



# STATE-OF-THE-ART REPORT

## ON

# RECOMMENDATIONS FOR THE SELECTION AND SPECIFICATION OF VALVES FOR BALANCE OF PLANT SYSTEMS IN LIQUID METAL REACTORS.

FINAL REPORT

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## ABSTRACT

This report reviews recent developments that have been made in the valve industry, provides recommendations for the restriction and standardization of valve selection, and identifies simplifications for procurement specifications.

It was determined that of the approximately 5000 non-nuclear valves in a power plant, 90 percent will lend themselves to standardization. Restrictions in valve types, sizes, and pressure ratings are suggested. The report advocates broader application of rotary valves (ball and butterfly in particular) for both on/off and flow control applications. The implementation of the standardization suggestions are shown to result in significant savings both during the initial procurement and over the life of the plant.

Drawing from the experience on the Clinch River Project simplifications to procurement specifications are suggested to make the specifications more attractive to vendors without jeopardizing the quality of the delivered product.

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## 1.0 Introduction:

This study was initiated as part of an effort by the Department of Energy to evaluate (a) the advances made by valve manufacturers, and (b) the experience and practices of nuclear and non-nuclear industries with respect to valves used for non-special applications. The study had two objectives:

- (1) To provide recommendations for the restriction and standardization of valve selection.
- (2) To simplify valve procurement specifications.

It was not the intent of the study to recommend a particular manufacturer or valve design but to identify the preferred types for general application and to identify restrictions for system designers in selecting valve sizes and ratings.

The multiplicity of components used in a power plant is a problem faced by the breeder program along with the rest of the power industry. To date no concerted effort has been made to reduce the various types of basic components used in a power plant in that the components selected for an application are a function of the peculiar requirements of that application and little or no consideration has been given to the use or substitution of perhaps less specific, but more standard components. Based on the experience with the Clinch River Project as much as 10 percent of the nearly 10,000 valves on a nuclear power project may be 1, 2 or 3 of a kind.

This percentage does not include sodium valves, main steam isolation valves, high pressure and temperature feed water regulator valves, relief valves, and check valves which are purchased separately. The specialized valves were not included in the study as they offered little prospect for standardization.

In addition to complicating the initial procurement, the extensive variety of components complicates the problem of spare parts support. Obviously, a wider variety of components require a wider variety of maintenance spare parts. This in turn requires larger warehousing facilities, and compounds the procurement of the spare parts.

Personnel at the Fast Flux Test Facility (FFTF) have noted that the procurement of replacement/spare parts is a particular problem. When replacing valves that are unique but which were purchased as part of a major contract, it has been found that the replacement costs have escalated to a point where they are prohibitive or, at best, excessive. Accordingly, it is in the interest of a project to maximize the use of standard components, to avoid 1, 2 or 3 of a kind type valves, and when practicable, to buy in quantity. To this end the study focused on ways to reduce the variety of valve types, sizes, and ratings.

Increased maintenance training and increased maintenance time are other problems resulting from an overly extensive array of diverse components. According to Reference 1 fully 30 percent of total plant maintenance is devoted to the repair and replacement of valves. Clearly the greater the number of different components in a plant, the more components maintenance personnel must learn to service and repair. The simple repacking of a

valve can present problems to repair personnel. How is the packing accessed? How is it removed? What replacement packing is used? How many rings? How are they arranged? Where does the lantern ring go? Ad infinitum. A mistake in any of the many minor steps may lead to a leaking or improperly operating valve which can in turn lead to expensive downtime. The standardization of valves would go a long way toward reducing this problem which would contribute to improved quality of valve maintenance and reduced down time.

The nuclear industry is aggressively pursuing the development of artificial intelligence to facilitate remote maintenance of equipment, i.e., robots. The myriad manipulations required in the performance of routine maintenance is one of the numerous factors that must be overcome before remote maintenance can be generally applied. By instituting a standard valve design the task of developing a competent robot would be simplified. Ideally, the valve design selected would be able to remain in line while maintenance is performed. This would eliminate the necessity to break into the piping system or to spring the piping to remove the valve. If all valves were similar, the manipulations required by a robot to effect repairs would be similar, thereby simplifying the task of controlling the device.

