



RP 43-3

SUBSEA ISOLATION SYSTEMS

June 1993

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FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory Volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory Volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Recommended Practice

This Recommended Practice sets out BP requirements not covered by national or international standards or regulation.

Application

Text in italics is Commentary. Commentary provides background information which supports the requirements of the Recommended Practice, and may discuss alternative options. It also gives guidance on the implementation of any 'Specification' or 'Approval' actions; specific actions are indicated by an asterisk (*) preceding a paragraph number.

This document may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP RPSE's, to assist in the process of their continuous improvement.

For feedback and further information, please contact Standards Group, BP International or the Custodian. See Quarterly Status List for contacts.



1. INTRODUCTION

1.1 Scope

This Recommended Practice gives general guidance for the design, construction and testing of subsea isolation systems to be used for submarine pipelines that transport crude oil, petroleum liquid products or natural gas.

A schematic of a subsea isolation system is indicated in Figure 1, and typically consists of a subsea isolation valve and subsea control equipment linked to a topsides control system by an umbilical.

The decision to install a subsea isolation system should be based on quantified risk assessment and the requirements of current legislation. This is outside the scope of this Recommended Practice.

This Recommended Practice does not include a comprehensive listing of all legislation, regulation, codes of practice and standards applicable to the detail design of all components of the subsea isolation system. It is the responsibility of the designer to ensure that the most recent version of the most appropriate codes of practice and standards are used for the design, construction, installation, testing and commissioning of the subsea isolation system.

The purpose of installing a subsea isolation valve is to reduce the potential consequences of release of the pipeline inventory on the adjacent offshore installation following failure of the section of pipeline between the subsea isolation valve and the topsides emergency shutdown valve.

In addition to this primary function, the subsea isolation system also provides an alternative means of isolation in the event of failure of the topsides isolation system.

2. SEABED LAYOUT

2.1 Proximity of Subsea Isolation Valve to Platform

The location of the subsea isolating system with respect to the platform shall be decided using the results of a quantified risk analysis which examines the variation in risk to the platform and personnel with change in location of the system.

The quantified risk analysis will typically include the following factors:-

- *Fluid type.*
- *Pipeline pressure distribution.*
- *Pipeline length and diameter.*
- *Riser location.*
- *Pipe damage scenarios.*
- *Mass of fluids between subsea isolating valve and the platform topsides.*
- *Sources of ignition near to the riser.*



- *Personnel location on platform*
- *Other mitigations such as prevailing wind, emergency support craft capability and escape craft capability.*
- *Subsea isolating valve closure time and mass of pipeline inventory passing through subsea isolating valve before effective isolation.*
- *Number of valves to be included in system.*

2.2 Pipework and SSIV System Configuration

Consideration should be given to the following factors in determining the configuration of the subsea isolation system and pipework.

- Longitudinal and lateral loadings/movements of the pipeline and spoolpieces due to pressure and temperature expansion effects for all anticipated operating conditions. The operating conditions should include anticipated loadings/movements during blowdown and maintenance activities.
- Ease of access for inspection and maintenance of all components of the subsea isolation system.
- Ease of removal and replacement of the subsea isolation valve for maintenance purposes. Consideration should be given to the use of flanged, or other field proven proprietary connections, to accommodate subsea isolation valve removal and replacement.
- Protection against snagging, impact, abrasion and interference of all subsea isolation equipment due to platform based activities.
- The routing of all adjacent pipelines and other services. This should include consideration of the routing of possible future pipelines and services.
- Ease of installation of pipework and subsea equipment.
- Use of diver and ROV aids required for valve removal and other maintenance activities.

2.3 Umbilical Configuration

2.3.1 General

An appropriate means by which to install and subsequently support the SSIV control umbilical through the water column from the topsides to the seabed shall be determined.

A J-tube is one means by which this is achieved, but when provision of a J-tube or equivalent is inappropriate, the control umbilical may be attached to a riser, routed through a conductor or the use of some other appertuance made.

2.3.2 Routeing and Protection

The length of umbilical between the subsea isolation valve and associated topsides control equipment and power unit shall be minimised.

Where practicable, the umbilical should be located within the jacket structure for protection against crane and supply boat operations.

Where umbilicals are routed outside the jacket structure, they shall be located as far as possible from crane and supply boat operations.

As an open structural sleeve, a J-tube provides the umbilical with lateral support, shielding from wave action and physical protection from minor impacts. Physical protection from major damage is to be provided by location and routeing of the J-tube within the platform structure.

If a J-tube is used then its top shall be located in a position that allows convenient use of temporary umbilical pull-in equipment, but it shall include as few bends as possible to minimise required pull-in loads.

3 MATERIALS

3.1 General

Prevention of corrosion of system components shall be provided by application of one or more of the following methods:-

- corrosion/erosion resistant materials
- corrosion inhibitors
- surface coatings or treatments
- cathodic protection

The design should ensure that galvanic coupling will not occur through the use of suitable materials. Where this is not practicable, consideration should be given to the use of electrical insulation, cathodic protection and surface coatings.

Where different materials are to be used in combination, a risk of accelerated corrosion due to galvanic coupling will exist.

