MANUAL

QUARTER-TURN ON/OFF ACTUATORS

DEP 31.40.70.30-Gen.

December 1997

DESIGN AND ENGINEERING PRACTICE

PREFACE

DEP (Design and Engineering Practice) publications reflect the views, at the time of publication, of:

Shell International Oil Products B.V. (SIOP)
and
Shell International Exploration and Production B.V. (SIEP)
and
Shell International Chemicals B.V. (SIC)

The Hague, The Netherlands,

and other Service Companies.

They are based on the experience acquired during their involvement with the design, construction, operation and maintenance of processing units and facilities, and they are supplemented with the experience of Group Operating companies. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use DEPs they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will expect them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal or its technical advisor.

The right to use DEPs is granted by SIOP, SIEP or SIC, in most cases under Service Agreements primarily with companies of the Royal Dutch/Shell Group and other companies receiving technical advice and services from SIOP, SIEP or SIC. Consequently, three categories of users of DEPs can be distinguished:

1) Operating companies having a Service Agreement with SIOP, SIEP, SIC or other Service Company. The use of DEPs by these Operating companies is subject in all respects to the terms and conditions of the relevant Service Agreement.

2) Other parties who are authorized to use DEPs subject to appropriate contractual arrangements.

3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) or 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, SIOP, SIEP and SIC disclaim any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any DEP, combination of DEPs or any part thereof. The benefit of this disclaimer shall inure in all respects to SIOP, SIEP, SIC and/or any company affiliated to these companies that may issue DEPs or require the use of DEPs.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, DEPs shall not, without the prior written consent of SIOP and SIEP, be disclosed by users to any company or person whomsoever and the DEPs shall be used exclusively for the purpose for which they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of SIOP and SIEP. The copyright of DEPs vests in SIOP and SIEP. Users shall arrange for DEPs to be held in safe custody and SIOP or SIEP may at any time require information satisfactory to them in order to ascertain how users implement this requirement.

All administrative queries should be directed to the DEP Administrator in SIOP.

NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

TABLE OF CONTENTS

APPENDICES

1. INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for subsea, shutdown and general-duty quarter-turn actuators for on/off valves. Specific requirements are included for pneumatic, hydraulic, spring-return, double-acting and electric types.

The actuator will normally be supplied with the valve by the valve Manufacturer. If the actuator is being supplied for valves already installed, a detailed specification of the valve and process data will be supplied by the Principal (or nominated design Contractor) for use in conjunction with the actuator specification.

In addition to the requirements for actuators, this DEP specifies some requirements for actuator/valve assemblies, actuator control systems, ancillaries and interfacing components.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP, SIEP, or SIC, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them (i.e. the distribution code is "F", as defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants, gas plants, oil and gas production facilities, and supply/marketing installations.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP, 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 DEP 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 DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that 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 duties of the Contractor.

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

The **Principal** is the party that initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may 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

Fail-safe actuator	An actuator which returns to the safe mode of the application (open or closed) if the operating medium fails.
Protective Applications	Applications which, in the event of malfunction, may result in harm, including ill health and injury, damage to property, products or the environment, production losses or increased liabilities. These include shutdown duties.
Class 'X' systems	Instrumented Protective Function for ultimate protection i.e. no other

	mechanical means such as rupture discs or relief valves. These systems were formerly known as HIPPS.
ROV	Remote Operated Vehicle, typically used in subsea applications.
Torque, Break-Open	The torque required to move the valve off its seat to the point where it has just started to open.
Torque, Break-Close	The torque required to move the valve off its seat to the point where it has just started to close.
Torque, Resistance	The torque required to overcome the resistance of the valve/actuator assembly, including forces applied by the process fluid or test load, during travel.
Torque, Static	The torque delivered by the actuator, at any point in its 0° to 90° range when the actuator mechanism in not moving. This torque is also referred to as "stall" torque.
Torque, Shearing	The torque delivered by the actuator which would shear part of the coupling to the valve.
Type	Category of actuators in the same design range.
SSIV	SubSea Isolation Valve.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced in this DEP are listed in (8).

1.5 GUIDANCE FOR USE

This DEP has been structured throughout to provide the requirements for three actuator application categories: General Duty, Protective and Special Applications.

Where requirements are common to all three categories, these are contained in Section 2.

Sections (3), (4) and (5) contain specific requirements for the three application categories mentioned above, whilst the remaining sections are applicable to all categories.

A pre-requisite of supply is that all actuators other than general duty actuators be Type Approved. For a typical Type Test Approval Procedure see (Appendix A). Deviations between this and the Manufacturer’s Type Approval Procedures shall be subject to approval by the Principal.

2. GENERAL REQUIREMENTS FOR ALL APPLICATIONS

2.1 ACTUATOR

2.1.1 Actuator mechanism and operating medium

Scotch-Yoke, Rack-and-Pinion or Helical-Spline mechanisms are acceptable. Any other mechanism will require the approval of the Principal.

Pneumatic, hydraulic and electric mechanisms may be considered.

An oil barrier should be provided if the supplied operating medium is not suitable as actuator operating medium, e.g. sour/wet gas, unfiltered instrument air.

For hydraulically operated actuators, see also DEP 31.36.10.30-Gen.

2.1.2 Actuator design

2.1.2.1 Springs

No rubbing or buckling of the springs shall occur. Compression of the return springs shall be limited so that scragging or blocking of the spring coils does not occur. If disc/washer springs are used, the Manufacturer shall ensure that the mechanism used to keep the springs aligned will not cause hardening of the materials at the contact points.

If multiple springs are used they shall be mounted so that a single spring failure will not result in a complete actuator failure

Spring cans shall have safety features to prevent inadvertent spring release.

2.1.2.2 Tie bolts/bars

Tie bolts/bars may be used on pneumatic and hydraulic actuators if measures are taken to prevent galvanic or environmental corrosion.

Failure of one tie bolt/bar shall not cause the actuator to endanger personnel. In-situ replacement of the failed bolt/bar should be possible.

2.1.2.3 Pressure-retaining and torque-transmitting parts

Power storage accumulators, hydraulic and pneumatic cylinders and fluid reservoirs shall be designed and fabricated in accordance with the requirements of the system design pressure and DEP 31.22.10.32-Gen.

Bolting shall be of a quality and strength equivalent to ASTM A 193, grade B7. Nuts shall be of a quality and strength corresponding to ASTM A 194, Grade 2H.

2.1.2.4 Speed controlling mechanism (integral)

Speed controlling mechanisms may be required to restrict the operating speed of a valve (i.e. to prevent excessive pressure surge). Alternatively mechanisms may be required to provide fast operation (i.e. dump valves).

Speed may be controlled by restricting the charging/discharging of the operating medium from the actuator. The closing/opening time shall be in accordance with the design. Such mechanisms shall be arranged so that the risk of their blocking the flow of operating medium from the actuator shall be minimised. Mechanisms which are integral to the cylinder are preferred to external ones.

All speed controlling arrangements require the Principal's consent.

2.1.2.5 Lubricants, packing and access

The actuator internals shall be packed for life with suitable lubricants.

2.1.3 Materials

2.1.3.1 Buna N

Buna N rubber shall not be used for any part exposed to gas.

2.1.3.2 Bearings

Bearings shall not contain aluminium and should be protected from the environment.

2.1.3.3 Pressure-retaining parts

Materials for pressure-retaining parts shall comply with DEP 31.22.10.32-Gen.

