

PETRONAS TECHNICAL STANDARDS

MANUAL

RISER DESIGN

PTS 31.40.10.10

OCTOBER 2011



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PTS Circular 2011 - 1



PTS No:	31.40.10.10
PTS Title:	Riser Design

This revision of PTS 31.40.10.10 – Riser Design (October 2011, Revision 1) has been reviewed and endorsed without any change from the previous revision.

The previous version of this PTS 31.40.10.10 (December 1999) will be removed from PTS binder / e-repository from herein onwards.

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Revision History

Rev No.	Reviewed by	Approved by	Date

PREFACE

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1. INTRODUCTION

1.1 SCOPE

This new PTS specifies requirements and gives recommendations for the design of offshore pipeline riser systems, which include the piping, riser clamp supports and any expansion spool or anchoring system at the base of the platform. This PTS identifies a broad approach to the design including:

- definition of riser system and interfaces;
- potential riser concepts;
- riser routing;
- analysis requirements;
- support design;
- J-tube design;
- fittings and materials.

This PTS does not present a methodology, but is intended to act as a checklist of design activities for consideration by an experienced engineer.

For the purpose of this PTS, it is assumed that the riser design is based on PTS 31.40.00.10.

The scope of this PTS includes only rigid metallic risers; flexible risers and non-metallic risers are excluded from the scope.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to companies forming part of the PETRONAS or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them.

This PTS is intended for use in offshore exploration and production facilities.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this PTS which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this PTS as closely as possible.

1.3 DEFINITION

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project, or operation or maintenance of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

J-Tube	J-shaped tube installed on a platform, through which a pipeline can be pulled to form a riser.
Piping components	items integrated in the pipeline/riser such as flanges, tees, bends, reducers and valves.
Riser support	structure intended for fixing the riser to the platform or for local or continuous guidance of the riser assembly.
Riser system	riser pipe, supports, integrated piping components and corrosion prevention system.

1.4 ABBREVIATIONS

ASCE	American Society of Civil Engineers
EPDM	Ethylene Propylene Diene Monomer
ESD	Emergency Shut Down
HAT	Highest Astronomical Tide
QRA	Quantitative Risk Assessment
LAT	Lowest Astronomical Tide
RTJ	Ring Type Joint
SMYS	Specified Minimum Yield Stress

1.5 CROSS-REFERENCES

Where cross-references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced in this PTS are listed in [\(15\)](#).

2. DESIGN INTERFACES

2.1 GENERAL

The riser system shall be designed as a part of the total offshore pipeline system. For design purposes, it is necessary to define the extent of the riser assembly and to establish the interfaces between the riser system and adjacent systems. The interfaces provide a point where loading and/or displacement, and the requirements of the various systems can be defined and reconciled.

The riser interface points can be summarised as follows:

- topside and supports;
- jacket and supports;
- pipeline/tie-in spool.

The riser analysis model shall take into account the effects of the interface points as further detailed below.

2.2 TOPSIDE INTERFACE

The design of the riser system requires detailed interfacing with the platform topsides. The code break for the riser system shall extend up to and include the pig trap (including associated pipework and valves) or, if no pig trap is fitted, to the first isolation valve off the riser. The riser supports fall outside the code break. The following design issues shall be addressed:

- design responsibility;
- exact location of code breaks marked on process engineering flow schemes (PEFS);
- piping layouts;
- structural layouts;
- instrument connections;
- electrical isolation;
- overlap of riser and piping analyses;
- support locations;
- access for pigging operations;
- access for valve overhaul.

2.3 JACKET INTERFACE

The design of the riser system requires detailed interfacing with the jacket structure. The riser supports fall outside the code break. The following design issues shall be addressed:

- design responsibility;
- code breaks;
- details of the structural layout and dimensions of the jacket members;
- platform deflections;
- riser routing;
- riser support locations and type;
- electrical isolation;
- riser loadings on riser supports;

- ESD valve location;
- structural protection;
- hook-up to top section of riser.

2.4 PIPELINE/EXPANSION SPOOL INTERFACE

The design of the riser system requires detailed interfacing with the pipeline/expansion spool. The interface between the riser and the submarine pipeline depends on the method of connection, geometry and type of riser and should be agreed in each case. The following design issues shall be addressed:

- design responsibility;
- location of code breaks;
- riser routing;
- pipeline approach;
- expansion spool layout;
- overlap of riser and expansion spool structural analysis (often performed in one analysis from pipeline to pig trap);
- the tie-in method.