In addition to normal operating conditions, the materials of all components of the subsea isolation system in contact with the transported fluid, and an appropriate length of the pipe on the pipeline side of the subsea isolation system, shall be designed to meet all potential local rupture process conditions likely to occur during the design life of the pipeline.

Adequate transient fluid flow analysis should be performed to determine minimum metal surface temperatures and the temperature distributions through equipment (e.g. internal valve components) for the duration of the transient conditions. The use of fluid bulk temperatures for material specification without further interpretation should be avoided.

Care shall be taken to prevent specifying excessively onerous demands on materials and equipment for use during low temperature operation.

Where sour fluids are to be transported, reference shall be made to the latest version of BP Group [GS 136-1](#) for material requirements.

The design requirements of subsea isolation valves and actuators are judged to differ from those of the remaining pipeline system. In the event of a significant pipeline rupture in a section of pipeline between the subsea isolation system and the topsides ESD valve, fluid temperatures may occur below those anticipated during all phases of operation, including controlled blowdown. It may be found to be impracticable to design the entire pipeline for these low temperatures, but it is necessary to ensure that the subsea isolation system pipework/valving and the pipeline materials immediately adjacent to the subsea isolation system, on the side away from the platform, can accommodate the anticipated condition.

Attention should be given to determining minimum metal temperatures, rather than the cooler fluid bulk temperatures, to avoid over specification of the low temperature material requirements. The main concerns are potential brittle fracture of the materials within the subsea isolation system and significantly higher valve torques during the low temperature conditions.

3.2 Valve Components

Consideration shall be given to the following factors when selecting material for the valve and its components.

- The minimising of deterioration due to the action of the transported fluids and from contact of the internal and external surfaces with seawater.
- The risk of galling, seizure and excessive wear of the components.
- The use of a corrosion resistant material for all wetted parts where the service is corrosive.

- The use of hard seating where the transported fluid contains sand or other abrasive solids.
- The elimination of galvanic corrosion.

Electrical isolation may be provided by using insulating materials suitable for the service conditions envisaged. The effects of rapid decompression shall be considered when selecting the insulating materials. The use of insulating materials shall not reduce the integrity of the pressure containment of the assembled valve.

Due to the number of components in electrical contact, galvanic corrosion in low receptivity electrolytes may occur.

- Operating temperature.
- The presence of crevices and areas of stagnant fluid in some valve designs.
- The use of corrosion resistant materials on the 'dry' side of 'O' ring seals.

Where elastomeric seals are to be used, independent data shall be made available or otherwise acquired to confirm the suitability of the material for the intended service conditions. The effect of entrained solids, rapid decompression and trace compounds in the transported fluids (e.g. glycol) should be considered. Elastomeric seals should be compatible with any chemicals which may be used or be present in the pipeline during installation, precommissioning and operations, including H₂S, CO₂, inhibitors and biocides.

3.3 Actuator

The actuator materials shall be selected to be compatible with the seawater environment and the chosen hydraulic fluids.

The actuator material shall be electrochemically compatible with the subsea isolation valve body material.

3.4 Control Equipment/Umbilical

Consideration shall be given to the following points when selecting materials for the control equipment and umbilical.

- The materials used shall be resistant to both flowing and stagnant seawater conditions.

Stainless steel, type 316L is not always suitable since it may suffer localised corrosion pitting and crevice corrosion in stagnant fluid conditions when not effectively cathodic protected.

Control equipment will be exposed to hydraulic fluids and seawater.

- Where external surfaces of boxes or housings are constructed in carbon steel, these should be provided with corrosion coatings and cathodic protection.
- Where electrical conductive connectors are in use, consideration should be given to the possibility of electrolytic corrosion due to current leakage at the connectors.
- All umbilical materials shall be suitable for use with the contained fluids including control fluid, corrosion inhibitor and biocides.
- Where cathodic protection is employed, the structure shall be electrically continuous throughout. This may be provided by cable bonding or welding.

The soon-to-be-published [API 17E](#) Draft Umbilical Specification will provide detailed specifications for umbilicals and includes requirements for materials compatibility.

3.5 Secondary Structures

Secondary structures includes covers or cages which may be used for protection of the subsea isolation system.

Where these are constructed of steel, corrosion protection shall be by surface coatings in conjunction with cathodic protection or cathodic protection alone. Electrical continuity and the effect of shielding on the effectiveness of sacrificial anodes should be considered in the design.

The objective of anode sizing and positioning shall be to achieve an even potential distribution over the surface of the secondary structure.

Cathodic protection of the secondary structure and its attachments shall be independent of the pipeline cathodic protection system.

3.6 J-tubes and Other Umbilical Supports

Consideration shall be given to the following points when selecting materials for umbilical supports.

- Corrosion protection coatings and an appropriate wall thickness corrosion allowance shall be provided for the J-tube and structural support arrangements.

- Where practicable, the umbilical support arrangements shall be protected by the jacket cathodic protection system.
- The internal corrosion protection requirements of the J-tube shall be determined.
- J-tube sealing shall be considered following umbilical installation and the introduction of oxygen scavenger and biocide.

