



RP 62-2

ISOLATION VALVE SELECTION PHILOSOPHY FOR OIL AND GAS PRODUCTION AND PROCESSING

September 1996

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BP GROUP RECOMMENDED PRACTICES AND SPECIFICATIONS FOR ENGINEERING			
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ISOLATION VALVE SELECTION PHILOSOPHY FOR OIL AND GAS PRODUCTION AND PROCESSING			
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This Recommended Practice gives technical guidance for the selection of valves for land based and offshore oil and gas processing facilities. The main purpose of this document is to provide guidance to all new projects and operating assets to help them minimize whole life cost whilst maintaining a consistent approach to valve selection which acknowledges company experience.			
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FOREWORD

Introduction to BP Group Recommended Practice 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 provides flexible valve type recommendations for the principal areas of oil and gas processing facilities adherence to which should ensure that whole life cost is minimised. The Recommended Practice also provides a benchmark against which alternative proposals can be assessed.

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.

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 Engineering Practices Group, BP Engineering or the Custodian. See Quarterly Status List for contacts.



1. INTRODUCTION

Valve selection has a major effect on the whole life cost of an asset. The need to replace malfunctioning equipment can soon wipe out CAPEX savings made by inappropriate selection.

In the past, BP Exploration has lacked a means of ensuring that valve selections being made by engineers working on new developments or asset refurbishment projects followed a consistent pattern which accorded with the knowledge gained by the company from operating and test experience. This document is intended to address that deficiency.

The philosophy is commercially sustainable (i.e. there are sufficient qualified suppliers of each recommended valve type to ensure competitive tendering or alternative sourcing - not always the case in the past) and, where possible, alternatives are proposed which may offer CAPEX or weight savings without unduly compromising operating life. In some cases more expensive alternatives are listed which may be found useful in especially onerous conditions.

In addition to providing general valve selection recommendations in Section 8, particular applications and valve types (e.g. riser emergency shut down valves, equipment isolation etc.) are addressed separately in Section 11. Important related issues are dealt with in Section 12.

It is recognised that there will be unique conditions relating to certain projects which have to be addressed; the aim of this Recommended Practice is to provide a benchmark with which alternative proposals can be compared and against which they should be justified.

This document is complimentary to BP Group [RP 62-1](#) "Guide to Valve Selection" which contains sufficient information for appropriate valve selections to be made but covers a much wider field than oil and gas production. The high textual content of this document may, perhaps, have discouraged busy project engineers from using it (but it should be noted that the computerised version (hypertext) can produce valve selections very quickly).

BP Group [RP 30-3](#) should be consulted by all those concerned with selecting or specifying actuated shut-down valves and this document also provides recommendations covering control valves

2. APPLICATION

This Recommended Practice is intended to be used by all new BP Exploration development projects (and significant asset modification/refurbishment projects) as the basis for a project specific valve selection philosophy. It has been written with a view to minimising whole life costs (on which valves can have a major impact) and accords with BP operating and test experience.



3. UNITS

Units are SI metric except for nominal pipe size (NPS) which is stated with the DN equivalent. Pressure units stated in bar refer to gauge pressures.

4. ASSUMPTIONS

The assumptions made regarding operating conditions are clearly stated and cover the most general case. Trim materials and, in some cases, valve types will have to be altered where particular conditions require this.

5. MATERIALS

This BP Group Recommended Practice is primarily concerned with functionality and makes the assumption that valve pressure boundary materials will be selected to be compatible with the connected pipe, the working fluid and the operating conditions. Except as included in Section 12.1, specific material recommendations are not made.

BP Group [RP 62-1](#) includes information on most commonly encountered valve materials.

6. CONSTRUCTION/ COMMISSIONING CONDITIONS

Conditions during construction, line flushing and plant start-up are frequently the most severe that a valve will see. Even where the normal operating conditions are clean, soft seated valves can suffer permanent damage unless appropriate steps are taken to protect them.

Selection of valves suitable for dirty service is the best course. Where this is not possible consideration should be given to installing critical valves after flushing is completed, although relative costs will have to be carefully evaluated. In the case of soft seated ball valves of moderate to large size, protection by means of sealant application has been shown to be effective and may offer the most economic alternative.

BP Sunbury Branch [report 124 240](#) deals with this topic and is available from the custodian of this Recommended Practice.

7. ASSUMED CONDITIONS FOR OIL/ GAS PROCESSING

For each zone of the system representing common operating conditions the assumed fluid condition (clean, dirty, wet etc.), along with the assumed typical maximum pressure and temperature are listed in Table 1. Where conditions are known to differ from the assumed case, appropriate adjustments should be made. In most cases the assumption is conservative, but not always (eg. fuel gas 'dry'). The recommendations are largely unaffected by the form of the produced fluid (oil, gas, multiphase) although



this will have to be taken into account (isolation and low temperature potential of gas, corrosivity of produced water etc.) when making a final selection.

