OIL & GAS
MAINTENANCE GUIDE

A PROACTIVE APPROACH TO VALVE MAINTENANCE

Brentforth
Energy & Oilfield Services Ltd.

♦ *On-Field Valve Maintenance*

▸ **Working to keep the world's energy system flowing in the most efficient and safe manner.**

Preface

Welcome to our first edition of ***Oil & Gas Maintenance Guide****—A Proactive Approach To Valve Maintenance*; the aim of this guide is to furnish Engineers, Technicians, Supervisors and Managers (that are involved in maintenance activities & planning) with a tool which equips them with technical data and information, often required for effective ***Maintenance*** works (especially on ***Valves***)*;* with applications in other areas, such as maintenance of: ***Pipelines, Pumps, Actuators, Wellhead Equipments etc.***

Usually, a Maintenance Personnel would have to make reference to multiple materials to keep touch with relevant technical data (often required for maintenance operations). What we have done, is to put together some of the regularly sort-after information, and a cache of our wealth of experience in the industry, all in one material so as to reduce the time gap between planning and work execution (hence, improving efficiency and the response time to maintenance calls).

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Director *Business Development & Operations*
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Disclaimer: We state that this brochure has been compiled meticulously and to the best of our knowledge, with the good intention of helping maintenance personnel operate better; however we can in no way guarantee the accuracy or completeness of the information. We therefore do not accept any liability for any damage resulting from actions or decision based on the information in question. *We reserve the right to combine, delete or change any section of this brochure at any time without prior notice.*

Reducing Maintenance Cost & Downtime, while Increasing Equipment Reliability.

Why Be Proactive

The consequences of running valves to point of failures, and then opting for the options of shutdown repairs or outright replacement of valves (when an incident has already occurred) can be hugely disastrous and uneconomical.

There are various reasons why proactive maintenance of valve is essential and beneficial:

- It reduces likelihood and severity of downtime.
- Proactive Maintenance is way cheaper than outright replacement of valves; and the astronomical cost or reputation damage which may arise in cases of incidents (due to poor maintenance culture) are hugely incalculable.
- It prevents catastrophic failures before they occur.
- It eliminates the need to keep large stocks of replacement valves (and the huge capital required to also maintain such stocks).

- It reduces the instances of having to wait-out the delivery times of valves, and their associated problems (as some can be extremely long).
- It improves worker safety and the protection of our environment.
- It supports optimal plant operation, capacity and productivity.

▸ Valves Failure Analysis

The causes of valve failures/problems are broadly attributable to two quarters, either the Manufacturer or the Operator (as illustrated below):

Valve Failures

Manufacturer

- *inadequate design*
- *poor manufacture/assembly*
- *deficient materials*
- *deficient system software*

Operator

- *incorrect installation*
- *incorrect sizing, specification or selection*
- *change in operating conditions*
- *faulty operating procedure*
- *inadequate/improper maintenance*
- *human error*
- *deficient QA procedures*
- *lack of training/incompetent personnel*

Note: The Operator also includes maintenance & engineering contractors/subcontractors.

Figure 1.

By reviewing the data of valves and their problems from various facilities in **U.K** and **Nigeria**, certain trends can be deduced about the failure types, root causes, and the most susceptible valve types in the industry.

The various kinds of valve problems (from a broad technical perspective), can be split into three levels or categories as detailed below:

<u>Valve Problem Classification Levels</u>

Levels	Categories	Description
1	Initial Valve Problem	This is the initial classification assigned to the valve problem, based on first impression or physical manifestations (prior to detailed investigation); and usually the initial reason for removal of valve from line.
2	Primary Problem	This is the classification assigned after the problem has been investigated more thoroughly or after the valve has been removed/stripped or examined more closely.
3	Underlying Cause	This is the final assessment after taking further accounts of the findings, background information and circumstances leading up to the valve problem (usually, the remote and immediate causes of primary problems).

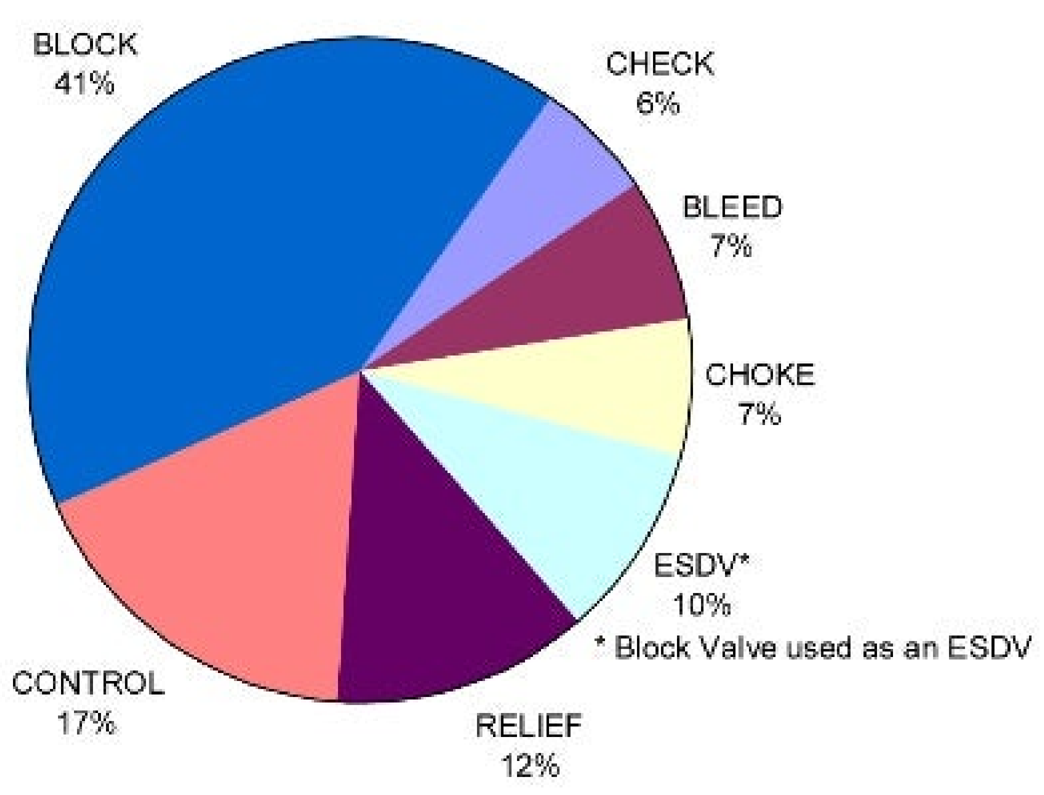
Table 1.

Sub-categories of the Classification Levels

LEVEL 1	LEVEL 2	LEVEL 3
INITIAL VALVE PROBLEM	**PRIMARY PROBLEM**	**UNDERLYING CAUSE**
• Fail to operate (open, close) • Through valve leakage (i.e internal/seat leakage) • External leakage • Difficult Operation • External Corrosion • Valve not operating properly	• Valve Seized • Stem, seal problem • Actuation problem (e.g. electric, hydraulics, pneumatics) • Control system problem (e.g. communications faulty, software problem) • Human error • Seat, seal problem • Body/bonnet, flange, trunnion problem • Erosion • Design defect • Materials defect • Corrosion	• Inadequate maintenance • Design inadequate, materials deficient • Lack of training, inexperienced staff • Corrosion • Sand erosion • System software, control system, signal data communications • Human error • Incorrectly specified, sized or selected • Quality Assurance issue - Procedures of manufacturer/supplier deficient (e.g. incorrect material fitted to valve) • Poor manufacture - e.g. poor welding • Quality Assurance issue - Procedures of operator deficient (e.g. dismantling procedure incorrect, process operating procedure defective) • Not commission properly

Table 2.