Where chemicals (e.g. biocide and corrosion inhibitors) are to be introduced into the annular space, these shall be compatible with the umbilical sheathing and insulating materials.

3.7 Associated Pipework and Fittings

The small bore pipework and fittings to be used for drains and vents and other associated pipework in the subsea isolation facility shall be in accordance with approved piping specifications.

Welding of associated pipework and fittings shall be in accordance with approved standards and procedures.

Suitable specifications for pipework may be found in BP Group [GS 142-6](#). A suitable welding specification is BP Group [GS 118-5](#).

4. DESIGN OF SUBSEA ISOLATION SYSTEM COMPONENTS

4.1 Valve

4.1.1 General

In selecting a valve for subsea isolation duty the following factors shall be considered:-

- The valve shall be designed for the operating and environmental conditions of the pipeline into which it is to be installed and any low temperature conditions anticipated following the rupture of the pipeline section between the subsea isolation system and the local topsides emergency shutdown valve. The cooling effect caused by seat leakage should also be given consideration.
- The valve should be capable of accommodating the pipeline hydrostatic test pressure in the fully open condition. The valve should also be capable of exposure to inhibited seawater (during hydrostatic testing) and exposure to a vacuum (during drying), as appropriate.



- Depending on valve type, the valve should be suitable for removal of valve internals, or full valve, subsea and require a minimum of maintenance, and have high reliability.

Note that choice of valve type and its body configuration may have a considerable impact on maintenance costs.

- Hard (metal, ceramic or composite) seats shall be provided for subsea isolation valve service. Internal cavity relief of one or both seats shall be provided.
- The valve shall be suitable for the passage of all commonly used pipeline pigs, and where appropriate, spheres and intelligent pigs.

Thus ensuring that the internal diameter of the valve is the same as the internal diameter of the pipeline.

- The pressure containment of the valve body shall be designed in accordance with [BS 5500](#) (Category 1) or [ASME VIII](#), Division 1.
- The hydrodynamic effects of valve closure speed shall be considered.

4.1.2 End Connections

Subject to satisfactory reliability analysis, both flanged and welded end connections may be used for subsea isolation valve installations.

4.1.3 Ball Valves

Ball valves to be used for subsea application shall have quarter turn operation. The valve shall be specified in accordance with [API 6D](#) and BP Group [RP 62-1](#).

Hard seated valves are specified for long term reliability.

Trunnion mounted ball valves should be used, incorporating line pressure energising seats, suitable for flow in both directions.

Consideration may be given to the provision of a double seating valve.

Note in a double seating valve, both seats seal against downstream pressure.

Stem and drive to the ball shall be capable of withstanding the maximum applied torque.



4.1.4 Gate Valves

If specifying gate valves for subsea isolation service, the following points should be considered:-

- Effects of possible debris accumulation in the valve body.
- Stem seal leak tightness.

The valve should be of a through conduit slab type providing sealing on both upstream and downstream seats.

The valve should operate such that closure is with stem rising, and non-rising stem designs should not be used.

Valves closing with the stem rising are less likely to fail to close due to debris build up and also benefit from pipeline pressure during closure.

4.1.5 Check Valves

For certain pipeline operating conditions the use of a check valve may provide a potentially simple solution to subsea isolation. Their use shall be justified from the QRA.

Check valves are not suitable for installation at the import end of a pipeline or on pipelines requiring depressurisation during an emergency.

In the design of check valves for subsea isolation service the following should be considered:-

- Check valves do not require a control system. They should not form part of a controlled shutdown operation.
- The ability of such a valve to pass pipeline pigs including, as appropriate, spheres and intelligent pigs.
- Check valves should be provided with an override to enable reverse flow and pigging where necessary.
- Potential damage to the check valve and associated pipework from 'slam shut' conditions.

4.2 Actuator

The actuator shall be in accordance with BP Group [RP 30-3](#), and BP Group [GS 130-6](#).

The following shall be considered in the selection of an actuator for operation of the subsea isolation valve:-

- The actuator system shall be fail-safe closed.
- The actuator shall be either spring return or double acting with subsea accumulation.
- Where justified, the actuator should be provided with remote position status indication in the adjacent platform central control room. The actuator should also incorporate a position indicator for the safe and convenient verification by diver or remotely operated vehicle of the valve status in poor visibility conditions.

Typically this is justified for function testing of the valve and if the pipeline is pigged on a regular basis.

- Provision of actuator handling frames.

As a minimum, the actuator shall be provided with balanced lifting points.

- Consideration shall be given to the effect of low fluid temperatures during pipeline rupture conditions on the torque required to close the valve.

4.3 Umbilical

Typically the umbilical is the means for routing high pressure hydraulic hoses from the topsides control unit to the SSIV. It can also include electric power and signal cables in the form of a composite umbilical.

The umbilical required to control the SSIV shall be designed, manufactured and tested to [API 17E](#) Draft Umbilical Specification.

Redundancy should be considered if economically justified.

4.4 Control System

4.4.1 General

The control system, typically comprising topsides hydraulic power unit with integrated control panels, topsides electro-hydraulic junction box, umbilical, subsea control pod, subsea accumulators and subsea interconnections should be assembled from highly reliable, field-proven components. Approval shall be sought for any component which does not comply.