2.1.4 Environmental

Actuators shall conform to the local environmental requirements stated in the purchase order and be suitable for continuous use.

If actuators may be drenched by sea water deluge in an offshore environment it is essential for the degree of ingress protection to be sufficient to prevent corrosion within the actuator, particularly on the spring, bearings, guides and cylinder surfaces.

2.1.4.1 General environment

The following details shall be specified by the Principal:

- Minimum and maximum temperatures;
- Maximum humidity.

2.1.4.2 Electrical protection

The following details shall be specified by the Principal:

- Area classification;
- Gas Group;
- Surface Temperature Requirement.

For details, refer to IEC 79-14 and DEP 80.00.10.10-Gen.

2.1.4.3 Ingress protection

Actuators and their ancillaries shall conform to IEC 529, ingress protection level IP56 (includes preventing insertion of fingers, hands etc. into the actuator and ancillaries) or as otherwise specified in the purchase requisition.

2.1.4.4 Anti-corrosion measures

The Supplier shall state in the bid that the actuator meets the requirements for anti-corrosion measures stated below.

Protective compounds and durable coatings shall be used to prevent corrosion in the event of water condensing inside the various housings, in addition to protection of external parts.

Paint shall be in accordance with the Supplier's standard paint specification provided that the Supplier can show it is equivalent to the Principal's paint specification.

Carbon steel parts shall be painted in accordance with painting and coating specifications relevant to the site of installation. If alternative equivalent coating techniques are proposed, details of these shall be submitted for approval.

Nickel plating may be used for the inside surface of cylinders to provide resistance to wear and corrosion. This shall be an electroless coating technique to DEP 30.48.41.31-Gen. The coating thickness shall be at least 75 μm. The underlying surface material shall be treated to provide corrosion resistance.

PTFE-type coatings may also be used for the inside surface of air cylinders for general-duty actuators, but not for shutdown actuators, as indicated elsewhere in this DEP. If PTFE-type coatings are used they shall conform to the coating and pre-treatment specification

reviewed and approved by the Principal during Type Test acceptance (see Appendix A). The underlying surface material shall be treated to provide corrosion resistance.

Carbonising/nitrating surface treatment processes may be used on internal parts such as piston rods, tie bars etc. but not on the inside surfaces of cylinders.

2.1.5 Interfaces

2.1.5.1 Available power sources

The Principal shall provide a specification for the power sources detailed below.

- Instrument air supply: minimum and maximum pressure, nominal dew point;
- Hydraulic fluid supply: minimum and maximum pressure, hydraulic fluid type, hydraulic fluid cleanliness;
- Electrical power supply;
- Instrument power supply.

The working range of instrument air pressure (i.e. between minimum and maximum pressures) should be specified as the minimum realistic value acceptable. Note that specification of an excessively wide range can result in onerous design requirements with consequential cost implications. The minimum operating pressure shall be specified by the Principal as a higher value than the low instrument air pressure trip setting.

Air filters and liquid catch pots shall be fitted if specified by the Principal. Lubricators shall be fitted if recommended by the Manufacturer.

The hydraulic fluid type shall be compatible with the remainder of the hydraulic power unit, including its components.

The Supplier shall include details of both the fill volume and the flow rate required to fully cycle the actuator.

2.1.5.2 Lifting eyes

Where necessary, the actuator shall be fitted with suitably located lifting eyes. These shall in accordance with local statutory requirements if applicable and otherwise guaranteed by the Manufacturer. The Supplier shall confirm that these are suitable for mounting and de-mounting the actuator in-situ with the specified valve orientation. If fitted, a minimum of two eyes and a configuration providing redundancy shall be provided. In addition, if specified, additional lifting eyes shall be provided on the spring cans to allow the removal of these with the actuator on the valve in the position specified.

2.1.6 Ancillaries

Ancillaries which are not mounted on the actuator body shall meet the same specification those standards as mounted on the actuator body.

Any actuator item which is pressure-retaining, including accumulators for double-acting actuators, shall be in accordance with DEP 31.22.10.32-Gen.

2.1.6.1 Limit switches and limit stops

Limit switches and stops shall be supplied in accordance with the project documentation.

The switches shall be such that they are closed when the valve is in the corresponding position. Each switch shall operate within 3° of the valve travel from the respective 0° and 90° limits. Switches shall be adjustable by 10° and repeatable to 0.5°. Mechanical protection shall be fitted to prevent disturbance/malfunction of the limit switches by inadvertent impact of portable tools and equipment. The switches shall be of the proximity type and suitable for use in the hazardous area classification specified. Limit switches shall be fully described in the Supplier's quotation, shall be subject to approval by the Principal and shall comply with DIN 19234 and VDI/VDE 3845.

For applications where the valve is required to be tested under operational conditions, additional limit switches may be fitted at either the 10° or 80° positions to allow partial closure tests to be conducted. These shall only be fitted at the Principal's request.

Adjustable limit stops shall be sufficiently robust so that adjustment is still possible after prolonged cycling of the actuator. The stops shall be such that they are normally securely locked in position and limit the overall actuator travel to within 0.5° from the set position for the lifetime of the actuator. The limit stops shall be arranged so that the valve travel can be adjusted at either end of the stroke with the actuator fitted to the valve. Allowance should be made in arranging the limit stops for the decelerating forces which result from stopping the valve travel at maximum speed as well as the forces applied by the spring and fluid pressure and operating piston.

2.1.6.2 Solenoid valves

Normal operation of the actuator shall be via normally energised solenoid valves driven by 24 V (dc). Pneumatic solenoid valves may also be used. On loss of signal or any other failure, the switching valve shall drive the actuator to its predetermined safe position. The solenoid valve manufacturer and type shall be specified by the Supplier and approved by the Principal. The electrical solenoid valve shall be provided with a local electrical manual or auto reset facility in accordance with the project requirements.

Direct acting solenoid valves are preferred. Pilot operated solenoid valves are not recommended.

IS (Intrinsically Safe) solenoid valves shall only be used with the Principal's consent.

2.1.6.3 Speed restricting mechanisms (external)

The requirements for speed restricting mechanisms which are not integral with the actuator are identical to those for integral mechanisms (see 2.1.2.4).

2.1.6.4 Field-mounted instruments

Flying leads should be avoided. Where flying leads must be used, they shall be terminated in a junction box to be provided along with the instruments by the Supplier.

2.1.6.5 Tubing and fittings

Tubing and fittings shall conform to local requirements.

Pneumatic and hydraulic power supply to the actuator shall be sized so that the speed of operation in the fail-safe direction is not limited by the tubing size or the bore of connectors. Tubing and compression type fittings shall be stainless steel unless otherwise specified by Principal.

The air passages in the solenoid valves shall be large enough to achieve the opening or closing time of the valve as specified. If this would lead to unrealistically large passages and consequently high power consumption of the solenoid valve, consideration should be given to the use of quick exhaust valves.

2.1.6.6 Pressure gauges and measurement points

Pressure gauges shall be provided as specified in the purchase order.

Any additional pressure measurement points included for use during performance monitoring or failure diagnosis shall be fitted with hand valves with capped outlets.

2.1.6.7 Local manual facilities and indications

If specified, a local manual control facility shall be provided for in-situ testing of the valve. Provision shall be made to protect this facility from interference or inadvertent operation. This facility shall not override the safety functions of the actuator.

Local valve position indication shall be provided.