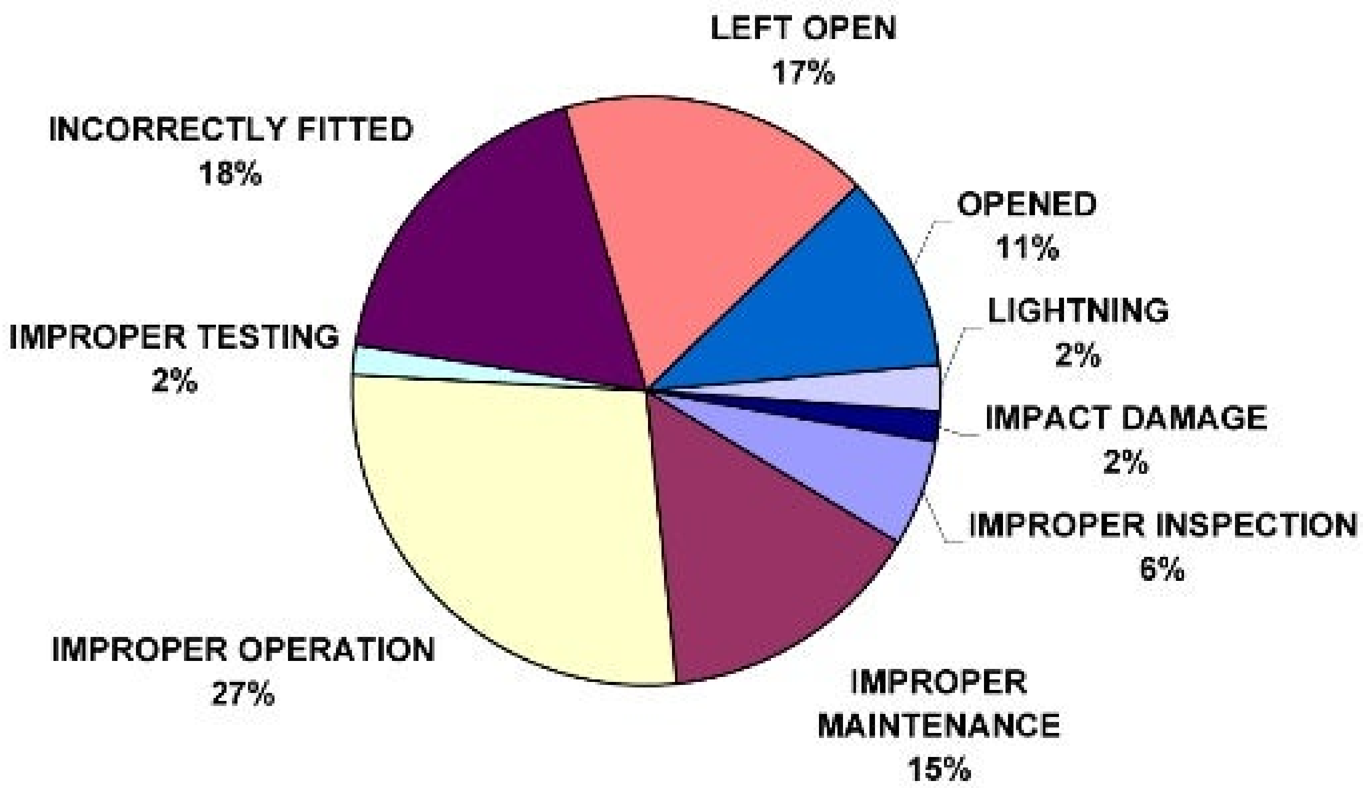
a) Hydrocarbon Release & Valve Types



Note: Block valves includes any of the isolation valves, such as - Ball, Butterfly, Gate, Plug, Diaphragm.

- From a data-set collected between 1993—1998, on a total of 253 valves from UK Offshore Oil & Gas Industry (by ***National Engineering Laboratory, UK***), a relationship was noticed, between the type of valve used and the incidents of hydrocarbon leakages to the atmosphere. Block Valves were identified to be mostly associated with hydrocarbon leakages at 41% - as illustrated by the pie-chart.
- Though Check Valves accounted for only 6% of the incidents, but an interesting fact was also noticed about big size check valves (i.e. from 10" above). The report indicates that large size check valves are more associated with hydrocarbon release incidents (hence, extreme care should be taken at the installation stage.)

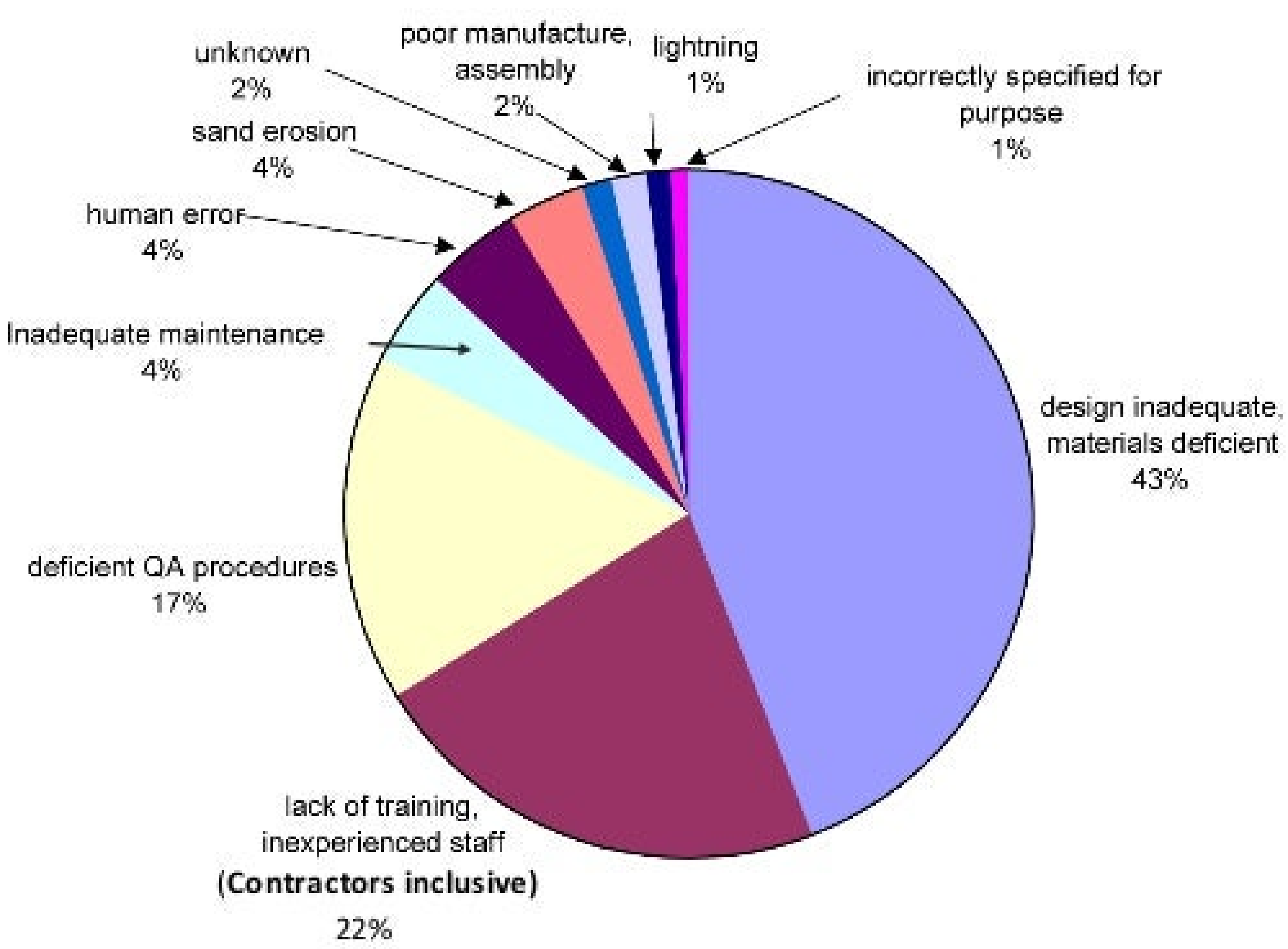
b) Hydrocarbon Release & Operational Causes



★ *Operational causes of failures can be effectively minimized or eliminated by* ***proper training of maintenance personnel*** *or selection of* ***competent Contractors/Sub-contractors*** *involved in operations, backed-up by a superb internal operational procedure and quality control systems.*

- Operational causes are failures which are not attributable to the valve itself, but to operational or procedural deficiencies of the operator (such as: poor maintenance, valve left by operator in an incorrect position, or the valve inadvertently operated).
- From analysis of the data-set used on page5, ***improper operation*** of valve stands as the major operational cause (at 27%) which is most responsible for hydrocarbon release into the atmosphere, followed by ***incorrectly fitted*** at 18%, and then closely followed by ***improper maintenance*** at 15%.

c) Underlying Causes & Hydrocarbon Release



★ However, it should be noted that the manufacturer cannot be blamed in a scenario where a valve is being used outwith its design parameters; for example, a case where process conditions changes after specification & installation of valve (e.g., presence of sand in process fluid), or wrong selection of valve.