8. RECOMMENDED VALVE SELECTIONS

Table 2 provides a list of recommended isolation/block valve selections against each zone of the system representing common operating conditions.

Table 3 provides similar recommendations for check valves.

Possible alternatives (which, in some cases, may offer CAPEX savings) are listed.

Most of the alternatives listed offer equivalent (or better) performance than the prime recommendation. It should be recognised, however, that some risk of reduced operating life (compared to the main recommendations) may be attached to a minority of these. Efforts to establish the suitability of these valve types from several suppliers are ongoing (via the NEL Valve User Test Consortium or, in some cases, field trials) but, until suitability is proven, caution is necessary. In case of doubt consult the custodian of this RP.

It is not intended that these tables be issued to subcontractors, vendors etc. unless accompanied by guidance from the project/ design contractor as to which alternatives are acceptable in the particular circumstances. If this advice is ignored, the cheapest alternative is likely to be selected regardless of any other considerations.

BP Group [RP 62-1](#) provides detailed information on the merits/limitations of the different valve types.

9. MAINTENANCE CONSIDERATIONS

The maintenance strategy being adopted for valves on the facility can affect both the ultimate choice of valve type and the spares requirements so it is important to establish this early in the selection process.

If it is intended that work will be carried out in situ, welded pipe connections become possible but valve internals will need to be capable of being accessed and removed via the bonnet etc. This facility is automatically provided in the case of gate valves, globe valves, swing check valves, plug valves and top entry ball valves. However, the ease with which internals can be withdrawn should be carefully investigated and it may be necessary to provide lifting/handling facilities in the case of large valves. It should be noted that in situ maintenance cannot be conducted on butterfly or wafer check valves.

Where the intention is to remove all valves to a workshop for maintenance maximum flexibility of valve selection is possible. Spares holding may be increased, however, because of the necessity to provide complete replacement valves.



10. ISOLATION REQUIREMENTS

Where double block and bleed isolation is required by the isolation philosophy this can be achieved in three ways:

- (1) Two single seated valves in series with a bleed from the connecting pipe. (Acceptable for all applications.)
- (2) A single valve having two independent seats sealing in the same direction and a connection into the cavity between the seats. (Cost savings may be realised by using a valve of this type compared to (1) above)

The most suitable valve types are those where the seat load is applied mechanically to both upstream and downstream seats simultaneously (e.g. expanding gate, wedge plug, expanding plug) i.e. they do not rely on line pressure to provide the seating force. Certain types of wedge gate valve (e.g. split wedge) may also be considered but sealing will not normally be as effective.

Valves which rely on the fluid pressure to provide a seal on both seats simultaneously (e.g. most slab type (through conduit) gate valves with floating gate) would be the second choice for this duty and are acceptable where sealing against very low pressure is not required.

Trunnion mounted ball valves having double sealing piston effect seats would be the third choice. They should ideally only be used where it is impossible to accommodate other alternatives since the second (downstream) seat will usually be effective only when the cavity has been pressurised. The design relies on the difference in annular area between outer and inner seat to body seals and the seat to ball seal which is located diametrically between them. This limits the freedom available to the designer and care must be taken to ensure that the normal seating function (particularly of metal seated ball valves) is not compromised. A solution to the latter problem is to make only the downstream (in the isolation direction) seat a double piston design but this then makes the valves directional.

In all such arrangements ensure that the vent (bleed) valve and pipework is of sufficient size to carry away leakage past the upstream valve or seat (especially in gas service). This connection should also be provided with a double block and bleed valve arrangement where access may be required in service (e.g. for hot oil flushing of leaking valves).

- (3) An integral manifold incorporating two isolating valves and a bleed valve.

Integral valve manifolds are ideally suited to isolation of static branches (e.g. instruments) in small sizes. For use in flowing systems or where wax, hydrates etc. are anticipated, manifolds should be full bore type. Refer to [EEMUA Publication 182](#) which incorporates a specification and set of application guidelines for these items.

For larger line sizes there are manufacturers who offer manifolded arrangements of two ball, plug or butterfly valves, in some cases with an overall length not exceeding that of a standard valve. It should be noted that these are usually of drastically reduced bore compared to the pipe. The potential effects of high velocity flow and increased pressure drop should be carefully considered where their use is contemplated.

BP Group [RP 44-10](#) gives guidance on isolation requirements for various operating conditions.



11. NOTES ON SPECIFIC VALVE TYPES AND APPLICATIONS

11.1 Main ESD Valves

ESDVs which isolate the process system from risers or pipelines are usually ball or gate valves fitted with a fail closed actuator. In theory they can be soft seated but if sand is likely, or the valves have to pass pigs, hard metal seated valves are more appropriate. Import risers and pipelines should always be fitted with metal seated valves unless the product is known to be thoroughly clean. A high degree of seat leak tightness is not generally required and, although the "as constructed" leak rate of metal seated valves will usually be worse than that of soft seated valves it is likely to be maintained without significant deterioration in adverse conditions. If soft seated valves can be justified, some sort of seat protection should be provided during installation/commissioning.

