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Guidance on Practice for Offshore Pipeline System Design and Construction

GP 43-21

**BP GROUP
ENGINEERING TECHNICAL PRACTICES**

Foreword

This is the first issue of Engineering Technical Practice (ETP) BP GP 43-21. This Guidance on Practice (GP) is based on parts of heritage documents from the merged BP companies as follows:

British Petroleum

GS 118-10	Welding of transmission pipelines, Supplementary to BS 4515
S/UTG1173/00	BP Amoco Exploration Ltd., "Design Guidelines for Steel Catenary Risers", Deepwater Developments, Upstream Technology Group, BP Exploration, Revision 3, December 2000, H-1284.03-10.05-NID-001.

Amoco

A PN-OFS-LC-C	Piping—Offshore—Line Crossings—Construction Specification.
A PN-OFS-RD-C	Piping—Offshore—Rock Dumping—Construction Specification.
A PN-OFS-SOP-C	Piping—Offshore—Surveying Offshore Pipelines—Construction Specification.
A PN-OFS-TOP-C	Piping—Offshore—Trenching Offshore Pipelines—Construction Specification.
A PN-PL-5L-G	Piping—Pipeline—API 5L Steel Line Pipe—Guide.
A PN-PLD-00-G	Piping—Pipeline Design—Guide.

This GP is not a stand alone document. It shall be used in accordance with other ETP Documents Series 43 for pipelines, which provide further detail necessary to undertake and execute a pipeline system design.

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1. Scope

This GP provides guidance on the design and construction of offshore pipeline systems for transporting hydrocarbons. This GP is applicable to offshore flowlines and pipelines, and their associated facilities and equipment. In addition to this GP, GP 78-08 provides guidance for deepwater pipeline system design and installation.

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.

American Petroleum Institute (API)

API RP 17B	Recommended Practice for Flexible Pipe.
API Spec 5L	Specification for Linepipe.
API Spec 17J	Specification for Unbonded Flexible Pipe.

BP

GIS 43-211	Guidance on Industry Standard for Offshore Pipeline Design and Construction (PD 8010-2).
GIS 43-212	Guidance on Industry Standard for Offshore Pipeline Design and Construction (DNV OS-F101).
GIS 43-317	Guidance on Industry Standard for the Manufacture of Carbon Steel Induction Bends for Pipelines to ISO 15590-1 in Grades up to X80.
GIS 43-318	Guidance on Industry Standard for the Manufacture of Carbon Steel Fittings for Pipelines to ISO 15590-2 in Grades up to X80.
GIS 43-319	Guidance on Industry Standard for the Manufacture of Carbon Steel Flanges for Pipelines to ISO 15590-3 in Grades up to X80.
GIS 43-334	Guidance on Industry Standard for the Welding of Corrosion Resistant Alloy, Internally Clad, or Mechanically Lined Pipe.
GIS 43-352	Guidance on Industry Standard for EN ISO 14723 Subsea Pipeline Valves.
GP 06-29	Guidance on Practice for Corrosion Protection During Hydrotesting.
GP 06-40	Guidance on Practice for Pipeline Coating Guide and Selection.
GP 43-02	Guidance on Practice for Principles of Offshore Pipeline Design and Project Execution.
GP 43-04	Guidance on Practice for QA/QC.
GP 43-05	Guidance on Practice for Environmental and Social Impact Assessment of Pipelines.
GP 43-07	Guidance on Practice for Selection of the Design Basis for Pipelines.
GP 43-08	Guidance on Practice for Selection and Use of Industry Codes and Standards.
GP 43-09	Guidance on Practice for Hydraulic Design of Pipeline Systems.



GP 43-10	Guidance on Practice for Route Data Acquisition and Route Selection for Pipelines.
GP 43-13	Guidance on Practice for Cost and Schedule Estimation and Reporting.
GP 43-17	Guidance on Practice for Risk Management.
GP 43-22	Guidance on Practice for Above Ground Pipeline Facilities.
GP 43-26	Guidance on Practice for Offshore Surveys.
GP 43-28	Guidance on Practice for Pipeline Crossings.
GP 43-30	Guidance on Practice for ESIA Preparation.
GP 43-31	Guidance on Practice for Linepipe Procurement.
GP 43-33	Guidance on Practice for Welding of Pipelines.
GP 43-34	Guidance on Practice for Automated Ultrasonic Testing.
GP 43-35	Guidance on Practice for Valves for Pipelines.
GP 43-36	Guidance on Practice for Pipe Protection.
GP 43-37	Guidance on Practice for Pipeline Control Systems.
GP 43-42	Guidance on Practice for Health, Safety, Security, and Environment (HSSE) During Pipeline Construction.
GP 43-46	Guidance on Practice for Pipeline Pressure Testing and Pre-commissioning.
GP 43-47	Guidance on Practice for Handover to Pipeline Operations.
GP 43-50	Guidance on Practice for Pigging, Pig Launchers, and Receivers.
GP 43-52	Guidance on Practice for Pipe Wall Inspection and Analysis of Results.
GP 64-01	Guidance on Practice for Fluid Measurement Management.
GP 78-08	Guidance on Practice for Design and Installation of Deepwater Pipelines and Flowlines.