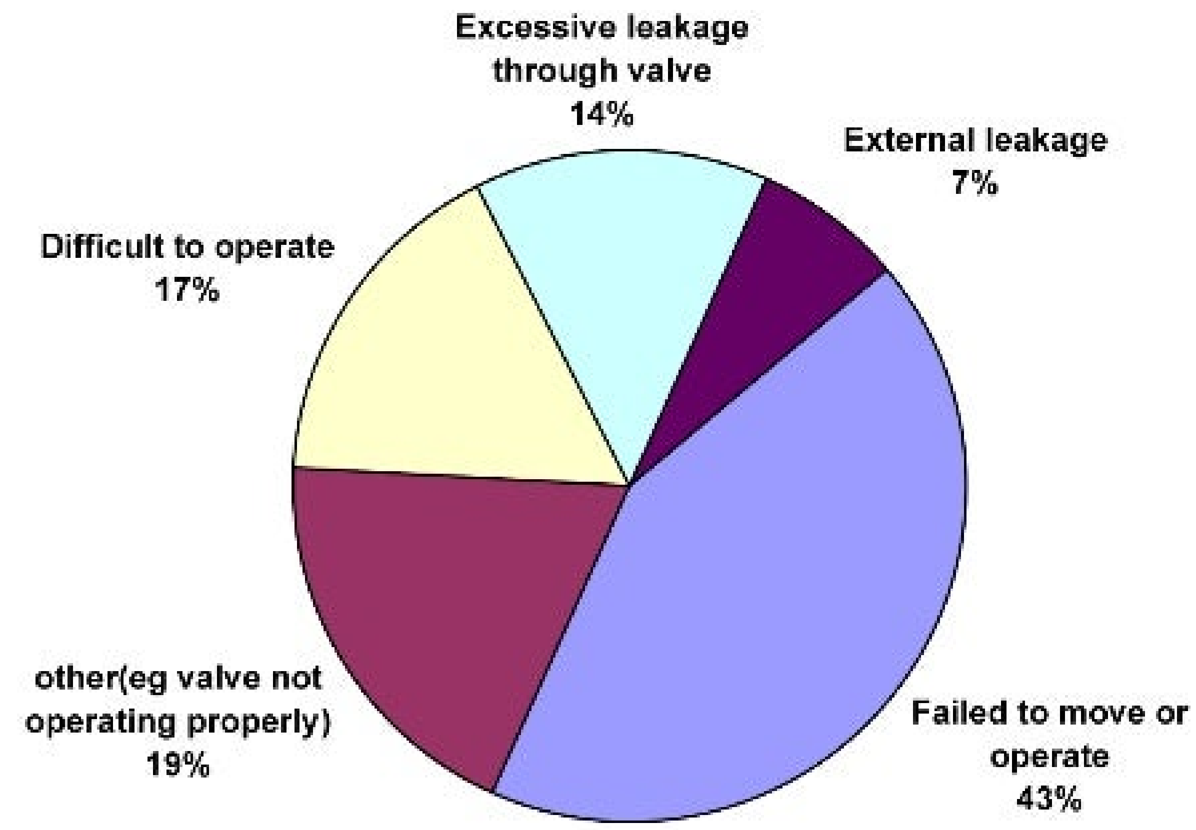
- All hydrocarbon release incidents in the data-set, were reviewed and the underlying causes were determined. The distribution of these is shown in the Pie Chart. The data shows that 80% of the hydrocarbon leakage incidents were accounted for by only three underlying causes, namely: design inadequate, lack of training and deficient quality assurance procedures.
- ***Design Inadequate, Materials Deficient***: By a large margin, these are the highest underlying causes at 43%, and these are attributable to the valve design itself (i.e the Manufacturer). Examples of these include:
  - internal/external corrosion
  - mechanical fatigue
  - mechanical failure
  - worn out
  - material defect (metallurgical)
  - design weakness
- ***Management & Operational Issues***: Put together: *lack of training/inexperienced staff, deficient QA procedures* & *inadequate maintenance* accounts for another 43%. These are management and operational issues, and not within the province of the manufacturer (as they are associated with where a valve is installed & how it is operated).

d) Initial Valve Problems & Production Hours Loss Analysis

- Entries of valve related problems which resulted in the **loss of production hours** in UK Offshore Facilities, were captured between January 2000 to July 2001; and an analysis of the data generated, shows the distribution pattern of Initial Valve Problems and their relationships with Loss of Production Hours.

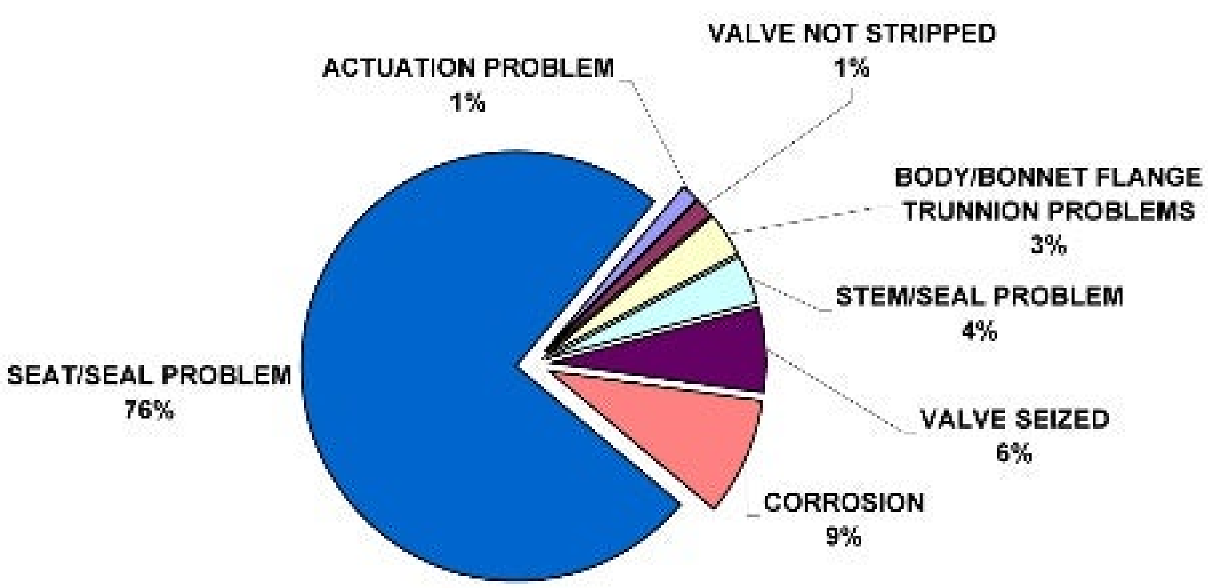
  The highest category at 43% by a large margin was the valve failed to move or operate. The next category was 'other' at 19%, e.g. valve not operating properly; closely followed at 17% by 'difficult to operate', then excessive leakage through valve at 14% and finally external leakage at 7%.

- Note that the initial valve problems as perceived and reported by staffs are usually not the same as the primary problems after investigation (Go to page 4, for descriptions of **Initial & Primary Valve Problems**).

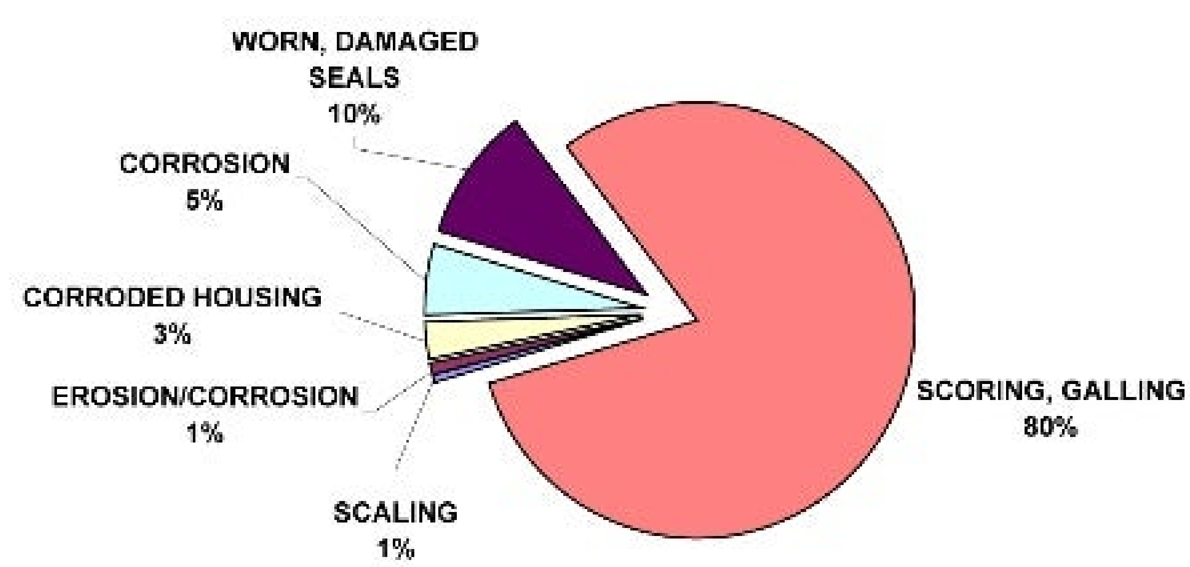


★ *A primary problem directly tells you the component or unit which failed; while a secondary problem gives you a physical description of the anomaly which made the component to fail. For example, a valve may have seat/seal problem (i.e. primary problem); while the seat/seal may have failed due to scoring/galling (secondary problem).*

e) Primary & Secondary Problems Responsible for Removal of Valves



DISTRIBUTION OF PRIMARY VALVE PROBLEMS



DISTRIBUTION OF SECONDARY VALVE PROBLEMS

- This data-set has a total of 2,300 entries recorded over a period of 21 years from 1993—2014 for a number of fields in **UK** and **Nigeria**; and is a record of valves that have been removed from the field. The reason for the valve's removal is generally identified together with the primary/secondary problems that have caused the valve to fail.

  - **Primary Valve Problems:** From the distribution of primary valve problems shown on the pie chart, it is not surprising to see that seat/seal problems dominate at 76%, followed by corrosion (internal & external) at 9%. Valve seizure occurred in 6% of the entries, stem seal problems 4% and then body/bonnet flange and trunnion problems at 3%. Interestingly only a very small 1% of the valves were identified as having actuation problems, meaning that most actuation problems could be sorted out without having to remove the valve from line.