2.1.6.8 Mechanical locking devices

Mechanical locking devices may be required for valves used in well cleaning and maintenance activities. These mechanisms shall only be fitted with the Principal's consent.

2.1.7 Service limits

The following service limits shall be specified by the Principal:

- service life (years) prior to replacement;
- number of operations per year.

This information is provided to enable the actuator Manufacturer to define maintenance requirements.

2.2 ACTUATOR/VALVE ASSEMBLY

2.2.1 Actuator torque

2.2.1.1 Actuator torque requirement

The torque requirements for the actuator at any point in the stroke shall be as specified in (3.2), (4.2) and (5.2), respectively. In selecting an actuator to meet the torque requirements, the Supplier should take all factors into consideration to ensure that the delivered actuator meets the required torque output but is not significantly over-specified. This is necessary to ensure that problems are not experienced with over-torquing of the valve stem, spool piece, bolts, etc. The factors which, when combined, may lead to significant over-torquing include:

- selection of an actuator from a standard range without allowing for valve torque;
- uncertainty about the specified valve torque;
- the Manufacturer's minimum torque tolerance factors;
- minimum and maximum supply pressures.

The actuator shall be capable of opening the valve with the maximum differential pressure across the valve equal to the maximum line pressure within the opening time specified, and of closing the valve from the open position with maximum line pressure in the valve within the closing time specified.

2.2.1.2 Maximum output torque

Calculations of the maximum output torque, from the actuator, which could shear the valve stem shall be based on:

- maximum air/hydraulic pressure (as achieved with the pressure relief valve fully open, i.e. 110% of relief valve set pressure);
- maximum spring force.

The maximum actuator torque shall not overstress any component of the actuator or valve.

2.2.2 Stroking time

The Principal shall specify the minimum and maximum times (in seconds) to fully open and close the valve. The Supplier shall quote maximum and minimum stroking times at the process conditions specified for the valve and the air/hydraulic supply pressure range and ambient condition range specified in (2.1.5.1) and (2.1.4.1), respectively.

2.2.3 Actuator-to-valve mounting

The actuator shall be mounted on the valve without overstressing the valve stem. Any requirement for additional supporting of the actuator other than that provided by the valve adapter shall be clearly identified in the quotation.

The arrangements for fitting the actuator to the valve shall be such that the operating torque is transmitted to the valve without any distortion, overstressing or slipping of the coupling, mountings or bolting.

The adapter shall be fully enclosed and fitted with pressure relief facilities to prevent over-pressure in the event of stem seal leakage. Arrangements shall be included to prevent leakage from the pneumatic/hydraulic cylinder over-pressurising the adjoining actuator body or spring housing.

The allowable stresses on the valve actuator flange, flange bolts and valve stem shall be

specified by the valve Manufacturer prior to selection of the actuator.

The Supplier shall specify whether any special equipment or arrangements are required for mounting the actuator. The Principal shall specify the required orientation of the actuator.

2.3 TESTING AND INSPECTION

2.3.1 Types of testing

The testing requirements for actuators are:

- **Production Tests:** The actuator Manufacturer's own standard tests;
- **Factory Acceptance Tests:** Testing and inspection tasks performed on specific components, materials and assemblies and at the Principal's request.
- **Statutory Tests:** Tests to satisfy statutory requirements i.e. pressure tests, lifting eyes, if applicable etc.

2.3.2 Test conduct

The Principal may specify whether repetition of all or part of the testing shall be performed if the specified criteria are not met. The Principal also has the right to include or exclude test results from the test report if there is reason to doubt the validity or accuracy of the test data.

2.3.3 Test equipment

All test equipment used to test the performance of the actuator shall be calibrated and used in accordance with ISO 10012-1. Test equipment shall be supplied by the Supplier.

2.3.4 Inspections

The actuator shall be assembled under clean conditions acceptable to the Principal. No loose materials, swarf or burrs shall be left in the actuator. Fluids used to fill the actuator shall be approved by the Principal for the specified operating temperatures and pressures. These fluids shall be free of water.

2.4 QA REQUIREMENTS

Actuator Manufacturers should be registered to ISO 9001 or equivalent standard acceptable to the Principal. All specified certificates shall be submitted to the Principal in a suitable agreed format and medium.

3. SPECIFIC REQUIREMENTS FOR GENERAL DUTY APPLICATIONS

The requirements of this section are additional to the requirements of Section 2.

3.1 ACTUATOR

3.1.1 Actuator mechanism

Spring-return and double-acting mechanisms may be used, as specified.

3.1.2 Limit switches

These shall be in accordance with the Requisition in the purchase order.

3.1.3 Materials

Aluminium, brass or copper may be used where suitable for the application and the location of the actuator. These materials shall only be used with the Principal's consent.

Pressure-retaining parts shall comply with DEP 31.22.10.32-Gen.

3.2 ACTUATOR/VALVE ASSEMBLY

3.2.1 Torque - spring-return actuators

The torque available from the actuator at any point in the stroke shall be a minimum of 1.5 times the valve torque required to operate a new valve for both the spring closing and externally powered opening strokes (or spring opening and externally powered closing strokes) including breakaway with the valve under maximum operating differential pressure, and breakout from open with the valve bore at the operating pressure and the valve cavity de-pressurised. Minimum air/hydraulic supply pressure should be used for these torque figures. For plug valves a minimum of 2.5 times the required valve torque shall be applied.

3.2.2 Torque - double-acting actuators

The torque output of the actuator, when operating in both the opening and closing directions, shall be at least 1.5 times the larger of the following:

- the torque required to operate a new valve, when in the open position, with the body cavity vented and the valve bore pressured to the maximum operating pressure of the pipeline;
- the torque required to operate a new valve, when in the closed position, against a differential pressure equal to the maximum operating pressure of the pipeline. Minimum air/hydraulic supply pressures shall be assumed for these torque figures.

3.3 ACTUATOR/VALVE TESTS AND INSPECTIONS

All general-duty actuators/valve assemblies shall be tested to ensure that they conform to their stated torque figures. This may be carried out directly using a constant-load torque device or indirectly by an appropriate alternative method (e.g. a known test load).

3.4 QA REQUIREMENTS

There are no special QA requirements for general-duty actuators.

4. SPECIFIC REQUIREMENTS FOR PROTECTIVE APPLICATIONS

The requirements of this section are additional to the requirements of Section 2.

This section defines the requirements of actuators used in applications which, in the event of malfunction, may result in harm, including ill health and injury, damage to property, products or the environment, production losses or increased liabilities.

Actuators used in protective applications should be selected from a Type Test approved range. For a typical Type Test Approval Procedure see Appendix A.

4.1 ACTUATOR

4.1.1 Actuator mechanism

The actuator shall be arranged so that if there is no control signal the valve will be driven to the safe (usually closed) position ("fail-safe"). This should be by spring-return action. Where spring-return actuators are not possible or practical, double-acting actuators shall drive the valve to the safe position using stored pressure in local accumulators. Double-acting actuators shall only be used with the Principal's consent or if specified by the Principal.

4.1.2 Actuator design

4.1.2.1 Springs

Coiled springs shall be manufactured and fitted in accordance with BS 1726. Spring Manufacturers shall be registered to ISO 9001 or equivalent standard acceptable to the Principal.

4.1.2.2 Limit stops

Limit stops shall be adjustable by at least ± 2.5° at both the 0° and 90° positions. Limit stops shall be easily field-adjustable without dismantling the actuator from the valve.