The capability to perform in-situ functional testing of units or sub-units of the subsea isolation control system shall be provided wherever possible.

Where a control system operates more than one valve, suitable subsea isolation should be installed to allow testing and maintenance work to be carried out on any one valve system, without affecting production through the other.

The control system shall be designed to meet the overall reliability requirements of the subsea isolation system (Section 5) and close the subsea isolating valve in the event of loss of actuation power (in the case of spring return actuated SSIV's) or loss of control signal from the platform (in the case of double acting hydraulically actuated SSIV's).

A direct hydraulic control system is preferred in cases where the distance from the platform to the SSIV is not very great (i.e. <500m). A piloted hydraulic system may be required if spring actuated closure of the valve is not practicable.

An electro-hydraulic system would only normally be employed where the distance of the SSIV from the platform makes hydraulic only system response times too great.

Attention shall be given to the provision of adequate instrumentation to rapidly detect the occurrence of all ruptures in the pipeline between the subsea isolation valve and the topsides emergency shutdown valve of size likely to cause hazard to the offshore facility and personnel.

SI 1029 covers the requirements of branches outboard of the ESDV, and precludes the use of instrument tapings on the platform outboard of the ESDV.

Consideration shall be given to the installation of a shutdown system override facility for use in specific instances such as for maintenance, or start-up.

All sensitive subsea control system components (e.g. shuttle valves, pilot valves, solenoid valves) should be contained in a retrievable, pressure compensated module or pod, filled with a benign fluid.

All subsea electronic equipment shall be designed to comply with BP Group [RP 30-4](#) under the section on Subsea Control Systems.

4.4.2 Subsea Accumulators

Accumulators should be used to provide the energy local to the actuator to close the subsea isolation valve where large torque requirements prevent the use of spring return actuators.

The sizing and pre-charge should permit the subsea isolation valve to be closed, opened and closed again without recharge. The

accumulators should be able to supply hydraulic fluid at a pressure adequate to provide twice the breakout torque on the last valve closure stroke.

This three stroke accumulator capacity is to ensure that the SSIV is able to fail safe at all times, including the period immediately following function testing or a spurious trip prior to recharging of the accumulators.

Consideration should be given to use of a subsea sensor to monitor the accumulator pressure change when stroking the subsea isolation valve. This will involve extra subsea connections thus marginally reducing the system integrity.

The accumulators should be located as close to the actuator as is practicable and included within any valve protection provision.

The routing of all hydraulic pipework shall be such that the length is minimised and level of protection maximised.

4.4.3 Control Fluid

The control fluid shall have properties adequate to satisfy the required response time and be compatible with hose material and the other control components.

Either water based fluids or low viscosity mineral oil based fluids may be considered.

Further guidance is given in BP Group [RP 30-4](#) Subsea Control Systems under the section on Hydraulic Power Supplies.

The requirements of the actuator shall be considered in addition to the control system in selecting the control fluid. In particular,

- Compatibility with the actuator components, particularly elastomeric seals and 'O' rings should be established.
- Compatibility with the fluids in other parts of the actuator (e.g. spring or rack-and-pinion cavities) must be established.

Long term stability of the fluid with, and without, small amounts of seawater present should be established.

All equipment which will be in contact with the fluid should be cleaned to the appropriate standard as stated in BP Group [RP 30-4](#) under the section on Hydraulic Power Supplies.

4.4.4 Hydraulic Power Unit

The subsea isolation valve Hydraulic Power Unit (HPU), required to supply clean hydraulic fluid to operate the subsea isolation valve, should normally be separate from other platform hydraulic supplies.

Integration of the subsea isolation valve actuator hydraulic supply with the other platform supplies may be considered providing that cleanliness and reliability of supply are not compromised.

Further guidance is detailed in BP Group [RP 30-4](#) Subsea Control Systems under the section on Hydraulic Power Supplies.

As the subsea isolation valve will be operated infrequently, the HPU should be designed as an unattended unit receiving minimum maintenance. The following features should be addressed in the design of the HPU:-

- Alarms

Faults (e.g. loss of pressure or reservoir level) should generate alarms in the platform central control room.

- Cleanliness

The unit should incorporate facilities for filtering the fluid to [NAS 1638](#) class 6, or the appropriate level specified. These filters shall incorporate differential pressure alarms and should be capable of being changed without shutting down the HPU.

- Shutdown

For direct hydraulic systems, the hydraulic header should incorporate a solenoid vent valve held in the non-vent position by an uninterruptable power supply (UPS). This valve should vent the umbilical main hydraulic supply hose on interruption of the UPS. In the case of piloted systems and double acting actuators, the solenoid vent valve shall be installed in the pilot line.

Venting the pilot line will cause the subsea pilot control valve to shift and thereby permit the stored energy in the subsea accumulators to close the subsea isolation valve.

Electro-hydraulic systems should use a 'watchdog' pulse system to monitor the subsea electronics. If a pulse is not received by the subsea electronics on a predetermined basis, an SSIV closure shall be initiated.