  - **Secondary Valve Problems:** Most of the valves removed were subjected to strip-down/examination to identify the problems (reasons) for failing. ***Scoring and Galling*** is the major dominating factor at 80%, which affects the internal mechanical movement of the valve obturator, stem and seals. ***Worn and damaged seals*** accounted for a further 10% of the problems, followed by corrosion at 5%, corroded housings 3% and erosion & scaling at 1% each.

Valve Maintenance Strategies

Introduction: The mind-set that maintenance is only necessary when an equipment is faulty or has broken down already (as a reactive or recovery measure) is totally a wrong one. We should be **proactive** in our approach to maintenance and NOT **reactive**.

The timing when maintenance action was initiated in the cycle of the equipment's failure development, determines the category such action would be classified (as described below).

a.) Preventive Maintenance: *Are all maintenance actions carried out on a planned schedule to keep an equipment in stated working condition through the process of checking and reconditioning.*

Preventive maintenance is a general term that encapsulates all precautionary actions taken to prevent an equipment from failing before the failure actually happens or before it becomes visibly evident. Most times these maintenance activities are carried out on a routine basis (whether the equipment actually needs it at that time or not). Preventive maintenance is also a form of proactive maintenance, but the emphasis is not so much on the precision of the timing which the maintenance activity is scheduled—it could be scheduled too early or too late in the life cycle of the equipment's failure development (based on the judgment of the planner).

Cut-away section of a Ball Valve

b.) Corrective Maintenance: *The unscheduled maintenance or repair to return items/ equipments to a defined state and carried out because maintenance persons or users perceived deficiencies or failures.*

The overriding reason of initiating a corrective maintenance activity is to restore an equipment to its normal operating condition (owing to obvious presence of failure characteristics that shows it has fallen short of acceptable state).

Reassembly of a Ball Valve during corrective maintenance

Corrective maintenance can be termed as a **reactive measure**, if it is applied after failure signs of an equipment have matured and materialized to tangible damages that impair the proper functionality of an equipment; and it can also be termed as a **proactive measure**, if it is applied at the early stages of failure development (before they could get a chance to materialize into something serious that impairs proper functionality of the equipment).

c.) Predictive Maintenance: *A maintenance technique that employs the use of modern measurement and signal processing methods to accurately diagnose equipment condition during operation (so as to identify any deviation from its normal operating state at an early stage).*

Predictive maintenance attempts to detect the onset of a degradation with the goal of correcting that degradation prior to significant deterioration in the component or equipment. The advent of intelligent control systems and instrumentation has made it possible to spot early signs of failures and initiate maintenance activities at the right time (which is the essence of predictive maintenance).

To be truly proactive, one should be able to identify and predict failure signs accurately early on before they're fully developed; and then nipping them in the bud immediately (by initiating maintenance activities at the right time).

d.) Equipment Reliability: *Is the probability that an equipment will perform its stated function satisfactorily for a given time period when used under the specified conditions.*

Equipment reliability is an important factor in maintenance engineering, because lower equipment reliability means higher need for maintenance or greater frequency of equipment breakdown.

When the reliability of an equipment has gone down below an acceptable limit; then, it is no longer economical to keep refurbishing that equipment - as it is bound to fail again. Hence, an outright replacement would be recommendable (instead of going round in circles).

► How To Proceed

It is extremely important to act as soon as the first sign of failure is noticed, because even relatively small damage to the sealing surface can quickly develop into a major leak, which may then require comprehensive and expensive repairs.

Preventive measures are extremely important for well-organized valve maintenance; this means regular checking of the condition of the valves (quality of sealing, tightness of closed valve). Valve failure/leakage can cause considerable loss of process fluid and can represent a major environmental hazard or even lead to catastrophe if toxic gas escapes (e.g. ***SEVESO*** in **Italy**, ***BHOPAL*** in **India**).

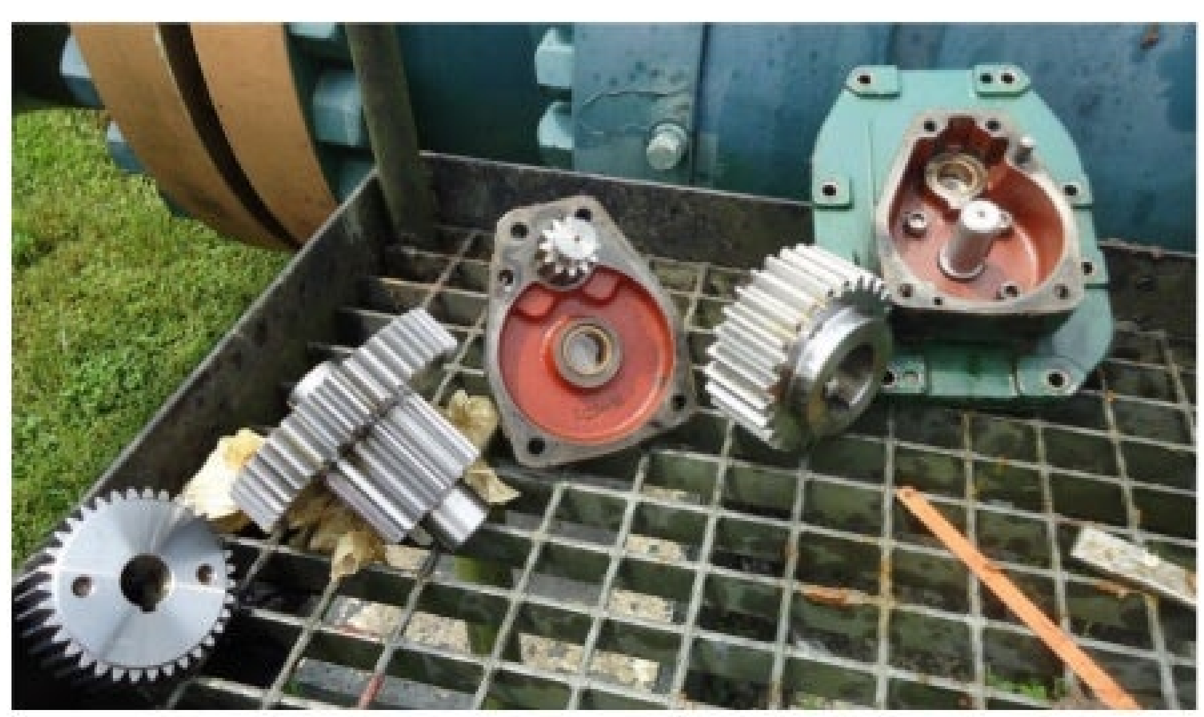
There are two major ways of maintaining valves:

1. On-field Maintenance: Generally speaking, this is a case where valves are required to be repaired or serviced right on site (within the facility where they are installed or utilized). However, if the valve is to be maintained while under system pressure without having to remove it from the piping system, then it is strictly referred to as ***online maintenance***.

Online maintenance is feasible for various kinds of valves in the industry. The maintainability features of the valve (as provided for, by the manufacturer) determines the level of work that could be done on it (safely) while still online.

Some Online Maintenance Activities include:

- Operating and greasing/closing of valve gearbox
- Removal of caked/denatured grease from the gearbox
- Provision and replacement of bearings, gaskets, injection ports, fittings and seals
- Servicing of bearings, spacers and washers
- Provision and injection of valve flush conditioner, and sealant to stop internally leaking valves
- Servicing of valve stem and operators (manual & automatic types)
- Testing of Torque and Limit Switches periodically, to ensure their operation in motor operated valves
- Periodic valve stroking & lubrication of stem threads, gears to prevent jamming and corrosion every six months (using appropriate lubricant)



► *Installed or in-service valves which are routinely maintained offer higher reliability and longer service life.*

In most cases where the problem is with the actuator alone (manual or automatic), as the case may be, the anomaly could be corrected online, without needing to remove the entire valve from the piping system (but this requires considerable skills and experience, so you don't cause a **blowout**).

2. Off-field/Workshop Maintenance: This allows for total repairs/stripping of the valve in a workshop (depending on the level of damage of the valve), and this is a more expensive option than the on-field maintenance.

The first phase of valve repairs in a workshop is usually sorting of the valves, then functionality tests, orientation markings, disassembly and visual inspection/damage analysis (to identify defects).

The valve must then be cleaned employing one or more of the following procedures (as suitable):

- Sand or shot blasting (using glass pearls or steel balls)
- High pressure cleaning (water or steam)
- Washing with chemicals (solvents/degreaser)
- Mechanical cleaning

Then the valves are maintained according to the categories & level of damage they have (as shown below), after which they are re-assembled & tested:

Category A. Valves requiring '***Build-up Welding***' and '***Turning***'.
Category B. Valves requiring ***replacement of badly damaged parts*** and ***servicing of dysfunctional components***.

► **Machining/Lapping**: To ensure reliable performance and prolonged service life of valves, the final control elements (and their counterpart mating parts) do not only require high dimensional and geometrical accuracy, but also require high surface finishing. Superfine surface finishing, can be achieved particularly through the process of *lapping*, while the dimensional and geometrical accuracy of the components can be achieved generally by the process of *machining* or *turning* (even without employing additional techniques). The quality of surface finishing has a vital role in influencing the functional characteristics of components, such as: *wear resistance, leak tightness, fatigue strength, corrosion resistance, and power loss due to friction.*

***Definition**:* Lapping can be defined as an abrasive process in which a rotating/moving lap, charged with a loose slurry, removes very small amounts of materials from metallic or non-metallic surfaces.

