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GP 78-19

Design and Operation of Subsea Production Control Umbilicals (ISO 13628-5)

Group Practice

**BP GROUP
ENGINEERING TECHNICAL PRACTICES**

Foreword

This Engineering Technical Practice (ETP) 78-19 supplements the latest 2006 issue of the subject industry standard ISO 13628-5.

This Group Practice (GP) is not a standalone document, but offers guidance to and qualifies the subject industry standard.

This GP has not been technically edited and does not meet ETP philosophy or format. The technical editing will be done in the near future as time permits.

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Introduction

Add

- a. Requirements for subsea production control systems are based on ISO 13628-5, 2006, Petroleum and natural gas industries - Design and operation of subsea production systems - Part 5: Subsea control umbilicals.
- b. Requirements of this GP are modifications to ISO 13628-5 and shall be read in conjunction with the ISO standard.
- c. Modifications to ISO 13628-5 are identified as Add, Modify to Read, or Delete.
- d. Paragraph numbers in this specification correspond to ISO 13628-5.
- e. Paragraphs of ISO 13628-5 that are not revised remain applicable.
- f. This GP shall be used in accordance with other ETP Series 78 documents for subsea equipment, which provide further detail necessary to undertake and execute a subsea project.



1. Scope

This Engineering Technical Practice (ETP) is part of a larger suite of ETPs that define BP's philosophy for the design and operation of subsea projects.

This ETP is intended to apply specifically to subsea projects, but may have application elsewhere.

The requirements of this GP take precedence over other standards or guidance documents in the design, manufacture and testing of umbilicals."

This GP provides assistance in the generation of procurement specifications and/or supplementary project specific technical specifications required for the purchase of subsea production control systems.

This GP does not contain descriptive details of previous "lessons learnt" but rather contains the resulting clear additions, deletions, replacements, or clarifications to the parent industry standard.

Full details of previous "lessons learnt" can be found on the BP E&G Segment "Exchange" public folders under the following address:

Public folders\How we are organised\BP Exploration\BPX Subsea Learning Group\Focus Areas\ Subsea Lessons Learnt.

The document should be reviewed periodically and revised to reflect changes in industry regulations and BP best practices.

The International Standard ISO 13628 – Petroleum and natural gas industries – Design and operation of subsea production systems – Part 5: Subsea control umbilicals, has been proposed as the basis of the ETP to be adopted for the design and operation of future BP subsea developments. This ISO is part of a series of 9 standards that have been developed from the API 17 suite of documents, NORSOK and oil company specifications.

The complete suite of ISO 13628 documents is as follows:

- Part 1: General requirements and recommendations
- Part 2: Flexible pipe systems for subsea and marine applications
- Part 3: Through flowline (TFL) systems
- Part 4: Subsea wellheads and tree equipment
- Part 5: Subsea Control Umbilicals
- Part 6: Subsea Production controls
- Part 7: Workover / completion riser systems
- Part 8: Remotely Operated Vehicles (ROV) interfaces on subsea production systems
- Part 9: Remotely Operated Tools (ROT) intervention systems

ISO 13628-Part 5, in section 1.0, defines the purpose, products and the applications of this code. It defines the functional and technical requirements for the design, material selection, manufacture, design verification, testing and installation of subsea control, chemical injection and service umbilicals and associated ancillary equipment. The umbilicals contain electrical conductors, optical fibres, thermoplastic hoses and metallic tubes, either singularly or in combination. It addresses electric, hydraulic and electro-hydraulic control, chemical injection, gas lift and utility umbilicals.



BP has collated a considerable database of valuable lessons in the design, fabrication, testing, installation and operation of subsea systems from recently completed projects and the operations of several major subsea developments. Most of the guidelines presented in this document have evolved from these lessons and it is intended that this knowledge should be applied to the future projects and operations to improve the performance.

While ISO 13628-5 fulfils the requirement for design and operations standard for Subsea Control Umbilicals, the guidance in this document is intended to highlight and complete all information within the ISO 13628-5 and make it relevant and applicable to BP projects.