See BP Sunbury Branch [Report 124-240](#), available from the custodian of this BP Group Recommended Practice.

Ball valves having double sealing piston type seats are sometimes used to provide two seals in series. For ESD service it is recommended that only the inboard (process plant) side seat should have this facility. This gives some additional security without degrading the performance of the main (outboard) seat. Double sealing capability on both seats also means the valve cavity may have to be fitted with a separate relief valve since overpressure relief is no longer available via the seats. In such cases the relief valve should be provided with double block and bleed isolation onto the valve body to permit inspection/maintenance. When defining test requirements for these relief valves it should be noted that valve lift at pressures up to 133% of ESD valve rated pressure is normally acceptable.

If drain and vent connections are provided on these and other important valves (e.g. pig trap isolators) it is worth fitting them with a double block and bleed valve arrangement since this will permit the valve cavity to be accessed with the system live should the need arise (e.g. for hot oil flushing to get a jammed seat to move).

The actuator and associated control system has a major influence on the performance of ESD valves and should be chosen with care. BP Group [GS 130-6](#) and [GS 134-1](#) provide guidance.

11.2 Pig launcher/Receiver Isolation

Valves isolating receivers (and launchers which may be reverse pigged) have to be able to withstand debris being pushed through whilst giving tight shut-off. Soft seated ball valves have consistently demonstrated their inability to cope with this service. Through conduit slab gate



valves are the most appropriate choice and floating gate versions have the advantage that they offer two isolations per valve (upstream and downstream seat simultaneously) and can be provided with a cavity bleed/vent valve. Expanding type gate valves which offer a positive isolation regardless of line pressure combined with double block and bleed in a single valve might be an even better choice (especially on gas service) provided the actuator requirements are properly addressed. ENP coated gates will usually be adequate in the case of launcher valves.

Tungsten carbide coated ball valves will cope with the service but, under certain operating conditions, can suffer from excessive leakage when two are provided in series, due to the fact that the second valve may not see a sufficient differential pressure to seat it.

Kicker valves and vent valves are used in throttling mode against a differential pressure and should be capable of withstanding the resultant high velocities (eg. on gas service) as well as providing tight shut-off. Again, soft seated ball valves are not ideally suited and alternatives such as balanced plug valves and (depending on pressure) triple offset butterfly valves should be considered. Globe valves may be appropriate for gas vent duty.

Receiver drain valves have to cope with highly abrasive service. Quarter turn valves having a high degree of resistance such as tungsten carbide coated balls, stellite coated balanced plugs etc. are the most suitable choice.

At least one valve manufacturer offers a modified ball valve having a side entry point which allows the insertion and removal of pigs. Whilst this may offer some operational facility there is only a single isolation between the operator and the process so the valve cannot be used on a live system unless additional isolating valves are provided on either side.

11.3

Butterfly Valves

Lug type wafer or double flanged butterfly valves offer attractive cost and weight savings over ball or gate types but are more sensitive to installation/handling. The short overall length means that, once chosen, the operator cannot subsequently change to another valve type without modifying piping. One way round this would be to buy flanged valves having the standard overall length of ball valves etc. or to fit a spool piece but this forfeits some of the cost/weight advantage.

Note that maintenance is only possible by breaking the pipe flange joint.

Butterfly valves are very economical of material and should receive serious consideration for larger diameter, low pressure lines.

In clean service they can provide excellent isolation and triple offset ('tricentric') designs are particularly good in this respect. However



metal seated types rarely employ abrasion resistant material and erosion of the seating faces can occur at high velocities in abrasive service (e.g. when valve is almost closed) leading to seat leakage which exacerbates the erosion. Test experience has been variable and caution is recommended in selection. Nevertheless a few designs have performed well in dirty service tests. (See Valve Test Summary report for further details).

Since all butterfly valves are torque seated they are very sensitive to errors/variations in the setting of end stops, air supplies etc.

All wafer type valves are potentially vulnerable to flange leakage in a fire. For this reason only lugged or double flange designs should be used and bolting material should be carefully selected. Fitting a steel casing around the joint is another possibility.

11.4

Plug Valves

These quarter turn valves can be attractive where weight and cost must be minimised. There are four types of interest:

- (a) Balanced, lubricated type (e.g. Serck Audco, Christensens, Nordstrom) which usually rely on injection of lubricant to provide a bubble tight seal;
- (b) Sleeved type (e.g. Durco, Tufin) which utilise a PTFE sleeve;
- (c) Semi- balanced type incorporating a thrust bearing (Texsteam).
- (d) Lifting wedge plug type (Stockham, Goodwin)

"Regular" pattern valves usually have a rectangular flow passage giving a reduced area compared to the pipe; "venturi" pattern have even greater area reduction and neither can pass pigs. Full bore types are available with corresponding increases in cost and weight. Flow areas vary between manufacturers so care should be taken when making comparisons.