Technical parameters of lapping process:

- Applied pressure
- The grain size of abrasive
- Concentration of abrasive in the lapping fluid (or vehicle)
- Lapping speed

General lapping procedure:

a) Start by selecting the appropriate grain size or abrasives (using the **Abrasive Charts** provided at ***Appendix A***).

b) Coat the lapping plate with a thin layer of ***lapping paste***.

c) Follow the ***Figure-Eight Motion***, if the surface to be lapped is a flat surface.

d) Apply only light pressure to the work-piece.

e) From time to time, change the orientation of the work-piece by 90 degrees (to achieve even abrasion).

f) When removing the work-piece from the lapping plate, be careful to pull it straight up (if done properly, you should hear a popping sound).

g) Use a magnifier and flashlight to inspect if further lapping is needed (with the same grit size).

h) If further lapping is needed, you can move to finer compounds of 500grit or 900grit, and repeat.

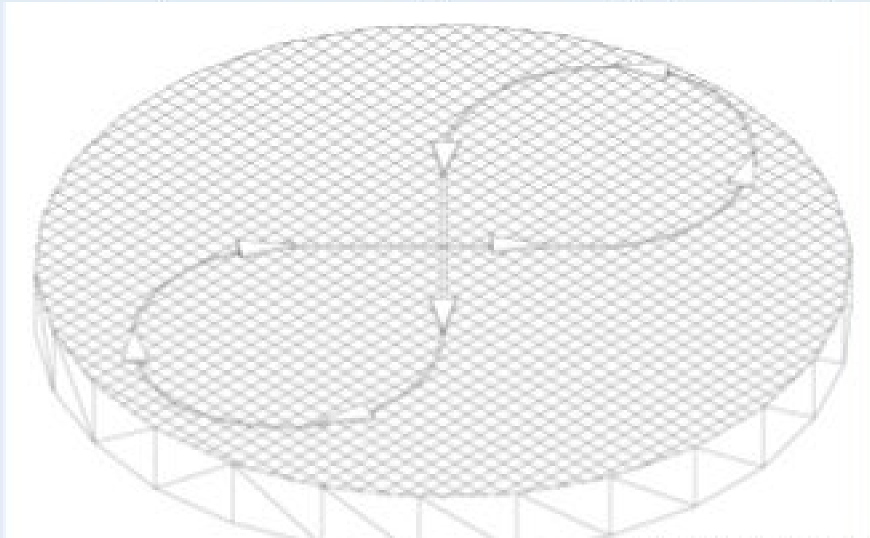
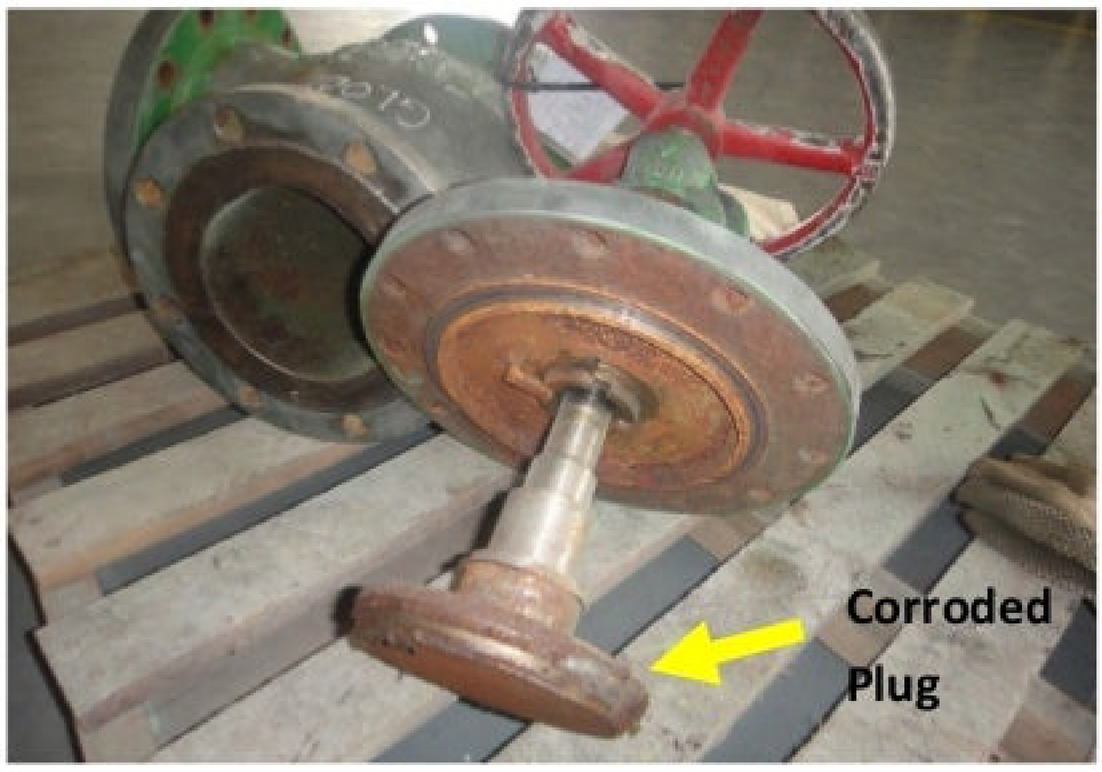


Figure-Eight Motion



► Plug of a Globe Valve which requires Lapping

► Valve machining process using a Lathe Machine

Reliable Valve Solutions

Passion . Commitment . Technical Competence

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Brentforth offers a reliable option in valve maintenance and procurement, as we ensure that the service life of valves are greatly enhanced (to withstand the severe process requirements expected back on-line), after carrying out maintenance services and quality tests on them.

Worst case scenarios of deteriorated valves can also be remedied or corrected; and this may require maintenance operations such as: component modification, machining, trim lapping, coating & blasting, resurfacing and polishing.

Valve services include:

- Control Valve Calibration/Bench Setting
- Relief Valve Maintenance & Certification
- Valve Pressure Testing
- Valve Leak Control & Flushing
- Online Preventive/Corrective Maintenance
- Offline Repairs
- Actuator Repairs & Stroking
- Valve Installations, Torqueing & Pipe Fitting
- Valve Procurement & Supply

Valve Types:

Ball Valves, Check Valves, Control Valves, Relief Valves, Gate Valves, Plug Valves, Butterfly Valves, Globe Valves, Diaphragm Valves etc.

Visit **www.brentforth.com** for more information

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Appendix: A

ABRASIVES & GRIT SIZES

Note 1:

The **lapping fluid** must be selected carefully. If the lapping fluid (e.g. oil), is too viscous, the film formed will be very thick, and if the grains are too small, then their tips protrude insufficiently from the film (hence, little or no work shall be done during lapping). However, if the film is too thin, then their protrusion will be too much (which will allow for metal-to-metal contact between the working plate and work-piece).

The Rule of Thumb:

GRAIN DESCRIPTION	SUITABLE FLUID TYPE
Large lapping grains	Thick (or viscous) lapping fluid
Small or fine lapping grains	Thin (or less-viscous) lapping fluid

Note 2:

The type of fluid used for lapping also depends on the type of lapping stone or work-piece material. When the work-piece is Aluminum, Brass, or Copper, a water-soluble compound is used. When the work-piece is Cast Iron, Hardened Steel or Tool Steel, a weak oil or grease-based fluid is often used.

The Rule of Thumb:

WORK MATERIAL	LAPPING FLUID
Aluminum	Water-Soluble Compounds
Brass	Water-Soluble Compounds
Cast Iron	Oil– or Grease-Based Compds.
Stainless Steel	Oil– or Grease-Based Compds.
Mild Steel	Oil– or Grease-Based Compds.

GRIT SIZE	PARTICLE DESCRIPTION
36	Very Coarse
50	
80	Coarse
100	
120	
150	Medium
180	
220	Medium Fine
240	
280	Fine
320	
400	Very Fine
500	
600	
800	Extremely Fine
1000	
1200	

ABRASIVE MATERIALS & APPLICATIONS

ABRASIVE MATERIALS	GRIT SIZE	APPLICATIONS
Silicon Carbide	100 - 400	- Tool-room lapping
	600 - 1000	- Roughing hard steels
Corundum	400 - 800	- Roughing and Finishing soft steels
Garnet	600 - 800	- Finishing Brass and Bronze
Ferric Oxide	1 Micron	- Polishing soft metals
Aluminum Oxide	400 - 900	- Finishing of soft steel & Non-ferrous metals
Diamond	0.5 - 20 Microns	- Hardened materials

