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GP 78-12

DRAFT- Well Jumpers and Flowline Connections

Group Practice

**BP GROUP
ENGINEERING TECHNICAL PRACTICES**

Foreword

This is the first issue of Engineering Technical Practice (ETP) BP GP 78-12.

This Group Practice (GP) is not a stand alone document, but is part of a larger suite of ETPs that define BP integrity, reliability, quality management, design and testing philosophy for subsea projects.

This GP shall be used in accordance with other series 78 (subsea) ETPs that provide further detail necessary to undertake and execute subsea projects.

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1. Scope

- a. This Engineering Technical Practice (ETP) GP 78-12 covers the Diverless Connection Systems used to make process connections between separately installed sub-sea infrastructure such as trees, manifolds, flowline structures and risers.
- b. This GP relates to the Major Projects Common Process (MPCP) cycle from Appraise, Select, Define through to Execute and thence into Operation.
- c. It provides guidance on the philosophy and processes that may be applied to aid selection of the most appropriate connection technologies for the specific project during its Appraise and Select phases.
- d. Guidance is also provided on the aspects of well jumpers and flowline connections that require consideration within the detailed design, specification, engineering and implementation activities during the Define and Execute phases of the project.
- e. GIS 78-18 (Supplement to ISO 13628 Part 6) covers the design requirements for Subsea Control Systems. GP 78-21 covers the requirements for Subsea Electrical, Optical Connectors and Cable Assemblies. GP 78-13 provides design guidance for Flying Leads and Terminations Together, these cover the requirements for:
 1. The umbilical connection systems used solely to convey hydraulic and electrical power, communicate control signals and supply specialist dosing/protection chemicals.
 2. Electrical Flying Leads, which may use jumpers as a convenient 'cable rack'
 These systems are therefore not considered within this document

2. Normative references

The following normative documents contain requirements that, through reference in this text, constitute requirements of this technical practice. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this technical practice are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

BP

GIS 18-011	Guidance on Industry Standard for Welded Fabrication and Construction
GN 18-003	Deposition of CRA Weld Overlay in Tubulars and Other Components
GP 18-01	Guidance on Practice for Welded Fabrication and Construction
GP 36-20	Materials Selection and Specification for Subsea Equipment
GP 43-46	Guidance on Practice for Pipeline Pressure Testing and Precommissioning
GP 65-72	Riser Vortex Induced Vibration Design
GP 65-75	Design of Unbonded flexible pipe risers and flowlines
GN 65-714	Guidance Note on Riser Flow Induced Pulsation
GP 78-03	Achieving Reliability in Subsea Projects
GP 78-05	Testing Guidelines for Subsea Equipment FAT, EFAT and SIT
GP 78-06	Qualification of Technology for Subsea Projects



GP 78-13	Design Guidelines for Flying Leads and Terminations
GP 78-21	Subsea Electrical (LV) and Optical Connections
GIS 78-18	Design and Operation of Subsea Production Control Systems Supplementary Guidance to EN ISO 13628 Pt.6
GP 78-30	Integrated Subsea Testing/Commissioning/Start-up

European Standards (EN)

EN-ISO-13628 Pt.6	Petroleum and natural gas industries - Design and operation of subsea production systems - Part 6: Subsea production control systems
EN-ISO-13628 Pt.8	Petroleum and natural gas industries - Design and operation of subsea production systems - Part 8: Remotely Operated Vehicle (ROV) interfaces on subsea production systems
EN-ISO-13628 Pt.9	Petroleum and natural gas industries- Design and operation of subsea production systems- Part 9: Remotely operated tool (ROT) intervention systems

3. Terms and definitions

For the purpose of this document the following terms and definitions apply:

Connection System

This term is used in this document, to describe the complete system used to make process connections between separately installed sub-sea infrastructure, such as trees, manifolds, flowline structures and risers, complete with associated tooling. This comprises:

1. Inboard (structure) hubs and associated hardware (guidance systems, connectors as applicable)
2. Spools or jumpers comprising
 - a) Outboard hubs and associated hardware (guidance systems, connectors as applicable)
 - b) Spool (rigid pipe) or jumper (flexible pipe)
 - c) Small-bore tubing and electrical leads (if applicable, e.g. for multibore jumpers)
3. Fabrication and Test Tooling (for inboard and outboard assemblies)
4. Installation Tooling (for offshore installation, testing and maintenance)

Jumper

The outboard components of the connection system, comprising:

1. Spools or jumpers comprising
 - a) Outboard hubs and associated hardware (guidance systems, connectors as applicable)
 - b) Spool (rigid pipe) or jumper (flexible pipe)
 - c) Small-bore tubing and electrical leads (if applicable)

Connector

Collet, clamp or bolted flange used to compress gasket(s) between opposing hubs

Lengths in 'Green'



spare length on spools which can be cut to accurate size

Inboard

Inboard components are mounted on sub-sea structures such as trees, manifolds, flow-line structures, risers

Inboard Porch

Hub and associated guidance structures and tooling interfaces mounted on an inboard structure.

Outboard

Outboard components are located on the 'other side' from the inboard components, generally a spool assembly, jumper, umbilical, pig trap or otherwise retrievable assembly

Technical Risk Assurance Process

The Technical Risk Assurance Process (TRAP) is used for assurance of design verification and is intended to be a formal, systematic, auditable, and transparent process with clearly established technical authority, accountability, and responsibility for actions.

The main objectives of the TRAP are:

- To assess the detailed technical risks associated with the design, engineering and testing of "non-standard", new (to COMPANY) and / or novel systems and equipment.
- To ensure the effective management and mitigation of the risks so identified.
- To thereby provide documented technical risk assurance.

4. Symbols and abbreviations

For the purpose of this document the following symbols and abbreviations apply:

BoD	Basis of Design
ETP	Engineering Technical Practice
FAT	Factory Acceptance Test
FLIP	Flow Induced Pulsation
FTA	Flowline Termination Assembly
GoC	Guidance on Certification
GP	Group Practice
HP	High Pressure
ID	Internal diameter
ITA	In-line Termination Assembly
ITP	Inspection and Test Plan
MOC	Management of Change



MPCP	Major Project Common Process
MSS	Manifold Support Structure
NCR	Non Conformance Report
NDE	Non Destructive Examination
PGB	Permanent Guide Base
PLR	Pig Launcher Receiver
ROV	Remote Operated Vehicle
SCM	Subsea Control Module
SIT	Systems Integration Test
SPS	Subsea Production System
SWT	Shallow Water Test
TRAP	Technical Risk Assurance Process
TRL	Technology Readiness Level
URF	Umbilicals Risers and Flowlines
'U' value	Heat Transfer Coefficient
VIV	Vortex Induced Vibration

5. Connection Systems Overview

During the MPCP 'Appraise' stage, the need for connection systems will be identified together with their basic parameters (in terms of water depth etc.). The following sections give an overview of the role of connection systems and their basic functionality.

5.1. Reasons for Connection Systems

- a. Connection Systems are required to facilitate:
 1. Offshore field construction –since installation of subsea infrastructure as a pre-connected whole would be impractical
 2. Commissioning – e.g. subsea pigging of flowlines, post installation testing of manifolds
 3. Field development and expansion – e.g. future in-fill wells and tie-backs
 4. Contingency operations - e.g. hydrate remediation
 5. Recovery of defective, redundant or end-of-life equipment
 6. Field decommissioning



- b. Diverless connection systems pre-dominate for new field developments due either to increased water depths or increased levels of safety demanded during field construction activities.
- c. As subsea systems become more complex assemblies such as pumps, separators and flowmeters will be designed for recovery. The use of subsea pig launching and receiving equipment will increase, and extend from commissioning into operation phases. The connection systems will need to accommodate multiple make/break operations, comply with isolation, integrity test/verification and hydrocarbon freeing requirements.