British Standards Institute (BSI)

PD 8010-2	Code of practice for pipelines – Part 2: Subsea pipelines.
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Det Norske Veritas (DNV)

DNV OS-F101	Submarine Pipeline Systems.
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International Organization for Standardization (ISO)

ISO 3183	Petroleum and natural gas industries – Steel pipe for pipelines – Technical delivery conditions.
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3. Terms and definitions

For the purposes of this GP, the following terms and definitions apply:

Design pressure

The pressure selected as the maximum sustained pressure exerted by the pipeline contents to which a pipeline is to be designed

Expected operating life

Period of time selected for the purpose of verifying that a replaceable or permanent component is suitable for the anticipated service



Flowline

A pipeline, rigid or flexible, that transports unprocessed fluids, typically at high pressure and temperature, from the wellhead to the first downstream process or collector component

Injection line

A pipeline, rigid or flexible, that directs processed liquids or gases into a formation, wellhead, or riser to support hydrocarbon production activity

Export line

A pipeline that transports oil and gas fluids, normally processed, between offshore platforms or between an offshore platform and a shore facility

Offshore pipeline

Piping that transports fluids between offshore production facilities or between a platform and a shore facility. Pipelines can be classified into three categories, flowlines, injection lines, and export lines. The use of the word 'pipeline' in this GP applies to all three categories.

Pipeline

The installation through which fluids or gases are conveyed, including pipe, pig trap, components and appurtenances up to and including the isolation valve(s) at the boundary limits

Pipeline system

The pipeline(s) including flow control, metering, tankage, pumping and compression, control and data acquisition, communications, and associated buildings

4. Symbols and abbreviations

For the purpose of this GP, the following symbols and abbreviations apply:

ESDV	Emergency shut down valve
HSSE	Health, Safety, Security, and Environment
NDT	Non-destructive testing
SSIV	Subsea isolation valve

5. Offshore pipeline system configuration

5.1. General

The design of the offshore pipeline cannot be undertaken without due consideration being given to the requirements of, and impact on, the necessary pump/compressor facilities, terminals and associated equipment and facilities. During the initial pipeline design phase the pipeline system configuration shall be defined.

- a. The offshore pipeline design and project execution shall follow the principles as defined in GP 43-02.
- b. The pipeline system project Select and Appraise phases shall be performed in accordance with GP 43-02.
- c. Key decisions made within this phase of the project should include:
 1. Route selection.



2. Pipeline hydraulics and flow assurance requirements.
For subsea developments or minimum facility installation tie-backs, decisions may be made regarding the use of multiple flowlines, manifolding arrangements, thermal performance requirements, and subsea or round-route pigging.
3. The number and location of the pump/compressor facilities.
- d. Key decisions made within this phase of the project may also include:
 1. Driver and pump/compressor type, machine configuration, fuel selection, and sparing.
 2. Need for surge relief systems/tankage.
 3. Number and size of storage tanks.
 4. Marine loading systems.
- e. Key considerations within this phase may also include:
 1. Availability of installation equipment in remote areas (e.g., Caspian).
 2. Limitations of available equipment, which may effect choice of pipe sizes, materials etc.
 3. Availability of experienced installation contractors.

5.2. Configurations

Offshore pipeline systems may include flowline and injection line systems between a subsea development or minimum facilities platform and a process facility, export pipelines between two platforms, or between an offshore facility and an onshore terminal, oil export lines between an offshore facility or onshore terminal and a tanking mooring/off-loading facility or offshore storage facility.