Lubricated designs are only recommended where maintenance procedures will include a re-lubrication schedule. Stellite coated designs (and the Texsteam plated design) have been shown to cope with abrasive service where maintenance lubrication is not carried out and frequent operation is required (e.g. manifold/diverter service). ENP balanced types may also offer acceptable service in this respect but have not been proven on test or in service at time of writing. If use of balanced valves without re lubrication is contemplated the supplier should be advised so he can take appropriate measures to cope with the increased operating torque.

Sleeved plug valves have been shown to be capable of acceptable performance where abrasives are present in the product and have the advantage that the working fluid is excluded from the valve body cavity. They should be limited to low pressure ratings and have a tendency for the operating torque to increase due to "bedding in" of the plug if not operated or exercised regularly.

Wedge plug designs incorporate an actuating mechanism which lifts the plug out of the body prior to turning. They can cope well with abrasive or other difficult fluid conditions and may be worth consideration in the smaller sizes.

11.5 Check Valves

BP Group [RP 62-1](#) includes detailed discussion of the different types of check valves and should be consulted when making selections. The following points are included here for ease of reference:

- (a) The only check valves capable of passing pigs are special types of swing checks. These do not generally have ideal dynamic characteristics.
- (b) Tilting disk and duo-disk valves are better at coping with unstable flows than standard swing checks. Axial flow designs are best of all and should always be used at compressor outlets unless there are pressing reasons for doing otherwise.
- (c) All check valves should be mounted at least three pipe diameters downstream of pipe fittings (elbows, valves etc.).
- (d) Check valves should always be selected such that under normal flow conditions they are fully open. Where swing check valves are used in pigged pipelines this will not always be possible. In such cases it is important to ensure that hinge pin and bearing design is adequate for the constant disk movement which may result.
- (e) Duo-disk, wafer type valves make extremely economical use of expensive material. Where used they should be in lugged or double flange form to reduce vulnerability. Bolting for lugged designs should be thermally compatible with the valve body material and flanges.
- (f) Lift type and swing type check valves should ideally not be fitted in vertical pipes and no check valve should be mounted in a pipe with flow vertically downward except axial flow type where the supplier is fully apprised of the condition.



12. RELATED ISSUES

12.1 Weight/Cost Minimisation

Where valves are being procured in expensive alloys the following techniques should be considered as a way of minimising weight and hence cost.

- (a) Use of compact connectors in place of standard ANSI etc. flanges.
- (b) Selective use of corrosion resistant overlays.
- (c) Butt welding of valves to pipework.

Offers maximum weight saving but necessitates access through valve bonnet for maintenance (automatic with gate valves, top entry ball valves etc.). Note that, since top entry ball valves are usually heavier than end entry, the weight saving in this case may not be large.

- (d) Use of pressure seal joints at the body/bonnet interface of high pressure gate, check, top entry ball etc. valves.

This design uses a split ring to transfer the pressure load on the bonnet to the body thus eliminating the heavy bonnet flange.

The joint should incorporate a graphite gasket, O ring or energised lip seal - old style metal gaskets tend to leak at low pressure and can be difficult to remove for maintenance.

- (e) Use of reduced bore valves wherever pigging is not a requirement.
- (f) Use of butterfly valves.
- (g) In the case of large pipe sizes, use of intermediate rating valves where design conditions fall between two standard pressure ratings (e.g. between Cl 900 and Cl 1500).

This allows reduced wall thickness, smaller internal flanges etc. but should be supported by sufficient analysis to provide confidence in the design.

Detailed analysis (e.g. FEA) may also be used to justify lighter construction standard rated valves when these are specified in accordance with pipeline valve standards. In such cases it is important to ensure that adequate rigidity is retained.

- (h) Use of plug valves.

Regular or reduced bore



- (i) Use of a single valve (e.g. expanding gate) to provide double block and bleed isolation instead of two independent valves.

12.2

Vent/Drain etc. Plugs

Taper threaded valve body plugs and needle type 'vent' plugs are a common cause of leakage incidents on gas production systems. This is usually due to a mixture of crevice etc. corrosion and poor mechanical strength (excessive PTFE tape application etc.). Where valve body connections are necessary for operational/testing reasons on larger size valves consider terminating them with a blank flange or a flange + block and bleed valve arrangement (see ESD above). Where not necessary for operational reasons they should be eliminated (in this case, manufacturer's claims that such body penetrations are necessary to facilitate manufacture should be challenged).