5.2. Types of Connection Systems

- a. The following categorisation of connection systems according to jumper type, deployment method, connector orientation and connector type is to provide understanding of the relative merits, to assist in the selection process.

5.2.2. Jumper Type

- a. The pipe or pipes between outboard connectors may either be of 'rigid' or 'flexible' design.
- b. Rigid jumpers are fabricated from steel pipe of a suitable specification to provide the required pressure rating, mechanical strength, corrosion and erosion resistance and insulated, when required for hydrate avoidance.
- c. A rigid jumper has a precise shape and size defined by subsea metrology and stress calculations.

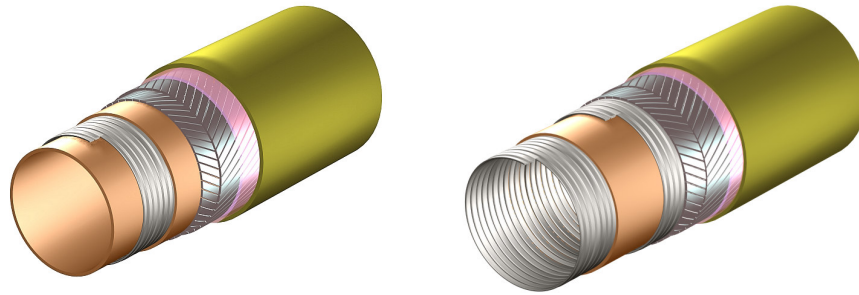
This has fundamental implications upon local field architecture, infrastructure installation tolerances and the construction schedule.

- d. Flexible jumpers are assembled from flexible pipe, being a fabricated structure which is able to 'flex' in a controlled manner under somewhat lower loads than rigid pipe.
- e. The flexible pipe is fitted with end terminations which are generally flanged for deck make-up onto the outboard connector.
- f. A flexible jumper has length, but no predefined shape.

This allows for more flexible design and installation, but places certain demands on the connector, tooling and installation.

- g. Rigid connection systems require careful review and modification before they can be expected to work with flexible jumpers.
- h. Although more 'flexible' than rigid spools, the fabricated structure of a flexible flowline (see Figure 1) imposes design, installation and operating constraints with respect to minimum bend radius, loads, pressure, temperature, gas permeability, 'U'-value and twist induced by installation and hydrostatic pressure. Further guidance is given in GP65-75 unbonded flexible pipe risers and flowlines.



Figure 1 - Construction of Flexible Jumpers

- i. Rigid spools or flexible jumpers can be fabricated in monobore or multibore arrangements.

5.2.3. Deployment Method

- a. Jumpers may either be 'deploy-to-place' or deployed (e.g. to seabed) and then pulled-in as a second operation.
- b. Connection systems of the 'deploy-to-place' type require that the outboard connector should be lowered into a guidance system on the inboard porch.

This may either bring the hubs into contact, or just short (usually for a vertical connector) or within reach of a stroking tool (usually for a horizontal connector).

The chief advantage of 'deploy to place' is speed of deployment when compared with 'pull-in' systems.

- c. Connection systems of the 'pull-in' type should have a means of applying a force, of some tonnes, which is employed to draw the opposing outboard hub, from some metres apart, toward the inboard hub.

The tooling generally used to achieve this comprises a subsea winch, often mounted on a connection tool, which mates with the outboard connector or the inboard porch and draws the opposing hubs together. This procedure can be assisted by the application of installation buoyancy to the outboard jumper.

- d. Older or more specialised pull-in type systems may use a surface winch operating through a subsea pulley block.
- e. The chief advantages of a pull-in system are that:
 1. A large horizontal pull-in force can be applied, which is difficult to achieve using 'deploy-to-place' systems particularly at depth.
 2. They can be used to pull an outboard hub into a porch which is otherwise obscured e.g. by structure trawl protection or riser buoyancy tank

5.2.4. Connector Orientation

- a. Connectors may be oriented with their hub axis 'horizontal' or 'vertical'.

