissioning activities are witnessed and verified by authorized personnel or third-party inspectors. This provides an additional layer of assurance that systems have been tested and verified according to the required standards.
- Documentation and Record-Keeping: Maintain comprehensive documentation of all commissioning activities, including test results, inspection reports, and any deviations from the plan. Proper documentation ensures traceability and records compliance with design specifications and performance standards.
- Handover Preparation: Prepare for the formal handover of the asset by ensuring all commissioning activities are completed and documented. This includes finalizing all test results, resolving outstanding issues, and ensuring that the asset is ready for safe and reliable operation.

- Final Validation: Conduct a final validation to ensure all commissioning activities have been completed satisfactorily and that the asset is ready for operation. This includes obtaining signoffs from all relevant parties and ensuring that the asset meets all performance standards and regulatory requirements.
- System Readiness for Start-Up: Confirm that the system is ready for start-up. This involves verifying that all commissioning activities have been completed successfully, all tests have passed, and the system is fully operational and safe to begin regular operations.

8 VERIFICATION PROCEDURE

8.1 VERIFICATION REPORTING

The TIV process will be documented with reference to the SCEs contained in document 123A90-DDL-SAF-RE-30003 Safety Critical Elements (SCE) and Performance Standard.

For each SCE GROUP, a Technical Integrity Verification Report (TIVR) will be issued.

Each TIVR will be submitted for signature to CPY representative.

The completion status of the TIV will be monitored using the Verification Activity Tracker (VAT), which will serve to track verification activities, link to verification evidence, and communicate the status of the verification activities.

The tracker will contain the following information:

- Performance standards identifying information.
- Brief description of the verification activity required.
- The verification activity's scheduled date(s) and action parties.
- Evidence of verification activities
- Date(s) verification activities are closed.

8.2 VERIFICATION PARTIES

Verification will be conducted by an independent, competent Engineer within Rosetti's organization who is not directly involved in the project. The Company must approve this Engineer before assigning verification tasks.

Additionally, certification for the primary structural steel will be performed by the Certifying Body, which is appointed by the Company. The Certifying Body's role is limited to verifying the design of the primary structural steel.

9 IMPLEMENTATION MATRIX

This implementation matrix provides an overview of the scope of Safety Critical Elements (SCE) included in the TIV Programme. It outlines the verification activities required for each SCE, the methods used for verification, the personnel responsible for conducting these activities, and the specific deliverables required

to ensure full compliance. The matrix is designed to be a practical tool for tracking and ensuring that all SCEs are properly verified, thereby ensuring that the project's safety and operational standards are met.

Implementation Matrix for Safety Critical Elements (SCE)

CE Group	SCE Item Description	Verification Activity	Verification Method	Responsible Party	Deliverables
Structural Integrity (SI)	Subsea Structures (SI001)	Visual and NDT Inspection	On-site Inspection, Ultrasonic Test	Structural Engineer	Inspection Report, Test Records
	Topside Structures (SI002)	Load Testing and Visual Verification	Physical Load Test	Project Quality Manager	Load Test Report, Compliance Records
Process Containment (PC)	Pressure Vessel (PC001)	Pressure Testing, Compliance Check	Hydrostatic Testing	Quality Control Engineer	Test Reports, Certification Records
	Relief System (PSV - PC007)	Functionality and Calibration Testing	Factory Acceptance Test (FAT)	Maintenance Engineer	Calibration Certificates, FAT Report
Ignition Control (IC)	Hazardous Area Ventilation (IC001)	Ventilation Flow Test	Flow Rate Measurement	HVAC Specialist	Ventilation Test Report
	Ex-rated Electrical Equipment (IC003)	Initial Inspection and ATEX Compliance	Visual Inspection, Continuity Test, IEC 60079 Inspection	ATEX Quality Inspector	Initial Inspection Report, ATEX Certificates
Detection Systems (DS)	Fire and Gas Detection (DS001)	Functional Testing, Sensor Calibration	Sensor Calibration	Instrumentation Engineer	Calibration Certificates, Functional Test Report
Protection Systems (PS)	Fire and Explosion Protection (PS002)	System Response Test	Physical Activation and Verification	Safety Systems Engineer	Functional Test Report
Shutdown System (SD)	Emergency Shutdown Valves (SDV - SD006)	Actuation and Leak Test	Valve Stroke Test, Leak Test	Commissioning Engineer	Actuation Records, Leak Test Certificates
Emergency Response (ER)	Muster Area (ER001)	Muster Drill, Signage Check	On-site Drill, Visual Inspection	Safety Officer	Drill Report, Inspection Checklist
Life Saving (LS)	Personal Survival Equipment (LS001)	Equipment Inspection, Expiry Check	Visual Inspection, Document Review	Safety Coordinator	Inspection Checklist, Certification Records

Additional Information

1. SCE Group: Identifies the category under which each Safety Critical Element falls.
2. SCE Item Description: Provides a brief description or tag number of each SCE.
3. Verification Activity: Details the type of activity used to verify the functionality and integrity of the SCE.
4. Verification Method: Specifies the method for verification, such as physical inspection or functional testing.
5. Responsible Party: Indicates the role responsible for ensuring the verification activity is completed.
6. Deliverables: Lists documents produced as proof of verification, such as reports or certificates.

Note: All verification activities listed in this matrix are carried out in reference to approved design documents, including calculations, specifications, and drawings. These documents are validated during the design phase and serve as the baseline for ensuring compliance during the verification process.