▸ Appendix: B

FLANGES & BOLT DIMENSIONS

Pipe Sizes		CLASS 150#					CLASS 300#				
		No. of Bolts	Diameter of Bolts (inches)	Length for **RF**		Length for **RTJ**	No. of Bolts	Diameter of Bolts (inches)	Length for **RF**		Length for **RTJ**
DN (mm)	**NPS** (inches)			Stud Bolts (mm)	Machine Bolts (mm)	Stud Bolts (mm)			Stud Bolts (mm)	Machine Bolts (mm)	Stud Bolts (mm)
15	**1/2"**	4	1/2"	60	55	-	4	1/2"	65	60	80
20	**3/4"**	4	1/2"	65	55	-	4	5/8"	80	65	95
25	**1"**	4	1/2"	65	60	80	4	5/8"	80	65	95
32	**1-1/4"**	4	1/2"	75	60	85	4	5/8"	90	75	100
40	**1-1/2"**	4	1/2"	75	65	85	4	3/4"	95	80	105
50	**2"**	4	5/8"	90	75	100	8	5/8"	95	80	105
65	**2-1/2"**	4	5/8"	95	80	105	8	3/4"	105	90	120
80	**3"**	4	5/8"	95	80	105	8	3/4"	110	95	125
90	**3-1/2"**	8	5/8"	95	80	105	8	3/4"	110	100	130
100	**4"**	8	5/8"	95	80	105	8	3/4"	120	100	130
150	**6"**	8	3/4"	105	85	120	12	3/4"	125	110	145
200	**8"**	8	3/4"	120	95	125	12	7/8"	145	125	155
250	**10"**	12	7/8"	120	105	130	16	1"	165	145	180
300	**12"**	12	7/8"	125	105	140	16	1-1/8"	180	150	190
350	**14"**	12	1"	140	120	150	20	1-1/8"	185	165	195
400	**16"**	16	1"	140	120	150	20	1-1/4"	195	170	210
450	**18"**	16	1-1/8"	150	130	155	24	1-1/4"	200	175	215
500	**20"**	20	1-1/8"	165	145	175	24	1-1/4"	210	190	225
550	**22"**	20	1-1/4"	170	145	185	24	1-1/2"	225	195	250
600	**24"**	20	1-1/4"	180	155	190	24	1-1/2"	230	210	260
650	**26"**	24	1-1/4"	185	155	-	28	1-5/8"	260	225	285
700	**28"**	28	1-1/4"	185	155	-	28	1-5/8"	270	240	295
750	**30"**	28	1-1/2"	190	165	-	28	1-3/4"	290	260	315
800	**32"**	28	1-1/2"	210	175	-	28	1-7/8"	310	270	340
850	**34"**	32	1-1/2"	210	185	-	28	1-7/8"	315	280	350
900	**36"**	32	1-1/2"	215	185	-	32	2"	330	290	360
950	**38"**	-	1-1/2"	-	-	-	-	-	-	-	-
1,000	**40"**	-	1-1/2"	-	-	-	-	-	-	-	-
1,050	**42"**	36	1-1/2"	225	195	-	-	-	-	-	-

▸ Appendix: B *Continued*

FLANGES & BOLT DIMENSIONS

Pipe Sizes		CLASS 600#					CLASS 900#				
		No. of Bolts	Diameter of Bolts (inches)	Length for **RF**		Length for **RTJ**	No. of Bolts	Diameter of Bolts (inches)	Length for **RF**		Length for **RTJ**
DN (mm)	**NPS** (inches)			Stud Bolts (mm)	Machine Bolts (mm)	Stud Bolts (mm)			Stud Bolts (mm)	Machine Bolts (mm)	Stud Bolts (mm)
15	**1/2"**	4	1/2"	80	75	80	4	3/4"	110	105	110
20	**3/4"**	4	5/8"	95	90	95	4	3/4"	120	110	120
25	**1"**	4	5/8"	95	90	95	4	7/8"	130	125	130
32	**1-1/4"**	4	5/8"	100	95	100	4	7/8"	130	125	130
40	**1-1/2"**	4	3/4"	110	105	110	4	1"	145	140	145
50	**2"**	8	5/8"	110	105	110	8	7/8"	150	145	150
65	**2-1/2"**	8	3/4"	125	120	125	8	1"	165	155	165
80	**3"**	8	3/4"	130	125	130	8	7/8"	150	145	150
90	**3-1/2"**	8	7/8"	145	140	145	-	-	-	-	-
100	**4"**	8	7/8"	150	145	150	8	1-1/8"	180	170	180
150	**6"**	12	1"	180	170	180	12	1-1/8"	195	190	200
200	**8"**	12	1-1/8"	195	190	200	12	1-3/8	225	220	225
250	**10"**	16	1-1/8"	220	215	220	16	1-3/8"	240	230	240
300	**12"**	20	1-1/4"	225	220	225	20	1-3/8"	260	250	260
350	**14"**	20	1-3/8"	240	230	240	20	1-1/2"	280	270	285
400	**16"**	20	1-1/2"	260	250	260	20	1-5/8"	290	285	300
450	**18"**	20	1-5/8"	280	270	280	20	1-7/8"	330	325	340
500	**20"**	24	1-5/8"	290	285	300	20	2"	335	350	365
550	**22"**	24	1-3/4"	310	305	325	-	-	-	-	-
600	**24"**	24	1-7/8"	335	330	340	20	2-1/2"	445	440	465
650	**26"**	28	1-7/8"	340	-	335	20	2-3/4"	450	-	485
700	**28"**	28	2"	335	-	365	20	3"	475	-	505
750	**30"**	28	2"	360	-	375	20	3"	485	-	515
800	**32"**	28	2-1/4"	380	-	400	20	3-1/4"	515	-	545
850	**34"**	28	2-1/4"	385	-	405	20	3-1/2"	540	-	580
900	**36"**	28	2-1/2"	405	-	425	20	3-1/2"	555	-	595
950	**38"**	-	-	-	-	-	-	-	-	-	-
1,000	**40"**	-	-	-	-	-	-	-	-	-	-
1,050	**42"**	-	-	-	-	-	-	-	-	-	-

▸ Appendix: B *Continued*

FLANGES & BOLT DIMENSIONS

Pipe Sizes		CLASS 1500#					CLASS 2500#				
		No. of Bolts	Diameter of Bolts (inches)	Length for **RF**		Length for **RTJ**	No. of Bolts	Diameter of Bolts (inches)	Length for **RF**		Length for **RTJ**
DN (mm)	**NPS** (inches)			Stud Bolts (mm)	Machine Bolts (mm)	Stud Bolts (mm)			Stud Bolts (mm)	Machine Bolts (mm)	Stud Bolts (mm)
15	**1/2"**	4	3/4"	110	105	110	4	3/4"	125	120	125
20	**3/4"**	4	3/4"	120	110	120	4	3/4"	130	125	130
25	**1"**	4	7/8"	130	125	130	4	7/8"	145	140	145
32	**1-1/4"**	4	7/8"	130	125	130	4	1"	155	150	155
40	**1-1/2"**	4	1"	145	140	145	4	1-1/8"	180	170	180
50	**2"**	8	7/8"	150	145	150	8	1"	185	180	185
65	**2-1/2"**	8	1"	165	155	165	8	1-1/8"	200	195	210
80	**3"**	8	1-1/8"	185	180	185	8	1-1/4"	225	220	230
90	**3-1/2"**	-	-	-	-	-	-	-	-	-	-
100	**4"**	8	1-1/4"	200	195	200	8	1-1/2"	260	250	265
150	**6"**	12	1-3/8"	265	260	270	8	2"	350	340	360
200	**8"**	12	1-5/8"	300	290	330	12	2"	390	380	400
250	**10"**	12	1-7/8"	340	335	350	12	2-1/2"	495	490	515
300	**12"**	16	2"	380	375	395	12	2-3/4"	545	540	565
350	**14"**	16	2-1/4"	415	405	430	-	-	-	-	-
400	**16"**	16	2-1/2"	450	445	475	-	-	-	-	-
450	**18"**	16	2-3/4"	505	495	535	-	-	-	-	-
500	**20"**	16	3"	545	540	580	-	-	-	-	-
550	**22"**	-	-	-	-	-	-	-	-	-	-
600	**24"**	16	3-1/2"	620	615	655	-	-	-	-	-
650	**26"**	-	-	-	-	-	-	-	-	-	-
700	**28"**	-	-	-	-	-	-	-	-	-	-
750	**30"**	-	-	-	-	-	-	-	-	-	-
800	**32"**	-	-	-	-	-	-	-	-	-	-
850	**34"**	-	-	-	-	-	-	-	-	-	-
900	**36"**	-	-	-	-	-	-	-	-	-	-
950	**38"**	-	-	-	-	-	-	-	-	-	-
1,000	**40"**	-	-	-	-	-	-	-	-	-	-
1,050	**42"**	-	-	-	-	-	-	-	-	-	-

▸ Appendix: C

SPANNERS & BOLT DATA

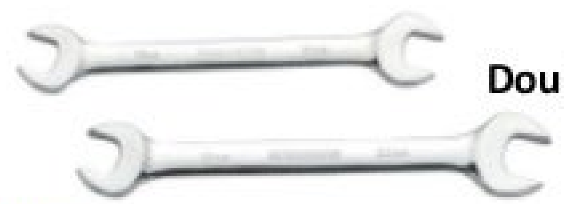
BOLT DIAMETER (inches)	SPANNER SIZE	
	Imperial (inches)	Metric (mm)
1/2	7/8	22
5/8	1-1/16	27
3/4	1-1/4	32
7/8	1-7/16	36
1	1-5/8	41
1-1/8	1-13/16	46
1-1/4	2	51
1-3/8	2-3/16	56
1-1/2	2-3/8	60
1-5/8	2-9/16	65
1-3/4	2-3/4	70
1-7/8	2-15/16	75
2	3-1/8	80
2-1/4	3-1/2	89
2-1/2	3-7/8	99
2-3/4	4-1/4	108
3	4-5/8	118
3-1/4	5	127
3-1/2	5-3/8	137
3-3/4	5-3/4	145
4	6-1/8	155