The rationale for this enhancement is:

- The available ISO information is generic to the subsea industry and specific guidance is required for BP applications.
- To present lessons learned on BP subsea installations in a guidance form that can be used directly within projects and operations.
- Subsea technology is being applied to projects in deeper water depths, longer step-outs with increasing complexity. The success of these developments will rely in part on managing the step change in environment by learning from previous projects and from the industry in general.
- To provide information to improve the performance of the increasing number of subsea production facilities.

The continued operation and integrity of control umbilicals is increasingly important for maintaining production and compliance with regulatory authorities.

2. Normative references

API—American Petroleum Institute

API RP 17I - Installation Guidelines for Subsea Umbilicals

API SPEC 17E - Specification for Subsea Umbilicals

ASME—American Society of Mechanical Engineers

ASME B31.3 - Process Piping

ASME SEC V - BPVC Section V - Nondestructive Examination

ASME SEC IX - BPVC Section IX - Qualification Standard for Welding and Brazing Procedures, Welders, Braziers, and Welding and Brazing Operators

BSI—British Standards Institution

BSI BS 6234 - Specification for Polyethylene Insulation and Sheath of Electric Cables

BSI BS 6622 - Specification for Cables with Extruded Cross-Linked Polyethylene or Ethylene Propylene Rubber Insulation for Rated Voltages from 3.8/6.6 kV up to 19/33 kV

ISO—International Organization for Standardization

ISO 9001 - Quality Management Systems - Requirements

SAE—Society of Automotive Engineers

SAE AS 4059D - Aerospace Fluid Power - Cleanliness Classification for Hydraulic Fluids

3. Terms, definitions and abbreviated terms

3.1 Terms and definitions

UTA: Umbilical Termination Assembly.



Fittings: tubes or hoses connection couplings supplied by umbilical manufacturer.

Bend Restrictor: equipment to prevent umbilical from going beyond the minimum bending limit at connectors' ends or splice boxes.

3.2 Abbreviated terms

MPcp: Major Projects common process.

FITA: Field Installable Testable Assembly.

WPS: Welding Procedure Specification.

PQR: Procedure Qualification Record.

UTA: Umbilical Termination Assembly.

TUTA: Topside Umbilical Termination Assembly.

HPU: High Pressure Unit.

NDE: Non-Destructive Tests.

SIT: System Integrity Test.

4. Functional requirements

4.1 General requirements

4.1.1 Umbilicals

Add the following paragraphs:

"Umbilical systems are crucial to the viability of subsea facilities.

The project requirements shall reflect the criticality of this product not only in identifying the physical characteristics and design life, but also identifying the project reliability and quality requirements and to ensure full implementation of the BP subsea reliability strategy.

The umbilical manufacturing contracts should be awarded as early as possible to allow early cross-section and umbilical termination design and subsequent installation definition and planning scheme, in order to minimize impact of umbilical interfaces."

4.1.2 End terminations and ancillary equipment

Add the following paragraphs:

"Normal industry practice is that subsea Umbilical Termination Assemblies (UTAs) are manufactured by the subsea control system supplier and free-issued to the umbilical manufacturer for integration onto the subsea end termination of the umbilical.

The contractual and logistical implications of this arrangement should be fully understood to ensure that the project execution plan and relevant documentation and processes address this arrangement.



BP should ensure that the same specifications and inspection criteria for materials and welding, for example, are used within the end termination or identify, understand and agree to any differences that may exist.

Umbilical manufacturers procure very large amount of high quality super duplex tube and if requested may supply umbilical grade tube to the umbilical termination assembly manufacturer.”

This can reduce the possibility of interface problems between umbilical tube and UTA.

Where possible, the supply of Super Duplex tubes to subsea control system supplier contractor should be considered in order to have materials specifications standardisation.

4.2 Project-specific requirements

Add the following paragraphs:

“Project requirements should be identified and communicated to the manufacturer.

Annex A of ISO-13628-5 provides a basis for identifying specific project requirements.

To ensure that the manufacturer has fully understood the project requirements, a detailed design specification should be requested from the manufacturer and be reviewed and approved by the project prior to procurement of materials.

A project specification shall be passed to umbilical manufacturer to cover all project specific characteristics.

The requirements of this ETP should be adopted in satisfying MPcp and the BP Way on contracting, designing, engineering, manufacturing, testing, installation, and commissioning of controls, injection, power, and communication umbilicals.