4.1.2.3 Limit switches

The actuator shall be fitted with at least two limit switches, one at each of the 0° and 90° positions.

4.1.2.4 Manual control facilities

Manual control facilities shall be provided as specified in the purchase order.

4.1.3 Materials

Aluminium shall not be used for any part of the actuator. Brass or copper alloys may only be used for internal parts not exposed to the environment.

4.1.4 Environmental

The spring housing shall be hermetically sealed to prevent ingress of air or moisture and should contain preservative.

Actuators shall conform to IEC 529, ingress protection level IP66 (includes preventing insertion of fingers, hands etc. into the actuator and ancillaries), or IP67 if they are liable to be drenched with water, or as otherwise specified in the purchase order.

Field-mounted ancillaries shall be weather-proof to at least IP56. Associated electrical equipment, including junction boxes and electrical enclosures, shall be to IP66.

4.2 ACTUATOR TORQUE

The torque available from the actuator at any point in the stroke shall be a minimum of 2 times the valve torque required to operate a new valve for both the spring closing and externally powered opening (or vice versa for fail-open applications) strokes and including

breakaway with the valve under maximum differential pressure and at maximum operating pressure. Minimum specified air/hydraulic supply pressure should be used for deriving these torque figures.

At the end of the closing stroke the actuator torque shall also be a minimum of 2 times the re-seat torque of the new valve. As this cannot normally be measured, the re-seat torque shall be taken as the valve breakaway torque required to open the valve, when in the closed position, against a differential pressure equal to the maximum operating pressure of the pipeline.

4.3 FACTORY ACCEPTANCE TESTS AND INSPECTIONS

4.3.1 Inspection of actuator welds, castings and steel parts

The Manufacturer shall perform all the necessary inspections to ensure correct and safe operation.

4.3.1.1 Inspections

The Supplier shall provide copies of all inspection certificates to the Principal.

Pressure-retaining castings, e.g. cylinders, shall be 100% radiographed in accordance with ASTM E 94 and the radiographs shall be judged against ASTM E 446. Defects in categories A, B or C shall not exceed a severity level of Class 2. There shall be no defects in categories D, E, F or G.

Radiography is not required on the actuator gearbox housing.

Pressure-containing welds shall be radiographed in accordance with ASME B31.3.

Ultrasonic examination shall be performed in accordance with ASTM A 609 on all pressure-retaining and torque-transmitting steel parts. The acceptance criterion shall be Quality Level 1.

Magnetic particle examination (in accordance with ASTM E 709) or liquid penetrant examination (in accordance with ASTM E 165) shall be performed on the following, and there shall be no relevant indications:

- sealing areas within the actuator body;
- the mounting boss of the actuator gearbox housing;
- pressure-retaining and torque-transmitting steel parts and welds.

4.3.1.2 Optional inspections

The Principal reserves the right to visually inspect the actuator to ensure that the general engineering and paint finish is satisfactory and that lubricants and corrosion protection have been applied correctly.

4.3.2 Production tests (actuator)

The Supplier shall perform the following production tests. The Principal has the right to witness any of these tests.

4.3.2.1 100-cycle test (Dynamic torque curve)

A 100-cycle test shall be conducted on each actuator. The load should follow the actuator's torque/position characteristic to 80% of static torque at the minimum specified hydraulic or air pressure. The pressure recorded during each opening stroke (or closing stroke for fail-open applications) of the actuator shall lie within 3% of the mean value at that point.

The actuator shall be tested on a suitable calibrated rig equipped with facilities to measure the torque delivered to the valve drive coupling. The torque measured will be the dynamic (running) torque and shall be measured continuously on a chart recorder giving an unbroken trace. The torque figures measured shall then be verified against the figures quoted by the Supplier in the quotation. This measurement shall be made at minimum air/hydraulic supply pressure for the valve opening stroke (or closing stroke for fail-open

applications). (Where an air-powered hydraulic system is included, measurements shall be taken at the minimum hydraulic supply pressure).

Each complete actuator shall be operated throughout its stroke to demonstrate correct action of local and, where applicable, remote control. This test shall also be used to confirm limit switch and position indicator operation and to ensure that the actuator operates smoothly without sticking at any point during the opening and closing stroke.

4.3.2.2 Pressure test

All pressure-containing components shall be tested to 1.5 times the maximum working pressure.

4.4 FACTORY ACCEPTANCE TESTS (ACTUATOR/VALVE)

The complete valve, actuator and control system shall be function-tested. Where an actuator is being supplied on its own, a simulated load should be used.

Function tests shall include:

a) Speed of opening with maximum and minimum supply pressure;

b) Speed of closing under spring load (or with max. and min. supply pressure for non-spring return actuators);

NOTES: 1. Tests a) and b) shall be carried out at the maximum process pressure and differential pressure specified for the valve. Operating pressures on the actuator shall be recorded as a guide to the torque being applied to the valve where applicable.

2. The conditions in a) and b) are reversed for fail-open assemblies.

c) Leakage tests on controls and actuator;

d) Stall test to demonstrate that with the valve jammed the maximum actuator output does not damage the stem and drive train.

NOTE: For double-acting actuators, the test shall be conducted with the valve stem held in a fixed position and maximum working pressure applied to the actuator in the position at which it generates maximum torque. For spring-return actuators the same test shall be conducted for the compression stroke. The spring-return stroke shall be tested by holding the valve stem in a fixed position (after applying maximum pressure to fully compress the spring) then evacuating the pressure cylinder to atmosphere.

e) Torque Test - break to fail-safe position

For valves which fail to the open position, the Torque-break-open test shall be conducted with the full differential pressure across the valve, while the supply pressure to the actuator is slowly decreased until the valve starts moving. Time shall be allowed for the pressure to stabilise. Subtracting the measured/calculated piston force from the given spring force gives the valve break to open torque.

For valves which fail to the closed position, the Torque-break-close test shall be conducted with the maximum operational pressure in the valve, while the supply pressure is decreased slowly until the valve starts moving. Time shall be allowed for the pressure to stabilise. Subtracting the thus measured/calculated piston force from the given spring force gives the valve break to closed torque.

NOTE: For fail-close actuators the break-open torque shall be measured at the minimum and maximum specified hydraulic/air pressure.

As part of the function testing the complete assembly shall be stroked ten times under simulated operating conditions. This shall be deemed to be the following:

The valve shall be operated from the closed to the open position four times. For fail-open applications the conditions are reversed.

The sequence for the first two cycles shall be:

1. Close valve fully.
2. Pressurise end A of valve to the maximum differential pressure specified in the purchase order data sheet.

3. Open valve fully.
4. Return pressure in the valve cavities to atmospheric pressure.

For the remaining two cycles the sequence shall be:

1. Close valve fully.
2. Pressurise end B of valve to the maximum operating differential pressure specified.
3. Open valve fully.
4. Return pressure in the valve cavities to atmospheric pressure.

In addition to this the valve shall be closed at least six times, simulating the emergency close action as detailed below.

The sequence for each cycle shall be:

1. Open valve fully.
2. Assembly pressurised to maximum operating working pressure specified.
3. Body cavity depressurised to atmospheric.
4. Valve operated closed by simulating ESD trip (using alternate solenoid valves).