3. RISER/TIE-IN CONCEPTS

3.1 SUMMARY OF MAIN RISER TYPES

Risers for platforms may be broadly grouped into the following categories:

- riser for steel jacket platform;
- riser for gravity base structure (concrete);
- J-tube riser - this category is further discussed in (8);
- caisson riser system; consists of a caisson which forms a structural encasement and a number of riser pipes which are installed in the caisson. Caissons are protective devices to eliminate environmental loading on the riser pipes. Caisson riser systems may reduce the number of riser supports which otherwise would be required for conventional risers;
- flexible riser for a floating facility (outside the scope of this PTS).

3.2 RISER INSTALLATION METHODS

3.2.1 General

Risers are usually pre-installed with the jacket structure. Otherwise they can be retrofitted onto existing platforms. This may be by the conventional method of lift, set and subsea tie-in.

Alternatively, one of the following methods may be used without the need for subsea tie-ins:

- stalk-on method;
- bending shoe riser method;
- barefoot riser;
- J-tube installation (8).

3.2.2 Conventional method

Retrofitted risers are fabricated in sections, lifted from a barge and lowered into suitable riser supports which may also be retrofitted onto the jacket. The number of riser sections depends on the water depth and the length of the barge. The riser normally consists of an upper section behind the jacket bracing (to provide safety against boat impact) which is connected to lower sections positioned on the outside of the jacket. After installation, a subsea tie-in is made to the pipeline.

A form of retrofit riser clamp may be installed after a jacket has been in service for some time. In this case, provision shall be made for aligning the clamps/guides. This is achieved by connecting the riser clamp/guide which is also clamped to a structural jacket member or stub, depending on the size of riser. Retrofitting of these clamps/guides involves considerable diver time. Alternatively, a riser ladder, or more simply riser support stubs, may have been installed on the jacket in the fabrication yard for future retrofitting of risers.

Retrofitting methods without the need for subsea tie-ins are described below.

3.2.3 Stalk-on riser method

For shallow water, this is the most commonly used riser installation method. After the pipeline has been laid with its end on the sea bottom and close to the platform, the lay barge is moored in position. The riser bend which will eventually connect the horizontal pipeline to the platform deck is measured and the location at which the pipeline will be cut for connection to the bend is marked. The pipeline is then lifted from the seabed by applying tension to the pipe. In very shallow water with small diameter pipelines, this is not a problem; however, larger lines in deeper water require a substantial length of pipe to be supported off the bottom to avoid overstressing the pipe. The pipe is then cut at the mark, the bend is welded onto the free end of the pipe and the pipe and bend are lowered down. This process of adding pipe is

continued until the pipe reaches the bottom. The riser is then secured to the platform using diver-operated clamps.

Expansion spools can be set simultaneously with this method.

In deeper waters, the handling of the pipe and riser becomes increasingly difficult and even hazardous to both pipe, equipment and personnel.

The main advantages of this technique are:

- weld connections are made above surface and can be fully inspected, ensuring weld quality;
- diver activities are relatively simple, requiring only a normally-skilled team using standard tools. The expense and time delay involved in mobilising specialised contractor personnel are avoided;
- there is no requirement for underwater welding.

The disadvantages of this technique are:

- the lifting, welding and lowering operation is vulnerable to environmental conditions;
- careful planning and strict compliance with the predetermined lifting and lowering procedures are vital to avoid overstressing the pipeline and riser;
- greater adjustability in the riser clamps is required because the riser cannot be moved before and after once it is welded to the pipeline.

3.2.4 Bending shoe riser method

This method, which was developed by Shell Oil Company, consists of installing a curvature limiting shoe on the platform during onshore fabrication. The pipeline is then laid to the structure and positioned under the bending shoe either by manoeuvring the barge or attaching cables to the line as it is laid and pulling it under the shoe. Once the line is in the correct orientation with respect to the centreline of the bending shoe, specially designed hydraulic clamps on the platform capture and secure the riser. These clamps may be installed either during onshore fabrication or immediately before the riser is installed offshore. In very deep water or for pipe with low stiffness, it may be necessary to install auxiliary cables on the riser to assist with the installation. Other than inspection, this method of riser installation requires a minimal amount of underwater work.