5. Safety, design and testing philosophy

5.1 Application

5.2 Safety Objectives

Add the following paragraphs:

“Overall safety objectives and criteria to be met should be established, planned and implemented covering all phases from conceptual development through life of field.

Such objectives and criteria shall satisfy BP’s HSSE requirements at typically the high overall level, but importantly more detailed objectives and requirements in specific areas should be identified and adopted as a basis for defining the safety requirements for a specific umbilical system.

A systematic review or analysis shall be carried out for all phases (e.g. installation and operation) in order to identify and evaluate the consequences of single and series failures in the umbilical, such that necessary remedial measures may be taken. The consequences include consequences of such events for people, for the environment and for the entire subsea system and commercial interests.”



5.3 Systematic review

5.4 Fundamental requirements

5.4.1 Requirements

5.4.2 Quality Assurance

Add the following paragraph: "For QA/QC requirements refer to:

- a) ETP 50-01 Quality Management Requirements;
- b) ETP 50-02 Program Quality Plan
- c) ETP 32-17 Inspection and Testing for New Equipment in Manufacture – Subsea Equipment."

5.5 Design philosophy

5.5.1 Design principles

5.5.2 Design basis

5.5.3 Design format

5.5.3.1 Basic considerations

5.5.4 Design methodology

5.5.4.1 General

5.5.4.2 Independent agent verification

Delete entire section and replace with the following paragraph:

"Independent verification by a third-party authority to review, evaluate, and report on the design methodology to establish the range of applications for which a design is suitable is recommended and should be stated in the umbilical design contract."

5.6 Testing

5.6.1 General

5.6.2 Qualification testing

Add the following paragraphs:

"Qualification testing shall be undertaken for new components, new cross-sections, all riser sections positioned over 800 meters water depth, and when BP's limit or operational experience is superseded.

Qualification should be identified and requested by the BP responsible team and executed and approved prior to start of manufacturing of the production umbilical.

A full set of qualification tests should be conducted for the selected cross-sections.

Only minimum changes on cross-section that do not change diameter-weight ratio may be considered not relevant to repeat a qualification process.

If there are power cables with characteristics superior of 3 kV, other specific tests may be applicable. Refer to ISO and ETP 78-06 in order to determine the list of qualification tests required.



Qualification testing shall be undertaken for components, end terminations, midline connectors, and ancillary equipment.

Acceptance criteria shall be identified for all qualification tests prior to test performance.”

5.6.3 Verification testing

Add the following paragraphs and comment:

“Verification is applicable for static cross-sections and facilities qualification for an existing cross-section.

Verification is used to ensure conformity to properties stated on umbilical data sheet of the manufactured product.

It should be carried out for components, end terminations, midline connectors, and ancillary equipment if necessary.”

5.6.4 Acceptance testing

Add the following paragraphs:

“Acceptance testing shall be undertaken on all components, finished umbilical lengths, end terminations, midline connectors, and ancillary equipment. “

6. Design requirements

6.1 General

Add the following paragraphs and comments:

“Installation impact should be fully understood and evaluated in the umbilical design.

Where the installation method is not confirmed at the design phase, the project should make an informed assumption based on experience or knowledge of installing a similar umbilical using a similar installation method.

This should be re-validated when installation contractor has been selected and the installation loads and impacts confirmed.

Changes to installation vessel equipment or configuration to cater for umbilical, end termination or ancillary equipment handling is very expensive, particularly in an active market.

Such modifications should be avoided, but where necessary should be identified as early as possible and incorporated into the installation contract prior to final award of contract.

If the umbilical design is outside the envelope of previously validated / proven qualified designs, then the project should request the umbilical manufacturer to perform sufficient prototype or qualification tests to verify the performance of the new umbilical design.

In addition to testing the mechanical properties of an umbilical and bend stiffener, prototype tests provide an opportunity to assess and optimise the performance of the component sub-suppliers as well as the umbilical manufacturing process.

The processes and procedures used and optimised for the prototype testing should also be used for the manufacturing process.



Any changes shall be highlighted, assessed and documented in the project MoC (Management of Change) process.”