Technical Bulletin [TB 0005](#) (available from the custodian of this BP Group Recommended Practice) provides guidance on this subject.

The same considerations apply to sealant injection fittings. Seat sealant injection can sometimes assist in achieving a single isolation with a soft seated ball valve but this operational advantage should be carefully weighed against the number of additional potential leak paths being introduced. Where used, fittings which incorporate double seated check valves may offer improved integrity.

12.3

Seal selection

O ring (or other elastomer type) seals in valves on high pressure gas service must have:

- (a) good resistance to the process fluids, dosing chemicals etc.
- and
- (b) maximum resistance to explosive decompression.

Special formulations are available for use at pressures above 70bar which have a relatively high hardness and include a filler to reduce gas permeability. These must be used with high strength, plastic back-up rings having low extrusion potential and scarf-cut joints.

At lower pressures high hardness will assist in resisting decompression damage.

It should be noted that, in the case of rings having section diameters above approx. 6 mm, it is very difficult to preclude e.d. damage unless decompression rates are very low - regardless of material formulation.



In the case of very large ring sections damage may be inevitable owing to the difficulty of avoiding manufacturing defects. Such seals should be avoided where possible and alternatives (re-inforced plastic lip seals, metal seals etc.) considered instead.

Valve suppliers knowledge of these considerations varies widely and seal selections should be reviewed against the recommendations of [ESR.93.ER.151](#) (BP Exploration's Elastomer Selection Guidelines) and [ESR.93.ER.124](#) (Avoiding Explosive Decompression damage in Seals), both available from the custodian of this Recommended Practice.

12.4

Fugitive Emissions

There is currently great interest in reducing fugitive emissions of volatile organic compounds from land based plants, the drivers being both environmental and economic (loss control). Whilst the economic factors may be less significant offshore (especially where gas is not being exported) the environmental concerns are similar and ways in which losses can be minimised should be considered at the design stage.

Because of the general activity in this area it should be possible to take advantage of improved performance at little or no increase in cost.

Site surveys of conventional plant generally indicate that rising stem (globe type) control valves are the worst culprits followed by rising stem (e.g. gate and globe) isolating valves (note that small valves are often worse than larger sizes) with conventional quarter turn valves (ball and plug) giving fewer problems. This is not a surprising result.

Valve gland packings are a major source of these emissions and BP has been conducting tests over a number years (principally on behalf of BP Oil and BP Chemicals) in order to obtain an understanding of the problem and explore possible solutions.

Tests on rising stem gate/globe (block valve) packings showed that:

1. all graphite packings perform better than asbestos;
2. that some quite simple low to medium density packings can give very good performance;
3. that the best performance was obtained from an "engineered" design of packing with some pressure energising capability (Garlok [EVSP 9000](#));
4. that graphite packings generally are relatively insensitive to stem damage;
5. that stem straightness and runout must be carefully controlled;



6. that whilst good surface finish and close tolerances may give improved sealing performance these parameters need not be better than is currently being achieved by the leading valve manufacturers.

Most manufacturers of rising stem (globe type) control valves have done work on reducing emissions and offer valves fitted with "low emission" packing arrangements at an increased price. Recent tests on six manufacturer's valves indicate that:

1. the majority performed well and it is possible to buy globe type control valves with excellent low emission performance, some of which are available with fire tested packing;
2. the additional cost of valves fitted with low emission packings as a percentage of total valve cost is not excessive in most cases (this should be especially true in a project environment);
3. good guidance of the valve stem is a prime requirement for actuated valves;
4. it seems that it is difficult to achieve good performance on modulating duty with graphite packing, although one manufacturer did succeed. The need to limit actuating forces and hence packing friction is important in the case of control valves and the best isolating (gate/globe) valve packing (with its relatively high friction) did not perform well.

An alternative approach is to maximise the use of quarter turn control valves (eccentric plug, ball, butterfly) in applications where operating conditions permit and cavitation (etc.) problems do not arise.

Small (2") quarter turn valves (seat supported ball, sleeved plug and butterfly) have also been tested. Stem seals covered a wide variety of types from a single PTFE ring through O rings to packed glands. Results indicate that:

1. quarter turn valves should not be major sources of fugitive emissions;
2. standard designs should give acceptable sealing performance;
3. there is no need to pay a premium for special "low emission" arrangements;
4. alignment of actuators to the valve stem can have a major effect on performance.



It is possible that results might have been somewhat different for large valves but, provided quality manufacturing ensures good concentricity/guidance of the stem (especially in the case of actuated valves) emission problems should be avoided.

12.5 Safety/Relief Valves

General requirements for provision and selection of relief valves are provided in BP Group [RP 44-1](#).

The provision (and management) of spare valves along with the use of bursting disk and buckling pin devices (especially where use of expensive materials must be minimised) deserves careful consideration if maximum operational facility is to be provided at minimum cost. Bursting disks and buckling pins can sometimes be used to advantage in parallel with spring loaded valves to facilitate 'on-line' changeout and buckling pins have the advantages of greater accuracy, insensitivity to fatigue and non-intrusive re-set.