Inch/Metric Bolting interchangeable for ANSI B16.5 Flanges	
Imperial	**Metric**
1/2”	M 14
5/8”	M 18
3/4”	M 20
7/8”	M 24
1”	M 27
1-1/8”	M 30
1-1/4”	M 33
1-3/8”	M 36
1-1/2”	M 39
1-5/8”	M 42
1-3/4”	M 45
1-7/8”	M 48
2”	M 52
2-1/4”	M 56
2-1/2”	M 64
2-3/4”	M 72


Combination Spanner


Double Ended Ring Spanner

**Ring Ends are more suitable for Stiff or High Torque applications.*


Double Ended Open/Flat Spanner

Note: *Flat or Open End spanners are not meant for High Torque applications.*


Ratchet Spanner

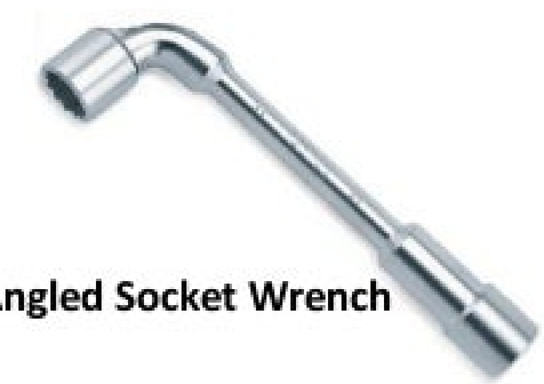

Chain Wrench


Strap Wrench


Slogging Wrench

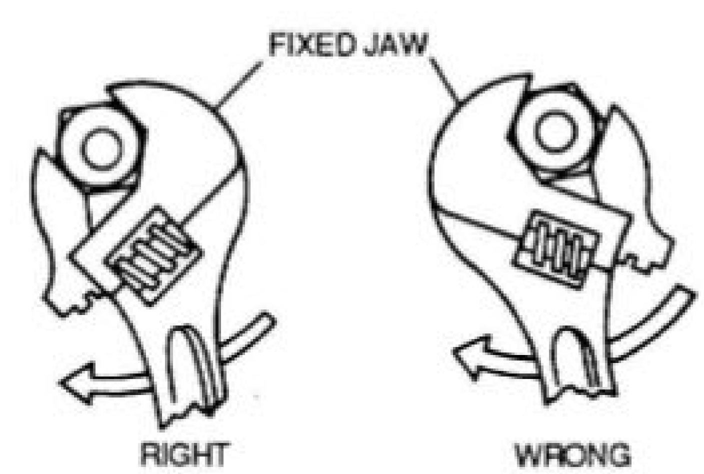

Swivel Head Wrench


Deep Socket Wrench


Angled Socket Wrench


Adjustable Spanner

USAGE GUIDE ➡




Allen Spanner/Hex Key


Hook Spanner


Crow Ring Spanner

▸ Appendix: D

WEIGHT OF VALVES & LIFTING GUIDE

CLASS 150# (FULL BORE)			
Valve Sizes		Weight	
		Full Bore	
(in)	*(mm)*	Kg	*lb*
2	*50*	28	*62*
3	*80*	55	*121*
4	*100*	88	*194*
6	*150*	162	*357*
8	*200*	255	*562*
10	*250*	385	*849*
12	*300*	559	*1232*
14	*350*	765	*1687*
16	*400*	1025	*2260*
18	*450*	1220	*2690*
20	*500*	1795	*3957*
22	*550*	2360	*5203*
24	*600*	3105	*6845*
26	*650*	3695	*8146*
28	*700*	4495	*9910*
30	*750*	5520	*11508*
32	*800*	6795	*14980*
34	*850*	7995	*17626*
36	*900*	8795	*19389*
40	*1000*	12550	*27668*
42	*1050*	14270	*31495*
48	*1200*	21890	*48258*
56	*1400*	34090	*75145*

FORGED STEEL BALL VALVES

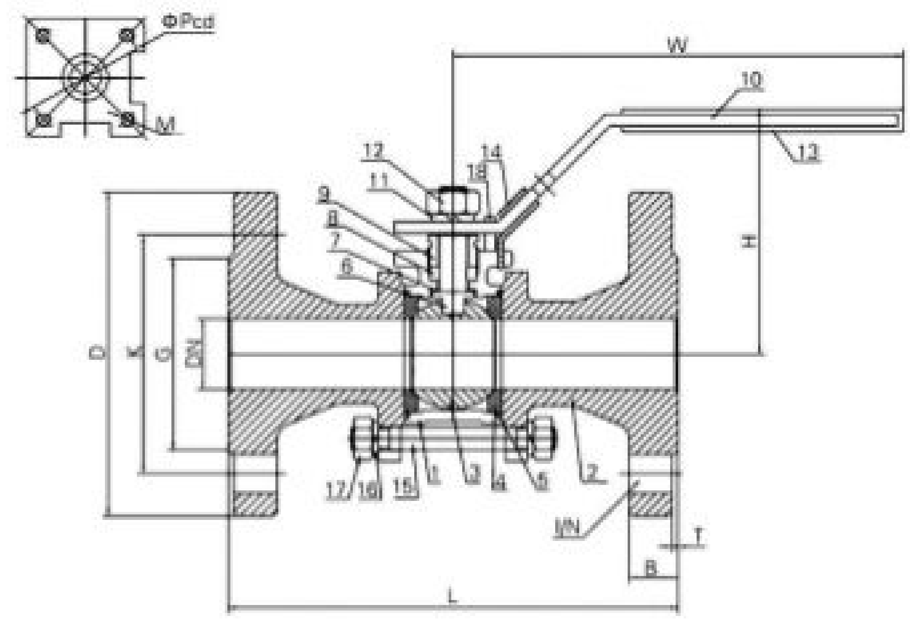
- These figures are specifically for ball valves, but could be used as a rough guide in handling other valve types.

CLASS 150# (REDUCED BORE)			
Valve Sizes		Weight	
		Full Bore	
(in)	*(mm)*	Kg	*lb*
2 x 1 1/2	*50 x 40*	27	*60*
3 x 2	*80 x 50*	32	*71*
4 x 3	*100 x 80*	62	*137*
6 x 4	*150 x 100*	101	*223*
8 x 6	*200 x 150*	186	*410*
10 x 8	*250 x 200*	293	*646*
12 x 10	*300 x 250*	465	*1025*
14 x 12	*350 x 300*	615	*1356*
16 x 12	*400 x 300*	699	*1541*
18 x 16	*450 x 400*	1063	*2343*
20 x 16	*500 x 400*	1111	*2449*
24 x 20	*600 x 500*	1972	*4347*
30 x 24	*750 x 600*	3249	*7163*
36 x 30	*900 x 750*	6315	*13922*

▸ Appendix: D *Continued*

WEIGHT OF VALVES & LIFTING GUIDE

CLASS 300# (FULL BORE)			
Valve Sizes		Weight Full Bore	
(in)	*(mm)*	Kg	*lb*
2	*50*	28	*62*
3	*80*	55	*121*
4	*100*	93	*205*
6	*150*	183	*403*
8	*200*	280	*617*
10	*250*	502	*1107*
12	*300*	735	*1620*
14	*350*	1030	*2271*
16	*400*	1419	*3128*
18	*450*	1594	*3514*
20	*500*	2198	*4846*
22	*550*	2791	*6153*
24	*600*	3462	*7632*
26	*650*	4669	*10293*
28	*700*	5768	*12716*
30	*750*	6595	*14539*
32	*800*	7939	*17502*
34	*850*	9045	*19940*
36	*900*	10097	*22260*
40	*1000*	13777	*30373*
42	*1050*	16109	*35514*
48	*1200*	24055	*53031*
56	*1400*	38155	*84116*