One of the problems of specification bidability in the breeder program stemmed from an overall plant design criterion (Reference 2) established at the beginning of the Clinch River Project which stated that, where practical, the availability of the secondary or balance of plant systems would be 96 percent. In an effort to achieve this high availability one of the

steps taken was to impose on suppliers for secondary equipment quality criteria that were similar to those imposed for nuclear systems. This was intended to significantly reduce secondary plant failures and help meet the plant availability criterion.

In order to support the policy established above, the CRBRP established strict fabrication, quality assurance, painting, and packaging requirements and had them included in its procurement specifications for both nuclear and non-nuclear components. The criteria imposed called for extensive welding requirements beyond those imposed by the ASME Boiler and Pressure Vessel Code and ANSI codes, including details concerning storage of electrodes, welder qualification, and repair welding. Criteria concerning painting, shipping and storage of equipment were also spelled out in detail. Although the intention of the criteria imposed was to obtain higher quality valves, the manufacturers were generally willing to provide off-the-shelf valves only. Accordingly, the additional criteria proved to serve no real purpose. Vendors would provide secondary plant components to meet these new quality criteria only if the purchaser was willing to pay a premium price for them.

The improvement in quality that resulted was small in comparison with the additional costs associated with these specification requirements. Many manufacturers when presented with a request for proposal which included major quality criteria either declined to bid or included a large factor for uncertainty.

This study reviewed the specifications written for non-safety related components of the Clinch River Breeder Reactor Plant and provides recom-

mended changes to make the specifications less design-oriented, and thereby, make the specifications more attractive to potential bidders.

The balance of plant (BOP) systems of a breeder reactor plant are similar to the BOP systems of a pressurized water reactor (PWR). As fully 50 percent of the valves in a plant (be it an LMFBR or PWR) are in the BOP and as most of these valves are not safety related, they are considered to have the greatest potential for standardization.

Although this study was initiated for the purpose of identifying cost saving measures for breeder reactors, as the study progressed it became apparent that the results would be applicable to conventional power plants as well as breeder reactor plants. Accordingly, the study has utilized data and information that was available for light water reactors in addition to that for breeder reactors in arriving at its conclusions.

## 2.0 Background Discussion

As an engineer designs a system and determines those parameters associated with a particular component he must select the component from a menu of available types, sizes, ratings and materials. The design engineer's major goal is to find the valve or valves which best suit the particular and specific requirements of the system or subsystem for which he is responsible. The impact of this local decision on the overall plant economics, procurement policies, plant spare parts program, and maintenance requirements are not apparent to him. In addition, the designer does not have foreknowledge of future uses and applications of his equipment which may affect the operation of his system or the valve requirements for it.

In light of this experience it was proposed that a nuclear plant could realize considerable savings by limiting the variety of valve types, sizes and ratings used in the plant's design. To this end this study was initiated by Burns and Roe for the Department of Energy to evaluate the practicality of standardizing valves and to provide recommendations toward achieving this goal. In addition, a review was conducted of the ancillary design, quality assurance, and packaging requirements to determine what, if any, simplifications could be made to procurement specifications to make them more acceptable to vendors without sacrificing the quality of the delivered product.

In order to evaluate whether the number of valve types can be reduced it would be beneficial to discuss briefly the different types of valves that are currently available and their important characteristics which might influence the recommendations made herein.