Pilot operated valves may help to reduce losses to flare where operating conditions are clean. Non-flowing pilot designs are usually to be preferred.

A risk based approach to in-service inspection of these items is ideally suited to the detail phase of a project where there is good knowledge of the reasons why safety/relief valves have been provided. The technique involves making an assessment of the probability that a valve will fail to fulfil its pressure relieving function coupled with an assessment of the consequences of failure and (ideally) the likelihood that it will be called upon to operate. A maximum inspection or endorsement interval can then be derived. A flow chart based method for performing such an assessment is available from the custodian of this Recommended Practice.

12.6 Subsea Application

The general principles of this Recommended Practice are applicable to subsea developments. However, to date, few such installations undertake any processing so the conditions of Zone A must be assumed to apply to the entire system.

Avoidance of maintenance and unscheduled intervention is paramount and for this reason only the most robust, reliable and wear resistant valve types should be considered. Seals must be long life, maintenance free and not subject to degradation by the process.

For this combination of qualities, and in the light of experience to date, it is hard to beat the tungsten carbide coated, slab gate valve. Alternatives may become apparent as experience of subsea developments accumulates. In the case of pipelines, ball valves offer a proven alternative and valve selection should take into account the particular process conditions and mode of operation eg. valves provided

to facilitate tie-ins are often required to seal until after the tie-in is made then function as a piece of pipe. Soft seated valves supplied (and left) in the closed position may be most suitable for this service. Other valves (eg. associated with pigging operations) will need to be debris tolerant to provide repeatable sealing over a long life. All valves will have to survive flushing and line clearing (see above) and may need to be protected during these operations.



SYSTEM/ ZONE DESCRIPTION	PRESSURE	TEMPERATURE	NOTES & ASSUMPTIONS RE. SERVICE CONDITIONS
(A) Flowlines, Diverters, Manifolds etc. Import & Infield Pipelines	< 200 bar (oil) < 500 bar gas	< 150°C	Usual case is gas/oil/water mixture. In the case of new developments it should always be assumed that sand will be present (dirty service).
(B) Stabilisation/ Processing (liquid line) Stage 1 Stage 2	10-90 bar < 10 bar	< 150°C < 80°C	2 Phase flow after interstage contr. valve. Still some sand/ water until after LP separator. De-salters (where provided) assumed to come after LP sep. - treat as "export oil".
(C) Produced Water (upstream of settling tanks)	< 90 bar reducing through system	< 150°C at HP separator cooling thereafter	Usually high sand content & can be very corrosive. Sand treatment can involve high cycle abrasive service.
(D) Export Oil	2 - 250 bar	< 60°C	0.5 to 2% water (max.) by wt. Relatively sweet even on sour service.
(E) Gas from HP separator	<90 bar	< 150°C	Wet & dirty initially. Clean service after scrubbers.
(F) Gas from LP separator	< 10 bar before compression.	< 80°C	Wet but generally clean except where high sand content in product. Clean service after scrubbers.
(G) Gas Treatment (drying, sweetening etc.) Mol. Sieves Glycol, sweetening Dew point proc.	< 80 bar	< 100°C < 300°C < 200°C - 30/40°C min.	Generally clean service but some dryers (e.g. mol. sieves) can introduce abrasive particles. Switching valves subject to high cycle wear. Potential for low temperatures exists (-20°C) throughout gas system.
(H) Export gas	< 170 bar	< 120°C at comp. outlet, <60°C at exp	Clean service but valves associated with pigging operations may see abrasive debris and flow at high differential pressure.

TABLE 1. ASSUMED CONDITIONS FOR OIL AND GAS PROCESSING



(I) Gas re-injection	< 350 bar	< 150°C	Clean service and dry but may be wet where corrosion etc. not a problem.
(J) Lift gas	< 350 bar	< 150°C	Clean service. Dry if high pressure, otherwise may be wet.
(K) Fuel gas	< 80 bar	< 100°C	Clean service and usually dry.
(L) Vent/ Flare/ Relief H.P.Flare L.P. Flare	< 12 bar < 1.5 bar	-100°C min (gas) -40°C min (oil) < 60°C	Clean service.
(M) Condense returns	As for main system	As for main system	Condense from HP & LP scrubbers etc. assumed to be dirty. Condense from dryers & downstream scrubbers etc. assumed to be clean.
(N) Open Drains	As for main system	As for main system	Only used for wash out/ purge with water or N ₂ . Not onerous service.
(O) Closed drains	As for main system	As for main system	Assume dirty service where this assumption is made for associated system
(P) Water Injection	< 250 bar	< 20°C	Filtered at LP and sand free after pressurisation.