5.2.1. General

Pipeline systems may include:

- *Pipeline and associated riser.*
- *Subsea and/or topsides pigging facilities.*
- *Metering and samplers.*
- *Corrosion monitoring coupons or probes.*
- *Leak detection system.*
- *ESDV linked to platform or terminal emergency shut down system.*
- *SSIV.*

5.2.2. Flowline systems

In addition, component parts of a flowline system may include:

- *Injection lines and chemical lines.*
- *Power, communication, and chemical umbilicals.*
- *Manifolds with associated valves and control systems.*
- *High integrity pressure protection system (HIPPS).*
- *Subsea separators.*
- *Riser gas-lift.*
- *Topsides separator/slug catcher.*
- *Flowline heating systems.*



5.2.3. Export pipeline systems

Component parts of an export system may include:

- *Pumps/compressors.*
- *Chemical injection facilities.*
- *Subsea tees and/or wyes.*
- *Water flushing facilities for off-loading lines.*
- *Storage tanks.*
- *Marine loading facility.*

6. Offshore pipeline system design basis**6.1. General**

- a. Design basis shall be established in accordance with GP 43-02 and GP 43-07 to provide uniform and consistent data for the pipeline system design.
- b. The design basis should include the design data, governing design codes, and applicable standards necessary for performance of the design.

Data necessary for the design of offshore pipelines typically includes:

- *Pipeline general design data.*
- *Transported fluid data.*
- *Operational data.*
- *Seabed bathymetry and geotechnical data.*
- *Environmental data.*
- *Route restrictions due to platform structure, subsea facilities and associated marine activities.*
- *Existing and planned developments in the vicinity of the pipeline route.*
- *General marine activities, including mooring areas*

- c. Selection of industry codes and standards for the project (referred to as “the governing design code”, hereafter) shall follow the guidance of GP 43-08.

Industry codes for offshore pipeline design include ISO 13623, BS EN 14161 (ISO 13623 Modified), BSI PD 8010-2, ASME B31.4, ASME B31.8, API RP 1111, and DNV OS-F101.

- d. Reference shall be made in the design basis to all relevant BP ETPs used in design.
- e. Use of the following pipeline industry standards shall be done following the guidance given in the following GISs:
 1. BSI PD 8010 refer to GIS 43-211.
 2. DNV OS-F101 refer to GIS 43-212.
- f. As new information becomes available, the design basis shall be updated in a controlled manner.

The design basis provides a means of ensuring that all sections of the pipeline system are being designed to consistent data and requirements.

- g. A change control procedure should be implemented. Updates of the design basis should be performed in line with 6.1.a above and controlled.



6.2. General design data

General design data shall include but not be limited to:

- a. Governing design code and applicable standards, battery limits, and code breaks.
- b. Expected operating life.
- c. Main system co-ordinates and dimensional references.
- d. Major crossings and features, and potential interfaces or conflicts with existing and new facilities, structures and pipelines.
- e. Potential route options, including restricted or sensitive areas (e.g. a “constraints” map).
- f. General limitations that may be imposed by the location of the pipeline system.

6.3. Transported fluid data

- a. Specific fluid data required for hydraulic analysis are given in GP 43-09.
- b. Fluid compositional data and parameters defining the corrosivity of the fluid shall be defined.
- c. Content of solids and other components that may give rise to erosion shall be defined.

6.4. Operational data

- a. Operational data shall be defined for the lifetime of the pipeline.

Operational conditions can change significantly through the life of the pipeline. The pipeline design shall accommodate all conditions encountered and therefore adequate through-life data is required.

- b. Operational design data shall include, but not be limited to:
 1. Design flow rates, including peaks and turn-down.
 2. Pipeline inlet/outlet pressure and temperature conditions, throughout the operational life.
 3. Wax, hydrate, or emulsion formation and control.

6.5. Offshore geophysical and geotechnical data

- a. An offshore geophysical survey and geotechnical investigation shall be conducted over the proposed pipeline corridor in accordance with GP 43-26 and GP 43-30.
- b. The geophysical and geotechnical data should facilitate the route selection, define the seabed bathymetry, characterize the soils along the route, and identify hazards along the route.
- c. The geophysical and geotechnical data shall include but not be limited to:
 1. Soil profiles and bathymetry within the surveyed area.
 2. Seafloor conditions and obstructions including natural hazards and man-made obstructions.
 3. Information on earthquakes, possible subsurface hazards such as mud volcanoes, etc.
 4. Sedimentary condition, geologic hazards, or constraints of shallow seabed strata.

Where trenching of the pipeline is proposed and at landfalls or other areas of burial, the sub-bottom conditions and strata need defining to a depth that ensures accurate definition of the construction requirements and methods. If subsea structures are to be installed, the sub-bottom conditions and strata should be defined to an adequate depth to allow for foundation design.