Each orientation has its advantages and advocates.

- b. A 'vertical' connection should have an upward facing inboard hub and a downward facing outboard hub.
- c. A principal characteristic of vertical connections is that the hubs may be brought face-to-face during jumper deployment. Note that such contact may be inhibited or controlled by a connection system or soft landing systems.



This generally results in simpler tooling, often deployed with the jumper.

- d. Guidance features are installed on the inboard structure and outboard vertical connector (or tooling), but these are generally fairly compact and light.

Rigid jumpers are generally configured to be planar (flat) in a vertical plane (simplifying construction) and flexible jumpers are generally fitted to a swan-neck on the outboard connector (increasing the initial bend radius of the flexible).

- e. A principal characteristic of the horizontal connection system is that the jumper is initially deployed into a parking position from whence the hubs are stroked into contact by the connection tooling.

A 'horizontal' connection has larger parking/guidance structures on the inboard porch and mating components on the outboard connector.

- f. A feature of the horizontal connection is that it is possible to mount the inboard guidance features on a permanent structure; e.g. the Permanent Guide Base (PGB) of a tree or the Manifold Support Structure (MSS) of a manifold, such that the retrievable portion of the structure may be recovered with the jumper(s) left in position (and the other end still connected). This feature is not always utilised and may not be relevant, e.g. for pipeline structures such as FTA/ITA.
- g. A second feature of the horizontal connection is that the circa 500mm stroke of hubs from their 'parked' position to their 'closed' position may be used to 'pre-stress' a rigid jumper which can help accommodate flowline movement.
- h. Jumpers may be planar in a near horizontal plane, but are more usually three-dimensional.

5.2.5. Connector Type

- a. The connector used to close the opposing hubs and thereby pre-load the gasket may be one of several types; conventional flange, collet or clamp.

Whilst suppliers of every system will make very similar claims about strength ('as strong as the pipe' typically), such claims lack utility.

1. The conventional API flange is simple, effective and strong. However the task of flange hole alignment, stud insertion, nut engagement and winding, which is relatively easily accomplished by hand onshore or by diver offshore, is a challenge for diverless subsea connections. Such flanges require complex diverless connection tools. A few suppliers offer such tooling for hire, at a premium.
2. Collets offer connections of reasonable strength and simpler connection tooling, than that for conventional flanges. The tooling that strokes the collet open/shut and in some circumstances strokes the hubs together or apart has a proprietary dimensioned interface with the collet.
 - a) This means that the tool may only be used for a limited range of collet sizes and projects may require two different sizes of tool or alternative sets of stroking plates to match the full range of connectors.
 - b) Designers working within these limitations should balance the required external load capacities against internal bore size, design pressure and maximum collet diameter.
3. Clamps offer connections of modest strength and the advantage of simple ROV tooling (typically torque tools with ROV interfaces to ISO13628).
 - a) In order to achieve the required load capacity, the hub diameter may be increased without attendant tooling complications, although this can result in quite heavy connector weights from large forgings with small holes.



- b) Clamps may sometimes be employed on the inboard structure and designed for subsea replacement.
- c) Clamps may also be utilised on collet-based connection systems to attach ancillaries, such as caps, without the weight or tooling requirements of a collet connector.

6. System Selection

During the MPCP 'Select' stage the listing of potential development options and their associated parameters will begin to highlight the key functionality required of the connection systems allowing for preliminary selection.

6.1. Overview

- a. Connection systems normally form part of a larger contract and therefore contracting strategy often influences their final selection.
- b. Experience has demonstrated that the non-optimal system can still be made to work, and work well.