3.2.5 Barefoot riser method

This method has been used successfully in the Gulf of Mexico. The method is simple and should find many applications, especially for deepwater platforms. The pipe weight and wall thickness are selected such that the pipe can be lifted vertically at the water surface without exceeding a specified, non-buckling, bend in the sag portion of the line. The method consists of approaching the platform with the pipe suspended vertically at the water surface. The pipe is then positioned at a tangent to and in contact with the upper end of a series of pipeline clamps on the platform. The lifting load is decreased according to a prescribed schedule which forces the riser pipe into each successive clamp and puts the bottom span into compression. The riser is then clamped to the platform once the desired curvature in the sag-bend is achieved. The necessary hydraulic or electrically operated riser clamps can be installed offshore using a rail guidance system to land each clamp at a predetermined elevation. Diver time, other than for inspection, would be minimal for this method of riser installation.

One other version of this approach to riser installation is called the Guide Rail method. This type varies from the previously described method primarily in the clamp used to attach the riser to the guide rail. The guide rail is a continuous "T" section or "H" beam welded to the platform side or jacket leg during shore fabrication. The installation sequence requires the lay barge to lay away from the platform while a riser barge attaches the riser clamp to the rail and continues to add pipe as the riser is lowered. The lay barge continues to move away from the platform during this operation. After the riser is in position, it is secured to the

platform by welding the clamps located above the water line to the rail and by having divers attach the submersed clamps with set screws.

3.3 SUBSEA TIE-IN METHODS

3.3.1 General

In most cases, tie-in of the pipeline to the offshore facility is achieved by inserting an expansion spoolpiece. The purpose of the spoolpiece is to absorb expansion loadings, and accommodate the installation tolerance on the pipeline.

The spoolpiece connections may be made up using one or a combination of the following methods:

- mechanical connectors;
- flanged tie-in using RTJ swivel ring flanges; or
- hyperbaric welding.

These tie-in methods are further described below.

3.3.2 Mechanical connectors

A variety of mechanical connectors are available and they generally consist of two components:

- a gripping system, to anchor the connector onto the pipe;
- a sealing system, using either metallic or elastomeric seals.

Mechanical connectors are alternatives or supplements to flanges and can offer certain advantages depending on their design, e.g.:

- some are easier to install (boltless flanges);
- some can accommodate a degree of misalignment (ball joints);
- some can be installed directly onto the bare pipe end;
- some are suitable for diverless application.

Mechanical connector systems are not yet as reliable as welded or flanged connections, hence they are mainly used for emergency repairs to pipelines where speed of repair is essential and the equipment for other repair methods is not available.

Mechanical connectors have been developed that can be activated from the surface by hydraulics and without direct diver intervention. To achieve this type of connection, accurate positioning of the end of the pipeline is essential. Once positioned, the pipeline is pulled into the connector which is then activated and clamps around a special hub fitted to the end of the pipeline.

3.3.3 Flanged tie-ins

Flanged tie-ins performed by divers on the seabed are effected by installing a flanged make-up spool between the flanged ends of the lines to be connected. The spool is fabricated at the surface to the exact dimensions required, using a template which has been made up on the seabed and retrieved at the surface.

Due consideration should be given to the location of the flanges and, where possible, they should be located to minimise bending loads in the flanged joint. The integrity of flanges when subjected to high bending loads shall be confirmed by analysis.

The following recommendations apply to flanged tie-ins:

- the flange shall be of the ring joint type;
- one of the flanges shall be of the swivel ring type, to facilitate alignment of bolt holes;

- the specified internal bore of the flange shall be the same as that of the pipeline;
- the gaskets shall be made of an alloy which is softer than the flange material;
- wall thickness differences between the flange body and the pipeline shall be accommodated by specifying a tapered slope of not less than 1:5;
- all bolts shall be tightened using hydraulic tensioning equipment.

Subsea flanges and fittings should be bolted together using hydraulic tensioning equipment. Hydraulic bolt tensioning equipment is used on either side of a flange to stretch the bolts to a predetermined tension. With the tension maintained on the bolt, the nuts are turned down onto the flange, to bar tight, prior to relaxation of the equipment. In this way the flange can be tensioned to meet the service load. Washers are not used on subsea pipe-to-pipe joints as these are prone to contact corrosion, which causes the bolts to slacken with time.

3.3.4 Hyperbaric welding

Sub-surface or hyperbaric welding is performed with the pipeline on the seabed. Special frames are required to align the pipeline ends to be welded, and the welding itself is performed in a special habitat. The systems presently available are operated from a barge or a diving support vessel. This method requires extensive diving capability and special welding procedures.

As an alternative to hyperbaric welding, the weld can be performed inside an atmospheric chamber into which the pipeline is pulled. However, this method requires further development to be fully operational and is not presently recommended.