- Availability

Consideration should be given to the provision of duplicate pumps driven by diverse power sources of high availability.

- Accumulators

Accumulators may be required to prevent excessive operation of supply pumps and to provide a limited storage in the event of a temporary loss of pumping capability.

4.4.5 Subsea Sensors

The requirement for subsea isolation valve position sensors should be fully justified and their function ascertained in detail.

Typically valve position sensors are justified when the pipeline is pigged regularly and when function testing of the valve is required.

For positive indication of valve position, non-contact inductive proximity sensors or linear variable differential transformers (LVDT) indicators shall be selected. Potentiometric devices and externally mounted position transducers are not acceptable.

Initial installed commissioning tests must confirm the correct functioning of the sensors.

Subsea sensors shall be designed so as to comply with BP Group RP 30-4 under the section on Subsea Sensors.

The following points should be considered when assessing the contribution of the subsea isolation valve position sensors to the operability of the system.

- *Where possible, independent confirmation of valve position should be sought.*
- *In systems using mineral oil or where the spent fluid is returned to the HPU, subsea isolating valve/actuator valve movement may be determined by monitoring this fluid.*
- *Failure of the subsea isolation valve position sensors may adversely affect the operator's perception of the overall integrity of the subsea isolation system.*
- *Consideration should be given to the importance of knowing valve position for such operations as pigging and function testing.*

If subsea isolation valve position sensors are to be used (e.g. For tests involving partial stroking of the valve), then direct transmission of the sensor signals should be considered unless the distances involved are above a few hundred metres. The sensors should be duplicated,

segregated and connected directly to the umbilical cables via wet-mateable, conductive connectors.

4.4.6 Shutdown and Alarm Initiation

Automatic closure of the subsea isolation valve should be limited to carefully selected circumstances. Closure philosophy will be application-specific and in general be initiated by the following:-

- The final stage of platform abandonment (Red shutdown).
Consideration should be given to the number of spurious shutdowns during the first year of operation.
- Fire local to the riser, up to and including the topsides emergency shutdown valve. Shutdown on high gas levels local to the riser should be considered.
- Failure of topsides emergency shutdown valve to close on demand from the platform emergency shutdown system.
- Manual initiation from the platform central control room or strategically placed local push-buttons.

Consideration should also be given to the following:-

- High or low pressure on the pipeline side of the platform emergency shutdown valve.
- Riser impact.
- Alarm indication of pipeline leak detection in the platform central control room.

To provide a back-up system initiating valve closure in the event of fire, fusible links in the signal tubing or cable in the vicinity of the riser should be considered.

4.5 System Integration Testing

The component parts of the subsea isolation system shall be subjected to factory acceptance tests. Factory acceptance testing shall, wherever possible, incorporate full functional testing of the individual components.



A full system integration test shall be conducted of all equipment in the control system including umbilical, actuator and, if practicable, subsea isolation valve. The system integration test shall be performed after the factory acceptance tests of the individual control system components and prior to onshore assembly of the subsea isolation system in readiness for offshore installation.

All equipment shall meet the required hydraulic cleanliness standards prior to testing.

The purpose of the system integration test is to demonstrate that the control system components and actuator function together as a system and that the specified performance objectives have been attained.

The actuator should be supported on a purpose-built test stand that will enable a torque to be applied to the actuator shaft equivalent to that which occurs when full differential pressure is applied across the subsea isolation valve.

5. RELIABILITY OF SYSTEM

5.1 General

Refer to BP Group [RP 50-2](#) for definitions and calculation details on the terminology used in this section.

The need for a subsea isolation valve is to be determined by a quantified risk assessment on the export facilities of a platform installation. The quantified risk assessment will also determine a target availability for the subsea isolation valve and control system which will be unique for each installation.

5.2 Control System Reliability

The reliability priorities of the subsea isolation system are:-

- (a) The primary objective is to achieve the target probability that the subsea isolation control system will close the subsea isolation valve on demand. This term is referred to as the availability of the subsea isolation system and equates to (1 minus FDT) , where FDT is the Fractional Dead Time.
- (b) To minimise the spurious trip rate consistent with the primary objective. Where spurious rate is defined as subsea isolation valve closure with no initiation signal.



- (c) To minimise the probability that the subsea isolation valve will not re-open immediately after it has been actioned to close on test.
- (d) To minimise the expected subsea rate of failure which would necessitate a subsea intervention/maintenance operation. This should include limiting subsea isolation valve and actuator intervention or replacement during the lifetime of the pipeline.

In achieving the above requirements, a design of minimum complexity, primarily incorporating high quality components should be used. Component redundancy should be used as necessary to achieve the required FDT. In utilising redundancy to improve the FDT, the possibility of increasing the spurious trip rate should be recognised.

Qualitative and quantitative evidence of the subsea isolation system performance in achieving the above reliability priorities shall be provided by the system vendor(s). This should include both revealed and unrevealed failure rates based upon a Failure Modes Effects and Criticality Analysis (FMECA), preferably included in the vendor quotation. If the test intervals are known and have been supplied to the manufacturer, the FDT can be matched to the target availability derived from the QRA. The analysis and supporting data should be independently assessed.