6.2 Loads

6.2.1 Load classification

Add the following paragraphs:

“API 2RD, Table 1 defines the industry accepted load cases that should be analysed to confirm that the umbilical will meet the criteria of the design basis.

The load cases should be checked using the acceptable load cases as defined in ISO 13628-5, Table 5.

Generally, 100 year storm cases should be used for the strength criteria requirements.

However, recent storms, especially in the Gulf of Mexico, have been near the extreme strength criteria levels. It is recommended that a check of the 1000 year case should be done.

This will determine the safety factor between the theoretical failure point and the 100 year case and provide an idea of the umbilical's overall capacity.”

6.2.2 Load combinations and conditions

6.2.2.1 General

Add the following paragraph:

“If BP imposes a condition where limits are violated, a case by case study should be developed for BP evaluation and approval.”

6.2.2.2 Extreme load combinations

Add the following paragraphs:

“The extreme case analysis should include, but not be limited to, the following:

- Design load cases identified as critical from frequency domain screening, or those design load cases in which the wave frequencies are selected in the proximity of both riser natural frequencies, and the vessel natural frequencies defined at the riser hang-off point
- Different vessel drafts and wave headings since the vessel natural frequencies and RAO amplitudes at the umbilical hang-off point change with each vessel draft and each wave heading
- Different vessel offsets and current headings since the riser natural frequencies change with each vessel offset and each current heading
- Design load cases for the determination of the point of no motion of the umbilical section lying on the seabed

The critical results from regular wave analyses should be verified with irregular wave runs to ensure that the extreme values of the response variables are captured.

The extreme value statistics may be derived by simulating the entire storm duration defined by the metocean criteria, or by calculating only the vessel response at the umbilical hang-off



point for the entire storm duration and selecting one 30-minute time-window around that maximum motion of the hang-off point.

If the extreme umbilical response is derived from frequency-domain analysis, then the umbilical manufacturer should demonstrate, with time-domain irregular-wave analysis, that all significant non-linear effects have been accounted for.

If effective compression at the umbilical touchdown is unavoidable, the umbilical manufacturer should demonstrate by detail stress and deflection analysis (supported by test data) the compression capacity of the umbilical cross-section design.

The following responses should be reported for each umbilical:

- The limiting combination of vessel heel and trim (the vessel's static roll and pitch angles in the absence of winds, waves, and currents) beyond which the umbilical-bend stiffener-porch structure assembly will be damaged.
- Maximum and minimum global loads, angles, deflections, and local stresses/strains at all critical locations along the umbilical arc length. The critical locations are defined at the structural, boundary, and geometrical discontinuities of the umbilical configuration in the bend stiffener, touchdown, sag bend, and hog bend areas.
- Range of umbilical touchdown point locations in Near and Far vessel offsets.
- Location of umbilical point of no motion on the seabed.
- Each umbilical component: extreme stress/strain, utilisation factors, and the installation and manufacturing tolerances used to calculate them."

6.2.2.3 Fatigue load conditions

Add the following paragraph: "Vortex-induced vibrations (VIV) analysis is required for all dynamic umbilicals."

6.3 Load effect analysis

6.3.1 General

Add the following paragraphs:

"All software used for global and local analysis should be verified and validated by recorded past experiences and testing or by an independent third-party to ensure reliability and accuracy.

All software should be calibrated to full scale qualification testing and evidence generated for conformance with further required test results.

Prior to analysis by the umbilical manufacturer, BP should review and approve the analysis methodology document to verify the inputs to the analysis, any assumptions used, the expected outputs and the programs to be used.

This will confirm that the manufacturer understands what is being asked and the acceptance criteria. This is more critical in cases where the umbilical vendor uses a third party to conduct the analysis.

A design basis or analysis methodology document should be created for each umbilical analysis to be performed.

This will identify what cases are to be analysed, what types of analyses are to be carried out; dynamic, VIV etc., how it is to be performed and what are the acceptance criteria.



Additionally, this document should contain the input data for the analysis so that it is documented for future review, such as a peer review.