5. Any archaeological significance.

6.6. Offshore environmental data

- a. Offshore environmental data of appropriate return periods shall be included to cover temporary and permanent conditions for which the pipeline is to be designed. This data shall include characterisation of water levels, temperatures, wind, wave, and current (and earthquake, if applicable).
Wind, wave and earthquake data are random in nature, and are usually presented by means of the statistical return period. Data is typically included for the temporary installation period and for the permanent operational period. Derivation of this design data may require compilation of available field records of wind, wave, and current conditions in and adjacent to the area, a program of measurements over a period of time, and hind cast modelling.
- b. The return period for meteorological and oceanographic data to be used for design shall be at least 3 times the period or duration to which the design is applicable.
- c. Directional distributions of environmental data should be included.
- d. Annual scatter of waves, currents, or winds may be required if a fatigue assessment is to be performed.
- e. The assumed thickness of marine growth should be defined.

7. Offshore pipeline route selection

7.1. General

- a. Selection of pipeline route and landfall, and assessment of ground hazards shall be in accordance with GP 43-10.
- b. A provisional route may be selected based on public domain information.
- c. Before finalizing the route, the geophysical survey and geotechnical investigation, assessing geohazards, shall be carried out, in accordance with GP 43-26 and GP 43-30, along the provisional route corridor to provide detailed design information for route selection.

7.2. Alignment

- a. Selection of the pipeline route shall comply with the government regulations that apply to the jurisdiction or country of the waters along the route.

Installation of a pipeline requires permits from regulatory agencies. Environmental regulations and permits are of particular concern as environmental approval delays are often significant.

- b. Pipeline route shall be selected with due regard to technical, environmental, and safety-related factors, as well as the anticipated developments in the vicinity of the pipeline.

Some basic criteria in selecting pipeline routes are:

- *Minimise the pipeline length, taking due regard of the following criteria.*
- *Avoid installations, subsea equipment, wellheads, and wrecks.*
- *Avoid ship anchoring zones, dredged areas, dumping grounds, and designated dangerous zones.*
- *Corridor with existing pipelines if possible.*
- *Minimise crossings of other pipelines and cables.*



- *Avoid seabed obstructions, outcrops, reefs, and depressions, which may cause pipe spans, point loadings, or high bending stresses.*
 - *Consider the pipeline installation options (e.g. laying or towing), as the installation may impact the pipeline route selection (e.g. route deviations and bend radii).*
 - *Minimize the pipeline length in unstable or mobile seabed areas. In mudslide potential areas, align the pipeline route as close to the mudslide direction as possible to minimize the risk of pipeline damage.*
 - *Avoid locations of planned future exploration and development.*
 - *Give regard to fishing grounds and avoid, if possible, shellfish beds. In locations in which there is a developed demersal fishing industry, liaison with fishermen's representative bodies should be undertaken at an early stage to avoid objections to and delay of issue of regulatory permits.*
- c. In the vicinity of a floating or fixed offshore installation, the riser and pipeline shall be routed to avoid or protected against:
1. Dropped objects from supply boats and other vessels.
 2. Interference with existing and other planned pipeline and tie-in spool pieces.
 3. Deposition of drilling mud and other waste materials.
 4. Footprint and/or anchor placement from jack-up rigs and other vessels.
- d. The requirements of initiation or lay-down of pipeline shall be considered in the selection of the pipeline route in the vicinity of the platform.
- e. A constructability review shall be performed on each route option to assess the effectiveness and risks associated with the proposed construction methodology.

7.3. Landfall and shore approaches

Landfall and shore approaches shall be evaluated to determine the best location(s) and construction techniques to be utilized for the installation.

The routing of the landfall is subject to the same general considerations as the offshore pipeline. Additional aspects that should be considered in the landfall selection are given below:

- *Location of the landfall to facilitate installation; locating an area having gradually sloping beach with deeper water nearby to enable the lay and construction vessel(s) to get close in.*
- *Environmental loadings from waves and currents.*
- *Presence of seabed soil scour, coast erosion, and beach movement.*
- *Feasibility of installation methods at landfall area.*
- *Environmental sensitivity and impact of construction.*
- *Onshore pipeline route.*
- *Anticipated developments in the vicinity of the landfall.*
- *Consultation with appropriate statutory authority.*

8. Hydraulic analysis, flow assurance and line sizing

- a. Hydraulic analysis of the pipeline system shall be carried out in accordance with GP 43-09 for the various pipeline routes and system configuration options to determine the required line size, pumping/compression requirements, and requirements for thermal performance.