Notes:

When making selections for wet gas systems the erosion/corrosion potential of entrained liquid should be considered.

TABLE 1. ASSUMED CONDITIONS FOR OIL AND GAS PROCESSING (CONT.)



ZONE	PRIMARY RECOMMENDATION	COMMENTS & ALTERNATIVES (Notes)
A	Slab type gate, tungsten carbide (WC) coated; Trunnion ball, WC coated;	These will be comparably priced. Both can handle service but gate v. will give better isolation. (1) Acceptable Alternatives: (2) Stellite coated balanced plug; (3) Rotating disk ("Everlasting"); (3) Eccentric ball ("Orbit"); Semi-balanced plug ("Texsteam" - limited range). (3) Axial piston (Mokveld) Note: In the case of infrequently operated valves in pipelines where sand content is low, soft seated trunnion ball valves may be possible provided they receive adequate protection during installation/flushing etc.
B	Slab type gate, WC coated; Trunnion ball, WC coated	Where sand content low, Stage 2 may be treated as D below. Acceptable Alternatives If sand exists for only very limited period, ENP coated gate valve may offer necessary abrasion resistance combined with good isolation at economic cost; (4) Stellite coated balanced plug; Sleeved plug (possible for lower pressure ratings and smaller sizes but ideally need regular exercising); Other alternatives as for zone A. (See below for import line ESDV and pig trap applications.)
C	Rotating disk ('everlasting'); Balanced plug, stellite coated; Semi-balanced plug; Trunnion ball, WC coated; Slab gate WC coated.	All types need careful material selection/corrosion protection. Acceptable Alternatives Eccentric ball; Wedge gate if little sand; Sleeved plug for lower pressure ratings (but ideally need exercising regularly);

TABLE 2. ISOLATING/BLOCK VALVE RECOMMENDATIONS



D	Applications other than pig trap isolation: Trunnion ball, soft seated; Wedge gate (smaller sizes). Pig trap isolation valves (see section 11.2): Slab gate; (ENP or WC coated) Expanding gate; Trunnion ball, WC coated.	Acceptable Alternatives Given appropriate material selection, most high pressure valve types listed above would be acceptable for the non-pig trap isolation service.
E1 (prior to knock-out)	Slab gate; Trunnion Ball, WC coated; Stellite coated balanced plug.	ENP coated gate could offer necessary abrasion resistance at economic cost. (4)
E1 (after knock-out)	Trunnion ball, soft seated; Wedge gate; Slab gate, ENP coated.	Acceptable alternatives Butterfly (< Cl 600) ENP coated balanced plug (4)
F	Trunnion ball, soft seated (seat supported $\leq 6"$); Wedge gate; Slab gate, ENP coated; (4)	Acceptable alternatives Butterfly; ENP coated balanced plug. (4) Sleeved plug (smaller sizes)
G	Trunnion ball, soft seated; Wedge gate; Slab gate, ENP coated; (4)	Switching/recycle valves associated with some gas dryers must withstand high cycle wear e.g. Trunnion ball, WC coated; Eccentric ball; Balanced plug, stellite coated; Rotating disc. High and low temperatures will affect selection. Acceptable alternatives Butterfly ($\leq$ Cl 600); ENP coated balanced plug. (4)

TABLE 2. ISOLATING/BLOCK VALVE RECOMMENDATIONS (CONT.)



H	General Isolation (other than pig trap): Trunnion ball, soft seated; wedge gate (small sizes); ENP coated balanced plug. (4) Pig trap isolation valves (see Section 11.2): Slab gate; (ENP or WC coated) Expanding gate; Trunnion ball, WC coated. Throttling duty (bypass, blowdown etc.) ENP coated balanced plug; Trunnion ball, W.C. coated;	Acceptable Alternatives Given appropriate material selection, most high pressure valve types listed above would be acceptable for the non-pig trap isolation service. However, careful consideration should be given to sealing integrity, tolerance of high differential pressure and low temperature tolerance. Triple offset, metal seated butterfly ($\leq$ C1600) may be considered for some throttling duties.
I & J	Slab gate, ENP coated; Balanced plug, ENP coated; Trunnion ball, soft seat (except where operated against high Δp).	Acceptable alternatives Given appropriate material selection, most high pressure valve types listed above would be acceptable. However, careful consideration should be given to sealing integrity, tolerance of high differential pressure and low temperature tolerance.
K	Trunnion ball, soft seated (seat supported $\leq$ 6"); Wedge gate; Slab gate, ENP coated; (4)	Acceptable alternatives Butterfly; ENP coated balanced plug. (4)
L	Butterfly; Trunnion ball, soft seated (seat supported $\leq$ 6")	
M1 (clean)	Trunnion ball, soft seated (seat supported $\leq$ 6");	
M2 (dirty)	Slab gate; Trunnion Ball, WC coated; Wedge Gate; Stellite coated balanced plug.	If little sand ENP coated gate could give necessary abrasion resistance at economic cost - otherwise WC coated. Acceptable alternatives Sleeved plug ($<$ Cl 600).
N	Seat supported ball/trunnion ball, soft seated; Globe	Depending on pressure rating

TABLE 2. ISOLATING/BLOCK VALVE RECOMMENDATIONS (CONT.)