6. PHYSICAL PROTECTION

6.1 General

The physical protection requirements shall be determined using the following approach:-

1. Identify hazard
2. Determine frequency of occurrence
3. Assess associated risk

All marine operations that are conducted in the vicinity of the subsea isolation system should be in accordance with strictly applied, procedural controls. Particular attention shall be given to the development of comprehensive procedures for all installation, inspection and maintenance operations on the subsea isolation facilities.

Where hazards exist that are outside the control of the operator and offer potential for significant accidental loading, physical protection may need to be provided for the subsea isolation system components. Such hazards shall include, but not be limited to:-

- dropped objects
- fishing gear interaction
- snagging cables

6.2 SSIV Protective Structure

6.2.1 Level of Protection Required

The level of protection is aimed at ensuring that the Subsea Isolation System remains available after a subsea incident, and shall be determined by the QRA.

Additional protection may also be justified to minimise downtime.

When considering the requirements for protection against dropped objects, the potential movements of all anticipated dropped objects through the water column and across the seabed shall be investigated.

If the SSIV is at a greater distance from the platform than the depth of the water then heavy objects and tubulars are unlikely to threaten the SSIV. Protection should be provided against light portable objects that could be dropped from an overhead vessel and damage sensitive equipment (such as handtools) and objects traversing the seabed (such as skips).

Protection against the dropping of heavy objects during installation and maintenance should be provided by the use of procedures.

If there is local fishing activity, then it shall be regarded as a hazard even within the 500 m installation exclusion zone.

The hazards are dependant on the type of fishing activities, but consideration shall be given to those associated with impact and snagging of fishing gear, and the entanglement of nets requiring diver intervention. Typically, the philosophy should be to deflect fishing gear. The risk of impact and snagging on control systems and actuators should be considered.

Where there is a risk of snagging, the protective structure shall incorporate arrangements to deflect slack and taut cables.

Physical protection against the snagging of dragged anchors is generally impractical, and the protection shall be limited to application of marine procedures for all activities in the vicinity of the subsea isolation system. These procedures shall include definition of anchor free zones containing the pipelines and all subsea isolation facilities.

6.2.2 Protective Structure

The structural frame for the SSIV should be designed to afford protection, typically featuring a continuous top perimeter member and corner sloping members. It should be kept free from potential

snagging points so as to deflect cables, trawlboards, nets, etc up and over the structure.

Sensitive items of equipment should be protected by localised structures or positioned such that they are shielded by more robust equipment.

When extensive protection is required, energy absorbing or deflecting structures shall be used covering all areas where damage would be unacceptable.

Deformation of the structure will typically be acceptable under extreme load cases but shall not lead to impact on or deformation of the contained equipment.

The structure shall be designed to provide snag-free access for divers and ROV's during installation, inspection and maintenance operations. The need for removal and replacement of part or all of the structure to allow maintenance work to be performed should be considered in the design.

Hinged or removable covers over top openings are typically used to provide vertical access.

Allowance shall be made for possible pipeline movements during operational and shut down conditions.

The structure shall be designed to avoid scour effects.

The structure shall be provided with a corrosion control system, using sacrificial anodes and corrosion coatings independent of, and compatible with, the pipeline corrosion control system.

6.3 Umbilical

Since the SSIV is a fail-safe device, damage to the umbilical is not a safety issue. Umbilical protection requirements are dependant on economic criteria.

Consideration should be given to provision of a 'weak-link' or anchor at the connection of the umbilical to the subsea facility to protect the subsea control equipment from loadings that may be induced should the umbilical be snagged.

Where an umbilical is to be suspended between the seabed and a subsea connection at the subsea isolation system or J-tube, consideration should be given to providing integral bend restrictors or support to limit curvature.

Consideration should also be given to the protection gained by the routing of the umbilical adjacent to the pipeline, and the use of mattresses should be considered.

6.4 Pipeline and Spoolpieces

A combination of physical protection measures and rigorous application of marine/work procedures shall be implemented to ensure that the pipelines and spoolpieces, in the vicinity of the subsea isolation facilities, are protected from external damage throughout the design life of the pipeline system.

The items of particular concern to be considered are:-

- Protection of corrosion coatings and sacrificial anodes.
- Prevention of damage due to dropped objects from platform based or local marine activities.
- Interference from installation, inspection and maintenance activities at the subsea isolation facility.
- Instability due to scour induced by the subsea isolation system protective structure.

6.5 J-tubes

The diameter and minimum bend radius of the J-tube shall be suitable for the safe installation of the umbilical with due consideration given to the limitations advised by the umbilical supplier.

7. TESTING

7.1 Onshore Assembly Trials

Following acceptance of the control system integration tests and fabrication of all components of the subsea isolation system and protective arrangements, onshore assembly trials shall be conducted using all components of the subsea facilities, protection, installation and maintenance aids. These trials shall be used to confirm that the facilities will fit together as required, to refine the installation and planned maintenance procedures and to give installation and operations personnel the opportunity to gain familiarity with the equipment before installation.

7.2 Hydrostatic Testing

Assembled spoolpieces shall be hydrostatic pressure tested onshore prior to installation. The installed spoolpieces should be included in the final pipeline system hydrostatic pressure test.