Consequently, whilst this section 6.0 provides summary guidance on system selection, it should be recognised that the majority of clauses are essentially advisory rather than mandatory.
- c. The merits of various configurations of connection system are tabulated in more detail within Annex A. In many respects this section 6.1, in conjunction with Annex A, should be considered as guidance on the characteristics of systems that should be avoided or given special attention for particular applications.
- d. A brief discussion on local field architecture, presented in the final section of this chapter, draws on some of the characteristics outlined below and in Annex A.

6.2. Jumper Type

- a. The relative advantages of flexible jumpers and rigid spool assemblies are tabulated in Annex A Table A1.
- b. In summary, the flexible jumper offers significant advantages in terms of design flexibility, final assembly, installation tolerances, sub-sea metrology requirements and construction schedules. Against this, the cost per metre is higher, high levels of insulation are not currently practical and operational conditions, such as temperature and pressure will be limited by materials of construction.
- c. Large rigid spools are difficult to install, particularly in inclement sea-states requiring large or specialist (semi-submersible) vessels with significant craneage. Flexible jumpers are over boarded vertically and thus less susceptible to wave impact.

6.3. Deployment Method

- a. The relative advantages of deploy-to-place and pull-in connection systems are tabulated in Annex A. Table A2.
- b. Summarising, deploy-to-place systems offer faster offshore installation at the expense of loss of some flexibility with respect to installation scenarios involving application of a large horizontal force at depth. e.g. pulling jumpers in under overhanging structures or pulling in flexible to lose surplus length.



6.4. Connector Orientation

- a. The relative advantages of horizontal and vertical connectors are tabulated in Annex A. Table A.3.
- b. Whilst horizontal and vertical connectors provide different design, fabrication and installation characteristics, in practice either system may usually be made to work in any particular field. As a consequence, this is one area where custom and local practice exerts considerable influence. This does, at least, confer some advantage of familiarity in the local fabrication yards.

6.5. Connector Type

- a. The bolted flange (e.g. to API 6A) combined with the Ring Type Joint (RTJ e.g. BX) makes a strong, structurally efficient, mechanical connection widely used for arduous duties (temperature & pressure) on topsides equipment and also employed on subsea equipment.
- b. It is also particularly easy to insulate compared with the bulk, mass and awkward shapes of the alternatives.
- c. Alternative forms of flange hub profile and gasket may be accommodated in proprietary 'compact flanges' (e.g. Taper-Lok, 'AX') and the bolts in these compact flanges can be replaced by a clamp (e.g. Grayloc, Destec).
- d. The vast majority of these flange connectors when employed subsea are made-up or disconnected on the surface or by diver.

The fundamental reason for this is that the apparently simple task of manually screwing a nut onto a length of studding involves a level of tactile feedback that is difficult to replace or replicate in ROV operations.

Screw threads designed for subsea engagement are altogether coarser and have specifically designed 'lead-in' features.

- e. There are a few connection systems designed to work with standard API flanges and bolting for intervention activities.

One construction contractor (Acergy) hires a connection tool (Matis) for new-build.

These bolting systems are valuable tools, particularly when the ultimate in strength is required, but they are complex tools which are slow in use, expensive to mobilise and potentially unavailable for unplanned interventions.

For new-build, they are best suited to large-bore connections on main flow-lines where the strength of the bolted flange is advantageous, high levels of insulation are required, and there is a high probability that the connection, once made, will not be disturbed for the life of field.

- f. For equipment that will or may require recovery during field life (e.g. manifolds and trees), connectors based on the collet or clamp should be used. The relative advantages of these alternative connector types are summarised against bolted flanges in Annex A. in Table A.4.

The collet generally offers a stronger connection than the clamp connector, but tends to have a more complex and heavier tooling requirement.

- g. Fairly basic clamp connectors may also be offered for ancillary equipment on collet based systems in order to reduce cost.

This is logical for caps, for example, which are subjected to negligible external load.