For non-fail open/closed valve/actuators the complete assembly shall be tested as for fail-closed valve actuator assemblies but operated from the closed to the open position six times. During each of the above operations the valve torque shall be measured via the actuator. If an increasing torque trend is seen from these tests the Principal's representative shall have the right to continue the testing until the trend stabilises. The assembly shall be inspected after testing to check that there has been no movement or slippage between the actuator, spool piece, or valve.

4.5 QA REQUIREMENTS

4.5.1 General

A certificate of compliance (ISO 10474, type 2.1), stating that actuator is of the type qualified by the Type Tests, shall be issued by the actuator Manufacturer to the Principal. Traceability of pressure-retaining and torque-transmitting items (except springs) to source is not required.

4.5.2 Materials certification

Springs shall have ISO 10474, type 3.1.B inspection certificates.

5. SPECIFIC REQUIREMENTS FOR SPECIAL APPLICATIONS

The requirements of this section are additional to the requirements of Section 2 and Section 4.

5.1 RISER VALVE ACTUATORS

This section defines the specific requirements for actuators used in riser valve applications.

All actuators used in riser valve applications shall be selected from a range of approved Type Tested actuators.

The actuator shall be arranged such that if there is no control signal, the valve will be driven to the safe (closed) position ("fail-safe"). This should be by spring-return action. Where spring-return actuators are not possible or practical, double-acting actuators shall drive the valve to the safe position using stored pressure in local accumulators. Double-acting actuators shall only be used with the Principal's consent or if specified by the Principal.

5.1.1 Torque

The actuator torque shall be a minimum of 2.5 times the torque required to close the new valve from the open position with the valve bore at the maximum operating pressure and with the valve cavity at atmospheric pressure. This torque figure shall be produced at the minimum specified operating air/hydraulic supply pressure.

5.1.2 Limit switches

In addition to the requirements under (4.1.2.4), limit switches for riser valve actuators shall also be provided for the 10° or 80° position (as appropriate) for valve test purposes.

5.1.3 Pressure gauges

Pressure gauges shall be provided as specified in the purchase order. They shall be fitted to the control system to indicate all key pressures in the system. As a minimum these should be fitted to:

- incoming air supply;
- actuator control supply (hydraulic or pneumatic);
- all regulated pressures in the control system.

Pressure gauges shall have stainless steel internals and cases and shall be equipped with blow-out backs (safety pattern design). Gauges shall be mounted so that the blow-out section is not obstructed. Laminated glass shall be used.

5.1.4 Materials

PTFE-type coatings shall not be used for cylinder linings.

5.1.5 Factory tests and inspections

5.1.5.1 Inspections

All butt-welding zones shall be 100% magnetic particle or ultrasonically examined over a width of 50 mm on both sides before welding. There shall be no laminations or relevant indications.

Liquid penetrant examination shall be performed on springs and there shall be no relevant linear indications.

5.1.5.2 Spring force

The spring force of each individual spring shall be measured and recorded at the open and closed position. This shall be used for performance monitoring over the actuator's life, therefore each spring housing will require a unique serial number. This number shall be recorded on the test certificates.

5.1.5.3 Static torque curve

At the end of the 100-cycle test (specified in 4.3.2.1), a continuously measured static torque curve shall be produced for the actuated and return strokes. The measurements shall be made at the minimum specified air/hydraulic pressure for the actuated stroke, and the (spring) return stroke measured with the cylinder vented. The torque shall be measured and recorded every 10° of travel over the full 0° to 90° curve.

5.1.6 QA Requirements

The spring, pressure-retaining components and critical drive train components shall have ISO 10474 type 3.1.B inspection certificates. These requirements shall apply to the actuator only and not to the ancillaries.

For non-critical components, ISO 10474 type 2.1 Certificates of Compliance shall be issued by the Manufacturer, stating that the material supplied corresponds with the purchase order requirements and has been checked by random production tests on the material supplied or on similar material.

Pressure-retaining and torque-transmitting items shall be traceable to source.

5.2 SUBSEA ACTUATORS

This section defines the specific requirements for actuators used in subsea applications.

All actuators used in subsea applications shall be selected from a range of approved Type Tested actuators.

5.2.1 Actuator mechanism and operating medium

Spring-return actuators are preferred for all Protective Applications (such as SSIVs). Double-acting actuators should normally be used for non-SSIV applications (e.g. tie-in valves) and may be used for SSIVs with the approval of the Principal. Subsea actuators shall be hydraulically operated.

5.2.2 Actuator design

5.2.2.1 Limit stops

Contrary to the requirements under (2.1.6.1), subsea actuators shall preferably have fixed, not adjustable, limit stops. If adjustable stops are provided they should be designed such that adjustment can only be made by means of special tools.

5.2.2.2 Limit switches/Position transducers

In addition to the requirements under (2.1.6.1), limit switches of the proximity type shall be provided for the 0° and 90° positions. Also a position transducer shall be provided to indicate valve position between 0° and 90°, allowing the proper operation of the assembly to be demonstrated by partially closing the valve by 10° and then re-opening it. This arrangement may alternatively feature a limit switch at the 10° position.

5.2.2.3 Local position indicators

A continuous local indication of the valve position shall be provided as an integral part of the actuator.

The local position indicator shall be sufficiently large, painted with fluorescent paint and fitted with a removable cover (chained to the actuator body) to prevent marine growth. Also it should be possible to feel the position with gloved hands i.e. by touch.

5.2.2.4 Seals

Double seals shall be used for dynamic duties. Single seals may be used elsewhere.

5.2.3 Materials

The materials for the actuator body and spool piece shall be electrochemically compatible with the material of the valve body.

The exterior of the actuator and the spool piece shall be suitably protected by the Manufacturer's standard paint finish unless otherwise specified in the purchase order.

Monel should be used for tubing and fittings.

PTFE-type coatings shall not be used for cylinder linings.

5.2.4 Environmental

All actuator cavities shall be oil-filled and the pressure equalised with external sea pressure to prevent ingress of sea water into the actuator.

The Principal shall specify the following information:

- Water temperature;
- Water depth.

5.2.5 Torque

The torque available from the actuator at any point in the stroke shall be a minimum of 2.5 times the valve torque required to operate a new valve for both the spring closing and externally powered opening strokes (or vice versa for fail-open applications). This shall include the valve break-open torque from closed to open with a differential pressure equal to the maximum operating pressure, or the break-close torque from open to close with the valve bore at the maximum operating pressure and the valve cavity at atmospheric pressure, depending on the direction(s) of travel. Minimum specified hydraulic supply pressure should be used for deriving these torque figures.

The above actuator safety factors apply to resilient-seated valves. For metal-seated valves the actuator safety factor shall be at least twice the new valve torque, and shall be justified by data from the valve manufacturer.

For non-SSIV applications, and only where the actuator will not be in compression for a prolonged period without being operated (e.g. short-term tie-in valves), the actuator safety factor shall be a minimum of 2 times the new valve torque.

5.2.6 Actuator-to-valve mounting

Splines on the shaft are the preferred method of drive transmission. A master spline shall be in line with the pipeline when the valve is in the open position. Only one position of the actuator on the valve shall be possible. If the actuator is asymmetric about the valve stem, the long axis of the actuator shall be aligned with the pipeline axis.

It shall be possible to remove and re-install the actuator from and back onto the valve, in location, even if the actuator or valve has failed at any position in its stroke. The actuator shall be designed to allow it to be retrieved by a ROV.