Installation cases should be included to the set of analysis cases. For a dynamic umbilical, in general, the following parameters should be confirmed through analysis:

- Minimum bend radius;
- Maximum tension force;
- Elimination of compressive forces in umbilical;
- Seabed clearance check;
- Fatigue life;
- Parametric sensitivity check;
- Variation of top tension force and top departure angle;
- History of top tension force versus top departure angle;
- Identify and rationalise buoyancy requirements;
- Determine transition point between static and dynamic umbilical sections;
- Interference analysis;
- On bottom stability check; and
- Crossing check.

The results obtained from the most critical cases should be used to clarify or satisfy the following umbilical performance requirements:

- Ensure sufficient fatigue life;
- Allowable maximum tensile capacity;
- Minimum bending radius;
- Effective tension at touchdown point;
- No compressive force in umbilical; and
- Minimising subsea spacing requirements.”

6.3.2 Global load effect analysis

Add the following paragraphs:

“Effects such as wave frequencies, drift responses, installation movements, and VIV frequencies and motions should be evaluated. Irregular wave time-domain and riser analysis are mandatory for dynamic sections.

Friction damage among umbilical and ancillary equipments should be considered (i.e. bend stiffener and umbilical sheath for I-tubes).”

6.3.3 On bottom stability analysis

Add the following paragraphs:

“On bottom stability shall be mandatory for cross-section review on manufacturer proposed analysis.

Umbilical fatigue near the touchdown point area and global compression due to extreme storm events should be evaluated.”



6.3.4 VIV analysis

6.3.5 Interference analysis

6.3.6 Free spanning analysis

6.3.7 Pull-in analysis

6.3.8 Structural analysis

6.3.8.1 General

6.3.8.2 Modelling and analysis requirement

Add the following paragraph:

“Manufacturer modelling may be verified, if applicable, with the presentation of sufficient historical data to BP of the cross-section itself or similar designs.

These models should be auditable by BP, including non-proprietary information for umbilical manufacturer.”

6.4 Fatigue life

Delete and replace with the following paragraphs:

“The fatigue life of the umbilical should be calculated for both the wave induced motions and the VIV.

These should be combined together to determine the overall fatigue life per the levels as defined in API 2RP.

Umbilicals should be designed to a fatigue life that is equal or greater than 10 times the service life, determined at the project specification.”

6.5 Reliability

Add the following sub-section:

“Reference shall be made to ETP’s 78-03, 78-04 and 78-06.

The umbilical manufacturer shall carry out a detailed and fully documented reliability analysis in order to provide reliability data to enable BP to assess the overall availability of each project facility, including both FPSO topsides and subsea equipment.

All assumptions made in the reliability analysis and data should be clearly stated.

In order to meet BP’s overall system availability requirement, the umbilical system components should be designed to meet or better the reliability goals specified by the project, and shall accord with the required basis for BP’s availability studies.

The umbilical manufacturer should indicate the level of operational spares holding required to support BP’s availability requirements.

In order to minimise equipment dependability, reliability risks, and optimise umbilical logistics, preference should be given to the transportation and installation of umbilicals fitted onto reels.

Every effort should be taken to achieve an umbilical design that is reel transportable and installable.



The benefits derived are likely to be:

- Better reliability of umbilical components manufacturing and logistics;
- Lower transport costs
- More manufacturing options around the world;
- No requirement to have carousel storage;
- Reels are handled by cranes onshore or offshore;
- Transportation of reels by commercial cargo vessels are reliable around the world;
- No need for spooling to installation vessels that require specialised personnel and equipment;
- A greater range of options for installation vessels that can successfully install umbilicals from reels; and
- Superior installation flexibility.

UTA sizes and weights that will fit on the reels should meet industry standard best practice.

If a long umbilical that does not fit on a reel is needed then options to reduce the umbilical diameter (quantity of components) and/or installation of a splice box or mid-section UTA should be evaluated as an option.”

7. Component design, manufacture and test

7.1 Design, quality plan, and materials selection

7.1.1 General

Add the following paragraphs:

“Meeting the requirements shall be demonstrated by qualification (in case of unusual designs, or designs significant different from previously verified), verification, and acceptance testing.

If qualification is required, it should be treated as a separate programme and should have its own quality plan, report, and approval.”

7.1.2 Quality plan

Add the following paragraph:

“Each component design or equipment should have its own quality plan.”

7.1.3 Materials selection

7.2 Electric Cables

7.2.1 General

7.2.2 Operating voltages