In order to avoid extensive pipeline hydrotesting, consideration should be given to the use of hyperbaric welding to tie-in pre-tested subsea isolation system pipework to the pipeline with 100% radiographic inspection of the completed weld as confirmation of the integrity of the weld instead of a final hydrostatic pressure test. Approval from the appropriate authorities should be obtained during detail design for use of this 'golden' weld technique.

Care shall be taken during hydrostatic pressure testing of spoolpieces containing valves to ensure that the valves are partially or fully opened to avoid isolating sections of the spoolpiece from the test fluid. The capability of the valve to withstand the test conditions shall be addressed during detail design.

The hydrostatic test shall be conducted to ensure that the spoolpiece is subject to the full longitudinal pressure effects.

7.3 Operational Function /Integrity Tests

An operational function test of the subsea isolation valve should occur at regular intervals, the aim of which is to demonstrate that the SSIV will operate on demand from the platform. The nature and timing of this test will be determined from the QRA, the availability requirement, the certifying authority requirements and any legislation applying.

At present there is no legislation covering SSIV testing in the UK. Function testing is typically carried out on an annual basis, based on QRA's carried out in the North Sea to date.

An appropriate authority should be invited to witness and accept the planned demonstrations and tests.

Closure of the subsea isolation valve during the normal course of platform operation due to a hazard condition or operational upset, may be accepted in lieu of a formal test providing that the relevant parameters are recorded in the appropriate manner.

When determining the nature and timing of testing, the following points should be considered.

The demonstration of operability may be full or partial closure of the valve. Where the demonstration of operability involves full closure, consideration should be given to performing a subsea isolation valve leak test.

The scope of each test shall include simulation of operation of the initiating device, operation of the emergency shutdown system through to confirmation of valve operation. Where possible the break-out torque or force should be monitored, and if appropriate valve closure and opening times recorded.

The requirement for leak testing shall be determined on an individual basis based on the QRA. Appropriate facilities should be provided to allow the leak test to be carried out, and the measurement of any leakage to be recorded.

7.4 Cleanliness of Pipework

Damage may occur to subsea isolation valve seals due to contamination during storage, handling and installation. The subsea isolating valve should be installed fully open and remain so until the line has been cleaned to minimise damage to the seals.

Consideration should be given to means by which damage to valve seals can be avoided during pre-commissioning operations (eg cleaning pipeline prior to installation of subsea isolation valve, internal pipeline coatings to reduce cleansing requirements following pipeline installation, application of silicone sealant within the valve to limit debris ingress into the seals).

8. MAINTENANCE

8.1 Maintenance Philosophy

Maintenance and inspection requirements of the components of the subsea isolation system should be fully addressed during design. Consideration shall be given to water depth, site condition, maintenance activities to be performed, need for subsea isolating valve and/or actuator removal, state of technology and safety in selection of maintenance intervention. The possibility for diverless intervention should be fully investigated and provision made where available, appropriate and cost effective.

Adequate access shall be provided for maintenance and inspection activities, including side access for ROV's. All equipment shall be robust and, as appropriate, permanent or temporary protection facilities shall be provided in order to prevent damage during maintenance activities.

Provision should be made to enable change out of all equipment without breaking pipeline containment. Equipment should be modularised to enable individual change out of units or sub-units. The units or sub-units should be designed to enable full functional testing to design conditions prior to offshore installation or change out.

Accumulators should be checked periodically as part of the pipeline inspection scheme.

This will typically comprise visual inspection, and ultrasonic thickness checks.

Consideration should be given to the provision of subsea flushing and venting points.

Attention shall be given to using common components wherever possible to allow interchangeability and reduce spares requirements.

Fully tested procedures and equipment shall be developed for inspection and maintenance operations. The maintenance procedures shall enable safe temporary suspension of maintenance activities at any time during the operation.

The maintenance procedures should be developed prior to installation of the subsea isolation system and have been demonstrated using actual equipment during the onshore assembly trials.

8.2 Maintenance Isolation

The isolating provision to give access for maintenance should be determined from consideration of:-

- Diver safety
- Containment of pipeline inventory
- Contamination of pipeline fluids (e.g. entry of seawater into gas pipeline)
- Constraints on timing or duration of works
- Contractual delivery obligations
- Effect on third party transportation in pipeline
- Effects of pipeline depressurisation
- Effects of pipeline flooding
- Environmental conditions

Maintenance isolation valves are not generally recommended. The provision of maintenance isolation valves should be subject to detailed justification including a reliability analysis.

Consideration should be given to isolation devices which may be inserted into the pipeline using pigging techniques. The performance and reliability of such isolation devices should be fully established prior to their proposed use. Where isolation is to be achieved with pigging devices, the location should be established prior to breaking into the line and should be monitored during all subsequent work.

Provisions shall be made to allow, and confirm, equalisation of pipeline pressure with ambient pressure prior to breaking into the pipeline. Provision should be made for the collection and disposal of

any oily water. Where pressure levels above ambient are to be maintained in the pipeline during the maintenance works, isolation shall be by double block with intermediate bleed.