The actuator shall be designed so that it can only be fitted onto the valve/adapter in the correct alignment. It shall be possible to fit the actuator onto the valve/adapter at an inclined angle up to 5° from the vertical. A self-aligning mechanism is preferred to the use of alignment templates or measuring tools.

5.2.6.1 Spool pieces

The Principal shall specify the minimum requirements for the spool piece connecting the actuator to the valve. This includes the specification of features such as flushing facilities, alignment facilities, limit switches, etc. It should be noted that complex spool pieces with a variety of features account for much of the cost of a subsea actuator. Where the installation has a short lifetime a standard simple spool piece is recommended.

If specified by the Principal, the spool piece shall be designed to allow an actuator to be interchangeable between a group of valves.

If specified by the Principal, a cover plate shall be supplied to replace the actuator.

5.2.7 Hydraulic fluid supply

The actuator shall conform to the following requirements:

- Hydraulic fluid cleanliness shall be to AIA/NAS 1638 Class 6.
- Water-based or oil-based hydraulic fluid as specified by the Principal.

5.2.8 Cable entry and connection

Cable entry type and methods for electrical and hydraulic connections shall be agreed with the Principal.

5.2.9 Factory acceptance tests and inspections

5.2.9.1 Inspections

All butt-welding zones shall be 100% magnetic particle or ultrasonically examined over a width of 50 mm on both sides before welding. There shall be no laminations or relevant linear indications.

5.2.9.2 Cycle tests

These shall be in accordance with the cycle test requirements specified in (4.3.2.1.)

5.2.9.3 Static torque curve

This shall be in accordance with the static torque curve requirements specified in (5.1.5.3).

5.2.9.4 Pressure test

This shall be in accordance with the pressure tests for the pressure-containing components specified in (4.3.2.2).

The actuator shall be tested in a hyperbaric chamber if the external pressure exceeds that qualified during Type Testing.

5.2.9.5 Actuator mounting

It shall be demonstrated that the subsea actuator:

- can be fitted to the valve/adapter inclined from the vertical at the angle specified;
- can be fitted with the actuator in any position in its stroke and that the correct alignment with the valve is guaranteed.

5.2.9.6 Actuator/valve assembly tests and inspections

These shall be in accordance with the actuator/valve assembly test and inspection requirements for Protective Applications actuator/valve assemblies (see 4.4).

5.2.9.7 Pressure compensation system

Where pressure compensation systems (e.g. bladders) are fitted, it shall be demonstrated by the Supplier that air has been satisfactorily bled from the system and the bladders are correctly primed.

5.2.10 QA requirements

5.2.10.1 General

QA requirements shall be in accordance with the general QA requirements for Protective Applications (see 4.5).

5.2.10.2 Materials certification

For non-SSIV actuators the springs, pressure-retaining components and the critical drive train components shall be supplied with ISO 10474 type 3.1. B inspection certificates. For SSIV actuators the spring shall have ISO 10474 type 3.1. C inspection certificates. These

requirements shall apply to the actuator only and not to the ancillaries.

For non-critical components, Certificates of Compliance (ISO 10474 type 2.1) shall be issued by the Manufacturer and signed by a person responsible for quality, stating that the material supplied corresponds with the purchase order requirements and has been checked by random production tests on the material supplied or on similar material.

5.3 TRUNK LINE APPLICATIONS

This section defines the specific requirements for actuators used in trunk line valve applications.

Trunk line applications (Beach valves, etc.) shall conform to the same requirements as riser applications specified in section 5.1 above.

5.4 CLASS 'X' APPLICATIONS

This section defines the specific requirements for actuators used in Class ‘X’ (formerly HIPPS) applications.

All actuators used in such applications shall be selected from a range of approved Type Tested actuators.

5.5 FIREPROOFING

The Principal shall specify whether fireproofing is required.

The Principal shall specify the following requirements for fireproofing:

- Flame temperature;
- Maximum valve body temperature;
- Burn duration (the actuator shall be able to perform 3 cycles at the end of the burn period).

The Supplier shall verify that the proposed actuator will meet the specified figures.

The Principal shall specify the maximum blast pressure and forces which may occur. The Supplier shall confirm that the proposed actuator will meet the specified figures.

5.5.1 Materials

PTFE shall not be used.

5.6 PIGGING OPERATION

A positioning accuracy of ± 0.25° of the ball in the open position and ± 0.5° in the closed position is required for valve/actuator assemblies in lines which are liable to be pigged.

5.7 MAJOR EMERGENCY SHUTDOWN (ESD) APPLICATIONS

Applications which require more rigorous standards than those detailed in Section 4 should meet the standards set for riser applications specified in section 5.1 above. These applications include major ESD valves.

6. PROCUREMENT - SUPPORTING INFORMATION

6.1 DOCUMENTATION REQUIREMENTS

The following information should be included in the documentation supplied:

- lubrication;
- recommendations for replacement of seals;
- production test torque measurements (general-duty applications);
- continuously measured torque curve (protective and subsea applications);
- variation in torque output for min. max. pneumatic or hydraulic pressure (Protective Applications);
- certified design drawings;
- assembly and disassembly procedures.

6.2 SPECIAL REQUIREMENTS

Special requirements, such as fireproofing or earthing of bearings against static build-up, shall be specified by the Principal.

6.3 PRESERVATION, HANDLING AND PACKAGING

The actuator shall be protected and packed in such a way as to prevent damage during storage and transport.

6.4 MARKING

The actuator shall have a permanently attached name plate, on which the following details are to be shown:

a) Supplier's/Manufacturer's name or trademark;
b) Supplier's/Manufacturer's serial number;
c) Model or type;
d) Actuator action;
e) Maximum working pressure;
f) Maximum torque output;
g) Type of hydraulic fluid/lubricant;
h) Tag number.

The information in a), b), c) and d) shall also be marked prominently on the actuator body by either using low-stress stamps or by having the marks cast into the actuator body.

7. TYPE APPROVAL

Subsea, Riser, Trunkline, and Class ‘X’ (formerly HIPPS) actuators offered for supply shall hold Type Test approval as defined in (Appendix A). Actuators used in general applications may also require Type Test approval at the Principal's request. Type Tests shall be witnessed by the Principal if specified.

Type Test approval is only required **once** to pre-qualify an actuator type. Re-qualification may be required if significant design changes or extensions to the range have taken place.

Type Test approval for subsea shutdown applications will require Type Testing to satisfy both the requirements of subsea and shutdown.

8. REFERENCES

In this DEP reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Electroless nickel plating (amendments/supplements to ASTM B 733)	DEP 30.48.41.31-Gen.
Pressure vessels (amendments/supplements to BS 5500)	DEP 31.22.10.32-Gen.
Hydraulic systems for operation of valves	DEP 31.36.10.30-Gen.
Area classification (amendments/supplements to IP15)	DEP 80.00.10.10-Gen.
Class 'X'; Instrumented Protective Functions	EP Report 97-1745

AMERICAN STANDARDS

Cleanliness Requirements of Parts Used in Hydraulic Systems	AIA/NAS 1638

Issued by:
Aerospace Industries Association of America Inc. (AIA/NAS)
1250 Eye Street NW
Suite 1100
Washington, DC 2005
USA.

Chemical plant and petroleum refinery piping	ASME B31.3

Issued by:
American Society of Mechanical Engineers
345 East 47th Street
New York NY 10017
USA.

Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service	ASTM A 193
Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service	ASTM A 194
Specification for Longitudinal-Beam Ultrasonic Inspection for Carbon and Low-alloy Steel Castings	ASTM A 609
Standard guide for Radiographic Testing	ASTM E 94
Standard test method for liquid penetrant examination	ASTM E 165
Reference Radiographs for Steel Castings up to 2in. (51mm) in Thickness	ASTM E 446
Standard guide for magnetic particle examination	ASTM E 709

Issued by:
American Society for Testing and Materials
1916 Race Street
Philadelphia 19103
USA.

BRITISH STANDARDS

Coil Springs	BS 1726

Issued by:

British Standards Institution
389 Chiswick High Road
London W4 4AL
United Kingdom.

GERMAN STANDARDS

DC Interface for Distance Sensor and Signal Converter	DIN 19234
Industrial process control valves; interfaces between valves, actuators and auxiliary equipment	VDI/VDE 3845

Issued by:
Beuth Verlag GmbH
Burggrafenstraße 6
Postfach 11 07
D-1000 Berlin 30
Germany.

INTERNATIONAL STANDARDS

Degrees of protection provided by enclosures (IP codes)	IEC 529
Electrical installations in explosive gas atmospheres	IEC 79-14

Issued by:
Central Office of the IEC
3, Rue de Varembé
CH-1211 Geneva 20
Switzerland.

Copies may also be obtained through national standards organizations

Quality systems - Model for quality assurance in design, development, production, installation and servicing	ISO 9001
Quality assurance requirements for measuring equipment; part 1: metrological confirmation system for measuring equipment	ISO 10012-1
Steel and steel products; inspection documents	ISO 10474

Issued by:
International Organisation for Standardisation
1, Rue de Varembé
CH-1211 Geneva 20
Switzerland.

Copies may also be obtained through national standards organizations.

APPENDIX A EXAMPLE OF TYPE TESTS APPROVAL PROCEDURE

A.1 INTRODUCTION

The purpose of the tests is to prove the durability and suitability of the design, materials and manufacture of the actuator.

The actuator Manufacturer shall select an actuator from a range for Type Testing. It shall be representative of the actuators in the range and shall be above the middle size of the range. Actuators selected for Type approval should be those that provide flexibility in mounting and installation (the actuator shall be capable of being fitted to a valve in any attitude without excessive stress on the valve stem and shall be capable of being provided with lifting points to enable it to be manoeuvred in any orientation).

Type Approval may extend to actuators in the same range if they conform to the following:

- actuators must be of the same design;
- different sizes are scaled equivalents of the tested device;
- no material or component differences are permitted;

When seeking Type Approval from the Principal, the Manufacturer shall submit:

- test records that demonstrate that the tests below have been successfully passed;
- evidence of independent witnessing of the tests;
- a certificate of independent design review;
- evidence of the spring fatigue life.

A.2 TYPE APPROVAL TESTS FOR SPRING-RETURN AND DOUBLE-ACTING ACTUATORS

All actuators to be tested shall be subjected to a visual inspection. Any markings on the actuator body or on a plate attached to the body giving information such as model, operating pressure etc. shall be noted.

The following tests shall be carried out at ambient temperature except where otherwise specified, using the operating medium intended for the service. The tests shall be performed in the order specified.

A.2.1 Initial tests and inspections

A.2.1.1 Spring Inspections

Prior to installation in the spring can, visually inspect the spring for uniformity of pitch, coil diameter, straightness, free length, coil ends.

Inspect the total surface of the spring by dye-penetrant examination.

Measure the spring load at the operational working lengths in the open and closed position. Compress the spring to the solid length (scragging) for 10 operations. Sufficient time should be allowed after operations to allow the spring to cool down. Repeat the measurements of spring load. The spring load measurement shall not change by more than 7%.

A.2.1.2. Assembled spring pack cartridge (for spring-return actuators only)

With the springs assembled in the spring can, repeat the spring load measurement at the operational working lengths in the open and closed position. The spring load measurement shall not change by more than 7%

A.2.1.3 Functional test (for spring-return actuators: with spring cartridge assembled to actuator)

A functional test is required to verify that the actuator is operating smoothly with no evidence of stick-slip or mechanical restraint. The actuator is to be mounted in a position to permit measurements at the following locations:

- axial deflections at the output shaft and indicator position when full operating pressure is applied;
- radial clearance/concentricity at the output shaft when full operating pressure is applied;
- rotational creep at both end stops when full operating pressure is applied.

Check that the local indicator moves with the actuator and that its orientation conforms to the design philosophy.

Check that the output of the actuator is within ± 0.25° at both the 0° and 90° positions. Record the actual positions and angle of rotation.

A.2.2 Cylinder pressure tests

A.2.2.1 Cylinder leakage tests

Connect the opening port to the pressuring system and ensure that the system is bled. Increase the pressure to 1.5 times the maximum operating pressure recommended by the Supplier. The entire cylinder (both sides of piston*)* shall be pressurised. Block the opening port and remove the supply pressure for a minimum of 6 hours for spring-return actuators and for a minimum of 2 hours for double-acting actuators. The cylinder pressure shall be recorded during the test and the actuator inspected for signs of leakage, either internal or external.

For double-acting actuators release the pressure and repeat the test with the closing port connected to the pressuring system.

A.2.2.2 Piston leakage tests

A pressure of 1.1 times the maximum specified operational pressure shall be applied to one side of the cylinder with the other side at atmospheric pressure. Close the opening port and remove the supply pressure for a minimum of 6 hours. The cylinder pressure shall be recorded during the test and the actuator shall be inspected for signs of leakage.

The test shall be repeated with the pressure applied to the other side of the actuator.

A.2.3 Main casing pressure test

Remove any relief valves, pressure compensating valves or similar fittings and replace with blanks. Connect the pressurising system and ensure that the system is bled. Increase the pressure to 1.5 times the maximum operating pressure or 1.5 times the relief valve setting (depending on casing design). Block the opening port and remove the supply pressure for a minimum of 6 hours for spring-return actuators and for a minimum of 1 hour for double-acting actuators. The casing pressure shall be recorded during the test and the actuator inspected for signs of leakage as before.

The pressure shall be released and the test repeated for all separate chambers within the main casing. If a valve spool piece is provided as standard by the actuator Supplier that could be subjected to pressure because of actuator or valve leakage, then the spool piece shall be considered a pressure-containing part and tested accordingly.

A.2.4 Initial performance test

At ambient temperature, continuously measure and record the variation in static torque of the actuator in both directions over the full curve. The torque shall be measured directly on the output shaft. The testing shall be carried out at 100% of the Manufacturer's indicated maximum operating pressure and at the minimum operating pressure.

A.2.5 Operational test under load

Operate the actuator for 6000 cycles at maximum allowable pressure and at a resistance torque of 90-95% of the static torque. The load shall be representative of a typical actuator torque/position curve. The temperatures shall be as follows:

- 3000 cycles at minus 20 °C;
- 3000 cycles at plus 55 °C.

For spring-return actuators only: One cycle sequence as follows (assuming spring-return to close):

(a)	operation closed to open	at 90-95% of static torque;
(b)	delay	2 minute delay in the spring-compressed position;

(c) operation open to closed spring-return action.

A.2.6 Performance test after operational test

Repeat the performance test in (A.3.4) at 100% operating pressure only and at approximately the same temperature used in the original test.

A.2.7 Compressed spring test (for spring-return actuators only)

Operate the actuator for one cycle leaving the actuator in the position that compresses the spring. Leave the actuator with the spring in the compressed position for 2 weeks. (Do not operate the actuator during this time.)