3.4 FLEXIBLE SPOOLS

Flexible spools can be installed directly without the necessity of preparing a template, and can considerably speed up the tie-in work. Flexible spools also have the ability to accommodate thermal expansion/contraction. The extra cost of the flexible spools should be weighed against the diving time savings on a project-by-project basis.

3.5 SELECTION OF RISER/PIPELINE TIE-IN METHOD

In general, welding is the preferred method for permanent tie-ins as far as this is practical and economic. The welding may be performed at the surface or on the seabed. The disadvantage of the hyperbaric welding technique is that it is a specialised activity, requiring dedicated spreads and a high level of training of the operational personnel. Alternatives shall be subjected to a cost/risk justification.

3.6 AVAILABLE CONSTRUCTION METHODS

Depending on the conditions at the intended location, such as weather, current velocity, wave heights, tidal effects, seabed conditions, water depth etc., there may be a preference for one of the possible construction methods. This in turn could put certain limitations on the selection of line sizes. The preferred construction method will also be dependent on the available construction equipment and on the cost of mobilising the required spreads with dedicated equipment and handling capability.

The type of riser to suit a particular application depends largely on the pipe size, the platform type, the direction of approach of the pipeline and whether the riser is to be installed during platform fabrication or at some time after the platform is placed.

4. RISER ROUTING AND LOCATION

4.1 BASIC ROUTING REQUIREMENTS

Selection of riser routing and location on a platform shall meet the following requirements as far as practical:

- the riser shall have the minimum exposure to damage;
- the riser shall not be located below the accommodation or the helideck, or close to escape routes from the accommodation or the temporary safe refuge;
- the riser shall be accessible for inspection and maintenance;
- in meeting these requirements, gas risers shall have precedence over oil risers.

The selection of riser routing and location shall also consider the following general factors:

- safe and economical installation;
- supply boat mooring area locations;
- location of future risers;
- minimisation of risk of damage by vessel collisions, by positioning risers within the structure above a depth of 20 m below LAT;
- minimisation of risk of damage by dropped objects;
- location of ESD valves, and their maintenance and inspection;
- minimisation of risk of interference with future construction, drilling, workover or platform maintenance or repair operations;
- access for subsea and topsides hook-up.

Consideration should be given to environmental loading conditions, particularly in the splash zone (5.3.3), where riser lengths and horizontal routing should be minimised.

Jacket bracing layout should be considered as this will determine the possible support locations and thus influence riser span lengths.

4.2 APPROACH TO PLATFORMS

Detailed consideration shall be given to the approach routes to the platform.

This will include consideration of:

- potential crossings;
- seabed obstruction;
- existing platforms/seabed facilities in close proximity;
- angle of pipeline approach;
- pipeline expansion requirements;
- routing to minimise risk of damage by dropped objects;
- accessibility for future positioning of jack-up rig.

When pipelines have to approach the jacket with angles greater than 30° from the perpendicular to the jacket face, the spacing between the risers should be increased to allow more space between the lines on the sea bottom.

If the direct approach of a pipeline would be hampered by the future position of a jack-up rig, doglegs can be installed. Doglegs should also be used in preference to tight curved approaches to jackets and provide a means of allowing for pipeline expansion. Consideration

should be given to the routing from the bottom riser clamp to the seabed as this section is particularly susceptible to riser expansion, platform movement and scour induced spans.

Where several platforms together form a complex, they should have a staggered layout along a straight line (spine) in order to:

- free as much of the jacket faces as possible for risers;
- allow easy barge access;
- position different production functions along the spine, so that future extension of any function is perpendicular to the spine;
- allow for new functions to be installed along the spine.

A dedicated riser platform may be installed to supply additional riser capacity (with scraper barrels and manifolds) and/or to improve safety and reduce the overall risk levels on production facilities.

For new developments and extensions of existing complexes a careful study of the new layout should be made in conjunction with anchor patterns (especially the drilling rigs), pipeline approaches, approach path for jack-up rigs and supply boat mooring.

4.3 SAFETY

The design shall include a safety assessment which shall quantify the effect of the risers on platform safety and may include the use of risk analysis to determine the need for additional protective measures. Consideration should be given to the use of cost-benefit analysis to assess the relative merits of different protective measures.

The requirement for and location of ESD valves should be addressed as part of the development of the platform specific safety case.

Any risk analysis performed shall take into account analysis of the risk from both natural and man-made hazards. Natural hazards shall include but not be limited to corrosion attack, marine life attack, extremes of temperature and environmental conditions. Manmade hazards shall include but not be limited to platform loading and off-loading operations, vessel activities, dragged anchors, trawl gear, abrasion by cables and chains, impact by vessels and dropped objects.