The integrity of all isolation devices should be demonstrated prior to breaking into the line and should be monitored during all subsequent work.



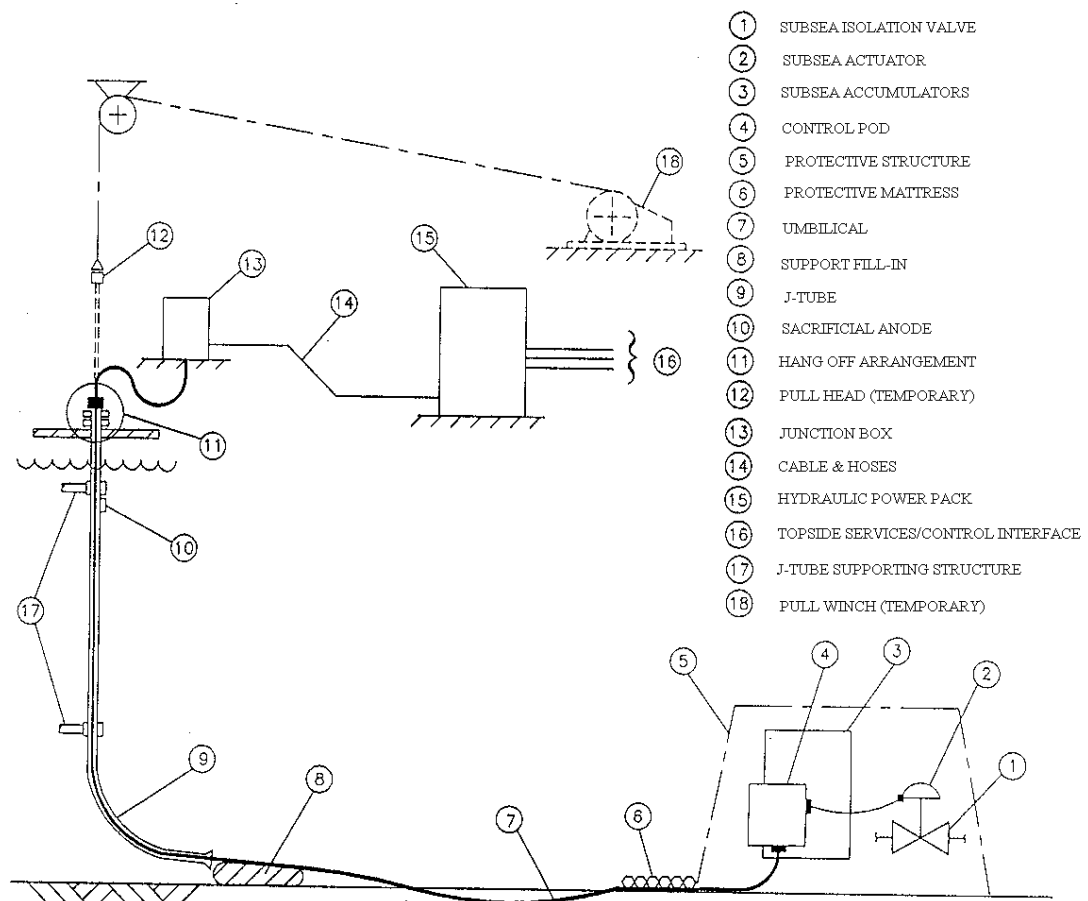


FIGURE 1
SUBSEA ISOLATION SYSTEMS COMPONENTS

DEFINITIONS AND ABBREVIATIONS**Definitions**

Standardised definitions may be found in the BP Group RPSEs Introductory Volume.

Abbreviations

ASME	American Society of Mechanical Engineers
BS	British Standard
FDT	Fractional dead time
FMECA	Failure modes effects and criticality analysis
HPU	Hydraulic power unit
NAS	National Aerospace Standard
ROV	Remotely operated vehicle
SSIS	Subsea isolation system
SSIV	Subsea isolation valve
UPS	Uninterruptable power supply

LIST OF REFERENCED DOCUMENTS

A reference invokes the latest published issue or amendment unless stated otherwise.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

American Standards

[ASME VIII](#) boiler and pressure code. Section VIII, Division 1

[NAS 1638](#) Hydraulic fluid cleanliness

British Standards

[BS 5500](#) Unfired fusion welded pressure vessels

BP Group Documents

BP Group [RP 30-3](#) Instrumentation & Control - Selection and Use of Control and Shut-off Valves
(replaces BP CP 18 Part 4)

BP Group [RP 30-4](#) Instrumentation & Control - Selection and Use of Control and Data Acquisition Systems.

*BP Group [RP 50-2](#) Guide to Reliability Engineering
(replaces BP CP 62)*

BP Group [RP 62-1](#) Guide to Valve Selection

*BP Group [GS 118-5](#) Fabrication of Pipework
(replaces BP Std 111)*

BP Group [GS 130-6](#) Actuators for Shutoff Valves

BP Group [GS 136-1](#) Materials for Sour Service to NACE Std MR0175-90
(replaces BP Std 153)

*BP Group [GS 142-6](#) Line Pipe and Fittings
(replaces BP Std 170)*