Measure the static torque over the full torque curve. In addition, by gradually lowering the applied pressure, measure the minimum pressure to hold the actuator in the 'spring compressed' state. (In this context 'hold' implies less than 5 degrees movement).

A.2.8 Performance test after compressed spring test (for spring-return actuators only)

Repeat the performance test in (A.3.4) at 100% operating pressure only and at approximately the same temperature used in the original test.

A.2.9 Repeat pressure tests

Repeat the pressure tests in (A.3.2) and (A.3.3).

A.2.10 Repeat initial tests

Repeat the test and measurements of (A.3.1.3).

A.2.11 Post-test inspection and assessment

A.2.13.1 Torque

The output of the actuator measured during the initial and repeated performance tests shall not differ by more than 5%.

A.2.13.2 Rotational stroke

The rotational stroke, as measured on the output shaft shall not differ by more than 0.5% from the pre-test setting in (A.3.1.3) to the post-test measurement in (A.3.10).

A.2.13.3 Leakage

During the tests, no external leakage past any seal shall be allowed. Where leak paths cannot be inspected visually, there shall be no fluid displacement from an adjacent chamber or pressure drop in the chamber under test.

A.2.13.4 Strip-down inspection

On completion of the testing the actuator, including the spring cartridge, shall be stripped down. All parts shall be inspected and the following assessed: (the items marked with an asterisk* apply to spring-return actuators only):

- *the disassembly procedure for the spring cartridge shall be reviewed for safety aspects;
- limit stops shall be inspected to ensure that they have not deformed or moved and that they are still adjustable;
- *no rubbing, scraping or buckling of the spring has occurred;
- no cracking, lifting, scoring or other damage on the cylinder bore is evident;
- critical component tolerances shall still be within Manufacturer's production tolerances;
- no leakage past any seals shall be evident;
- the condition of oil and lubricants shall be examined for contamination and deterioration;

- *visually examine the spring for uniformity of the coil pitch, and inspect the total surface of the spring by dye-penetrant examination.

For acceptance testing criteria after strip-down see (Appendix B).

A.2.13.5 Spring load (for spring-return actuators only)

The spring load measurements in (A.3.1.2) shall not change by more than 7% (scragging is not required).

A.3 ADDITIONAL TYPE APPROVAL TESTS FOR SUBSEA ACTUATORS

In addition to the testing detailed above, the following tests shall be conducted for subsea actuators. Where proof is required this may be either by inspection/examination or by physical tests.

A.3.1 Fitting and alignment

A.3.1.1 Removal after failure

It shall be demonstrated that the actuator can be removed from the valve when it is in any position of its stroke (simulating failure in mid-travel), either by inspection or operational tests as appropriate.

A.3.1.2 Fitting and alignment

It shall be demonstrated that the actuator can only be fitted to a valve/adapter in the correct alignment. The actuator may be placed to any position in its stroke.

It shall be demonstrated that the actuator may be fitted to a valve stem inclined at an angle up to 5° from the vertical.

If alignment tools are required it shall be demonstrated that these may be used with heavily gloved hands similar to those used subsea. The effects of poor visibility shall be considered when using these tools. The Supplier shall provide verification from a diving company that the alignment tools are suitable.

A.3.1.3 Diver operations

All operations that would be required of a diver or ROV, such as spool piece flushing, drive disengagement and position indicator checking, shall be demonstrated as being feasible. The constraints of heavily gloved hands and poor visibility shall be considered.

A.3.2 Pressure and cycle testing

A.3.2.1 Operational test under load

For subsea actuators, Type Testing will be carried out in accordance with sections A.1, A.2, and A.3. The operational test of (A.3.5) shall consist of a 3000-cycle test at 5 °C and not the 6000-cycle test specified. The resistance torque shall be 90-95% of the static torque (at the maximum supply pressure).

A strip-down inspection in accordance with (A.3.13.4) shall be conducted. The actuator shall be reassembled without any refurbishment (unless specified by the Principal) for hyperbaric testing.

A.3.2.2 Pressure testing (hyperbaric)

The actuator (and adapter if appropriate) shall be placed in a hyperbaric chamber and subjected to a pressure of 25 bar at plus 5 °C for 1 hour.

The functionality of any pressure compensation systems shall be demonstrated.

A.3.2.3 Pressure/cycle testing (hyperbaric)

Following the pressure testing, with the actuator still in the hyperbaric chamber at pressure,

the actuator shall be stroked through 500 cycles under full load. The temperature shall be maintained at 5 °C for the first 10, and the final 10, strokes. The static torque shall be measured (at the same point in the stroke) every 50 cycles and recorded. The variation in these figures shall be no more than 5%.

The position indicator shall be viewed to ensure correct operation at the start of the tests.

Following the cycle tests the following shall be tested:

- spool piece flushing;
- drive disengagement.

The actuator and ancillaries shall be stripped and inspected to ensure no further deterioration or leakage has occurred since the first inspection. Inspection and acceptance criteria are specified in (Appendix B).

APPENDIX B INSPECTION AFTER CYCLE TESTING

B.1 GENERAL

This appendix specifies the inspection tasks to be performed on an actuator following cycle testing. The actuator shall be disassembled to permit the inspections to be performed.

The inspection shall include all parts which could affect the performance of the actuator or could lead to its catastrophic failure.

Inspection techniques shall include visual inspections (with photographic evidence), dimensional checks, and the appropriate non-destructive examination methods for detecting cracks. Dimensional checks shall be made on pressure retaining parts, torque transmitting parts, moving parts, and parts subject to plastic deformation.

The inspection shall be done after the 6000-cycle test specified in Appendix A. For subsea actuators the inspection shall be after 3000 cycles and again after the 500-cycle hyperbaric test. No components may be replaced between these two tests. The results from the 500-cycle test shall be compared with the results of the 3000-cycle test to determine the effects of the hyperbaric testing.

B.1 INSPECTION TASKS

B.1.1 Seals

B.1.1.1 Hydraulic seals

These shall be inspected to ensure that none of the following failures has occurred:

- Leak paths between the piston and the cylinder;
- Dynamic seal deformation, permanent distortion/extrusion or damage;
- Excessive wear or scoring of the cylinder or rod surfaces (i.e. damage which may eventually cause a hydraulic leak).

B.1.1.2 Casing seals

These shall be inspected to ensure that none of the following failures has occurred:

- External leak paths into the unit;
- Leak paths from one pressure-containing part to another (e.g. for subsea, from the main mechanism housing to the spool connection to the valve);
- Seal deformation, signs of extrusion, or damage.

B.2 LOAD-BEARING COMPONENTS

B.2.1 General components

All load-bearing components shall be inspected for any signs of unexpected plastic deformation by comparing results with the original dimensions. Bedding-in marks are acceptable. Excessive measurable plastic deformation or excessive wear is not permitted.

B.2.2 Torque mechanism

The torque mechanism (i.e. Scotch Yoke, etc.) shall be inspected for cracking, scoring or indentations caused by wear or plastic deformation. None of these are permitted.

Some general wear after the cycle test may be permitted. Although a dimensional survey may not be meaningful in all cases such a survey may highlight excessive wear. However, an accurate check on the fully open and closed position of the drive shaft together with torque measurements should be used to demonstrate that any wear on the Scotch Yoke mechanism is still acceptable.