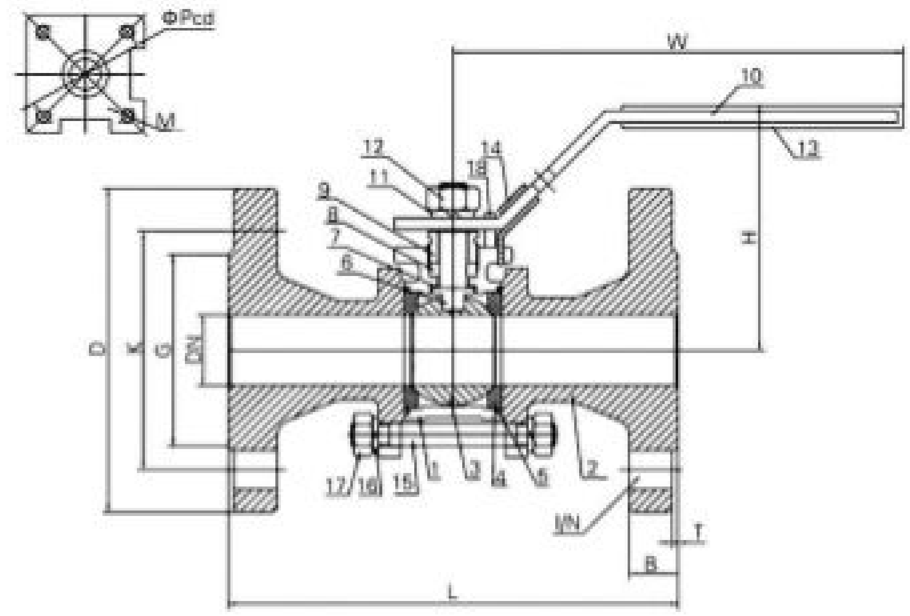


CLASS 300# (REDUCED BORE)			
Valve Sizes		Weight Full Bore	
(in)	*(mm)*	Kg	*lb*
2 x 1 1/2	*50 x 40*	27	*60*
3 x 2	*80 x 50*	33	*73*
4 x 3	*100 x 80*	63	*139*
6 x 4	*150 x 100*	114	*251*
8 x 6	*200 x 150*	218	*481*
10 x 8	*250 x 200*	293	*646*
12 x 10	*300 x 250*	595	*1312*
14 x 12	*350 x 300*	815	*1797*
16 x 12	*400 x 300*	967	*2132*
18 x 16	*450 x 400*	1591	*3507*
20 x 16	*500 x 400*	1661	*3662*
24 x 20	*600 x 500*	2666	*5877*
30 x 24	*750 x 600*	4481	*9879*
36 x 30	*900 x 750*	8181	*18036*

▸ Appendix: D *Continued*

WEIGHT OF VALVES & LIFTING GUIDE

CLASS 600# (FULL BORE)			
Valve Sizes		**Weight**	
		Full Bore	
(in)	*(mm)*	Kg	*lb*
2	*50*	33	*73*
3	*80*	64	*141*
4	*100*	115	*254*
6	*150*	255	*562*
8	*200*	488	*1076*
10	*250*	760	*1675*
12	*300*	1069	*2357*
14	*350*	1085	*2392*
16	*400*	1526	*3364*
18	*450*	2099	*4627*
20	*500*	2639	*5818*
22	*550*	3786	*8347*
24	*600*	4737	*10443*
26	*650*	5645	*12445*
28	*700*	6759	*14901*
30	*750*	8379	*18472*
32	*800*	9739	*21470*
34	*850*	11339	*24998*
36	*900*	13289	*29297*
40	*1000*	18339	*40430*
42	*1050*	21359	*47088*
48	*1200*	32001	*70549*
56	*1400*	47489	*104694*

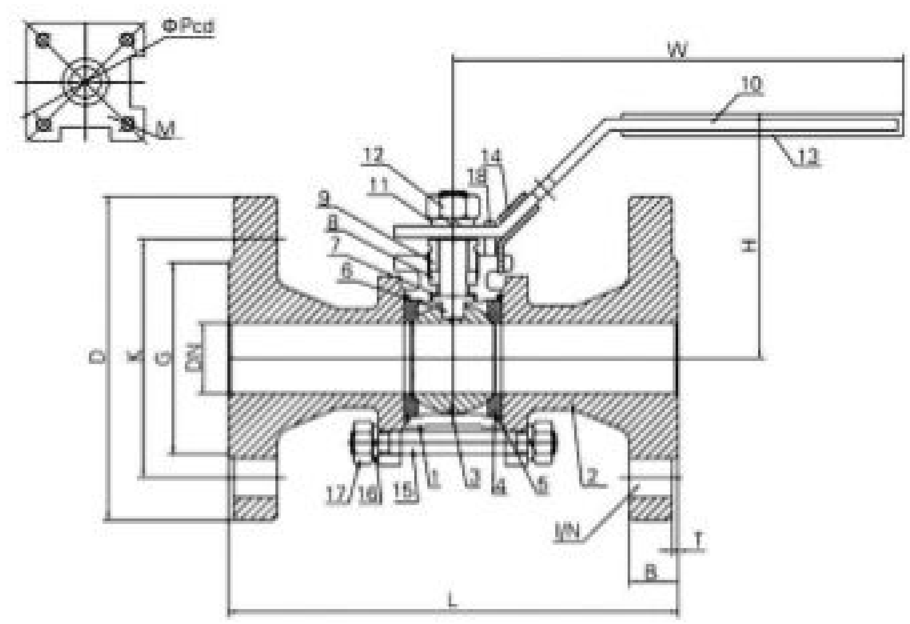


CLASS 600# (REDUCED BORE)			
Valve Sizes		**Weight**	
		Full Bore	
(in)	*(mm)*	Kg	*lb*
2 x 1 1/2	*50 x 40*	32	*71*
3 x 2	*80 x 50*	41	*90*
4 x 3	*100 x 80*	81	*179*
6 x 4	*150 x 100*	153	*337*
8 x 6	*200 x 150*	297	*655*
10 x 8	*250 x 200*	553	*1219*
12 x 10	*300 x 250*	813	*1792*
14 x 12	*350 x 300*	1147	*2529*
16 x 12	*400 x 300*	1351	*2978*
18 x 16	*450 x 400*	1689	*3724*
20 x 16	*500 x 400*	2075	*4575*
24 x 20	*600 x 500*	3251	*7167*
30 x 24	*750 x 600*	5799	*12784*
36 x 30	*900 x 750*	10379	*22881*

▸ Appendix: D *Continued*

WEIGHT OF VALVES & LIFTING GUIDE

CLASS 900# (FULL BORE)			
Valve Sizes		**Weight**	
		Full Bore	
(in)	*(mm)*	Kg	*lb*
2	*50*	51	*112*
3	*80*	57	*126*
4	*100*	147	*324*
6	*150*	362	*798*
8	*200*	582	*1283*
10	*250*	1012	*2231*
12	*300*	1512	*3333*
14	*350*	1552	*3422*
16	*400*	2165	*4773*
18	*450*	2826	*6230*
20	*500*	4208	*9277*
24	*600*	6806	*15004*
28	*700*	9910	*21847*
30	*750*	12185	*26863*
32	*800*	12820	*28263*
34	*850*	17205	*37930*
36	*900*	18902	*41671*



CLASS 900# (REDUCED BORE)			
Valve Sizes		**Weight**	
		Full Bore	
(in)	*(mm)*	Kg	*lb*
2 x 1 1/2	*50 x 40*	43	*95*
3 x 2	*80 x 50*	55	*121*
4 x 3	*100 x 80*	97	*214*
6 x 4	*150 x 100*	206	*454*
8 x 6	*200 x 150*	442	*974*
10 x 8	*250 x 200*	699	*1541*
12 x 10	*300 x 250*	1156	*2549*
14 x 12	*350 x 300*	1639	*3613*
16 x 12	*400 x 300*	1732	*3818*
18 x 16	*450 x 400*	2444	*5388*
20 x 16	*500 x 400*	2879	*6347*
24 x 20	*600 x 500*	5402	*11909*
30 x 24	*750 x 600*	8706	*19193*
36 x 30	*900 x 750*	15361	*33865*

Appendix: D *Continued*

WEIGHT OF VALVES & LIFTING GUIDE

CLASS 1500# (FULL BORE)			
Valve Sizes		Weight	
		Full Bore	
(in)	*(mm)*	Kg	*lb*
2	*50*	52	*115*
3	*80*	99	*218*
4	*100*	200	*441*
6	*150*	482	*1063*
8	*200*	823	*1814*
10	*250*	1503	*3313*
12	*300*	2253	*4967*
14	*350*	2857	*6299*
16	*400*	4072	*8977*

CLASS 1500# (REDUCED BORE)			
Valve Sizes		Weight	
		Full Bore	
(in)	*(mm)*	Kg	*lb*
2 x 1 1/2	*50 x 40*	43	*95*
3 x 2	*80 x 50*	69	*152*
4 x 3	*100 x 80*	125	*276*
6 x 4	*150 x 100*	287	*633*
8 x 6	*200 x 150*	568	*1252*
10 x 8	*250 x 200*	1023	*2255*
12 x 10	*300 x 250*	1763	*3887*
14 x 12	*350 x 300*	2503	*5518*
16 x 12	*400 x 300*	2811	*6197*

CLASS 2500# (FULL BORE)			
Valve Sizes		Weight	
		Full Bore	
(in)	*(mm)*	Kg	*lb*
2	*50*	89	*196*
3	*80*	189	*417*
4	*100*	383	*844*
6	*150*	773	*1704*
8	*200*	1359	*2996*
10	*250*	2103	*4636*
12	*300*	3213	*7083*

CLASS 2500# (REDUCED BORE)			
Valve Sizes		Weight	
		Full Bore	
(in)	*(mm)*	Kg	*lb*
2 x 1 1/2	*50 x 40*	67	*148*
3 x 2	*80 x 50*	157	*346*
4 x 3	*100 x 80*	267	*589*
6 x 4	*150 x 100*	513	*1131*
8 x 6	*200 x 150*	1093	*2410*
10 x 8	*250 x 200*	1667	*3675*
12 x 10	*300 x 250*	2559	*5642*

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