O	As for main system	Acceptable alternatives - Sleeved Plug (<CL600) for dirty service - Globe
P	Trunnion ball, soft seated (except where operated against high Δp or water not sand free, in which case see I & J above)	Acceptable alternatives Butterfly in L.P. Wedge gate.

Notes:

- (1) It is sometimes difficult to accommodate slab gate valves in existing piping systems because of their height but this should never be a problem with a new development where the design contractor should consider their use from the outset.
- (2) Suppliers of valves intended for dirty service should have demonstrated good performance in a type test conducted by BP or NEL unless there is sufficient operating experience in similar service to give confidence of successful application.
- (3) Particularly suited to frequent operation and higher sand content.
- (4) Electroless nickel plating is porous as is chrome plating. Base material selections must exhibit adequate resistance to corrosion by the working fluid.

TABLE 2. ISOLATING/BLOCK VALVE RECOMMENDATIONS (CONT.)



ZONE	≤ 2" NPS (DN 50)	> 2" NPS (DN 50)
A	Ball check, hard faced, straight or "Y" pattern (1)	Duo-disk wafer check, hard faced or rubber seated with metal back-up. Acceptable Alternatives Swing check, hard faced; (2) Axial flow "non-slam" check; (3) Tilting disk check. (3)
B	As for zone A	As for zone A
C	Ball check, hard faced, straight or "Y" pattern (1); Diaphragm check.	Duo-disk wafer check, hard faced or rubber seated with metal back-up; Swing check. (2)
D	Piston check. (1)	Duo-disk wafer check; Swing check.
E1 (prior to knock-out)	Ball check; (1)	Duo-disk wafer check, hard-faced or rubber seated with metal back-up; Acceptable alternative Swing Check
E2 (after knock-out)	Piston check; (1)	Duo-disk wafer check. Acceptable alternative Swing check
F	As for E2	As for E2
G	As for E2	Duo-disk wafer check. Acceptable alternative Axial flow check.
H	As for E2	Axial flow check (4) Duo-disk wafer check; Tilting disk check.
I & J	As for H	As for H
K	As for H	As for H
L	As for H	Duo-disk wafer check.
M1 (clean)	Piston check; Ball check. (1)	Duo-disk wafer check; Swing check.
M2 (dirty)	Ball check (1)	Duo-disk wafer check, hard faced or rubber seat with metal back-up; Swing check, hard faced.
N	Piston/Ball check (1)	Swing check
O	As for main system	As for main system
P	Piston/Ball check (1)	Duo-disk wafer check; Swing check

Notes:

- (1) Where "in line" type ball or piston check valves are used in horizontal pipes they must be fitted with a closing spring. Consider piston type where frequent flow/pressure variations expected.
- (2) Wafer style, single disk check valves are not recommended.
- (3) Usually only to satisfy diversity requirements in this service.
- (4) Must be used at outlet of reciprocating compressors

TABLE 3. CHECK VALVE RECOMMENDATIONS



DEFINITIONS AND ABBREVIATIONS

Definitions

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

Abbreviations

ANSI	American National Standards Institute
CAPEX	Capital Expenditure
DN	Nominal Diameter
EEMUA	Engineering Equipment and Material Users Association
ENP	Electroless Nickel Plate
ESD	Emergency Shutdown
ESDV	Emergency Shutdown Valve
FEA	Finite Element Analysis
NEL Ltd	Formerly National Engineering Laboratory
NPS	Nominal Pipe Size
PTFE	Polytetrafluoroethylene
WC	Tungsten carbide

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.

BP Documents

BP Group RP 62-1	Guide to Valve Selection
BP Group RP 30-3	Instrument and Control - Selection and use of Control and Shutoff Valves.
BP Group RP 44-1	Overpressure Protection Systems
BP Group RP 44-10	Isolation of Equipment for Maintenance
BP Group GS 130-6	Actuators for Shut-off Valves
BP Group GS 134-1	Hydraulic Power Supplies
BP Group ESR.93.ER.151	Elastomar Selection Guidelines
BP Group ESR.93.ER.124	Avoiding Explosive Decompression damage in Seals
BP Group TB0005	Auxiliary Connections in Valve Bodies
BP Sunbury Branch Report 124 240	The Protection of Valve Seat during Commissioning by use of Silicon Sealant

Others

EEMUA 182	Specification & Application Guidelines for Integral Block & Bleed Valve Manifolds for Direct Connection to Pipework.
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