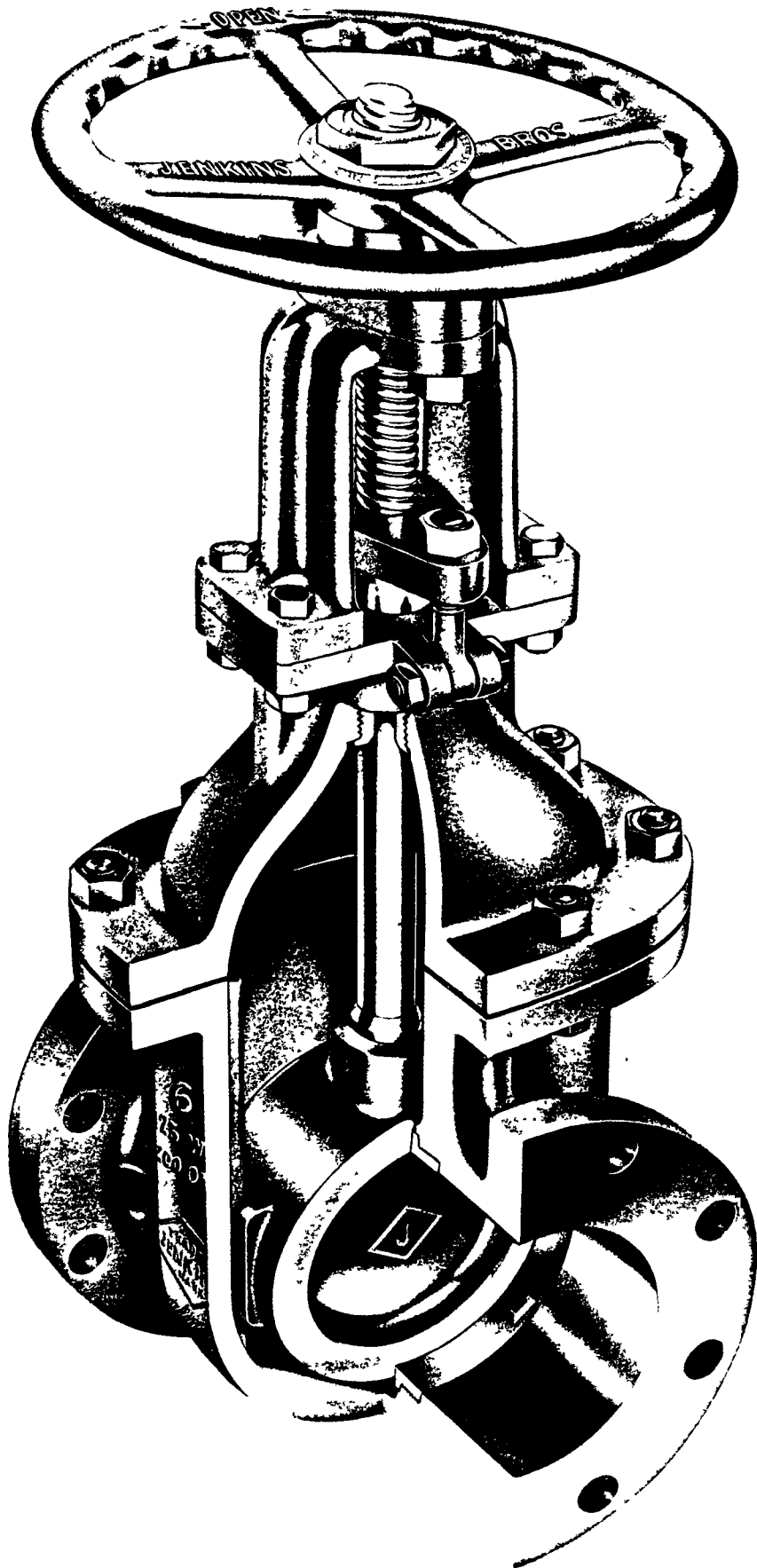
## 2.1 Valves

There are a variety of valves used in any power plant. Some have very specific functions or limited applications whereas others may serve a variety of functions. Generally, there are six types of valves used for throttling, control, or on/off service. They are: gate, globe, butterfly, ball, plug, and diaphragm. Any one type may have a number of variations. For example, one may have straight through globes, angle globes, wye type globes. The valve selected should be the least expensive for the life of the plant as well as serve the intended purpose. A brief description of the different valve types and their functions follows:

### 2.1.1 Gate Valves:

These valves (Figure 1) are used primarily to effect flow on/off service. They perform poorly as throttle valves because the disk tends to chatter and cause flow fluctuations. Gate valves are available in several disc designs such as solid wedge, flexible wedge, split wedge and parallel seat. The flexible wedge (Figure 2) consists of a solid disc with the areas behind the seating surfaces hollowed out to allow more flexibility to compensate for changes in seat alignment. This provides improved seating while maintaining the rigidity of the disc center membrane.

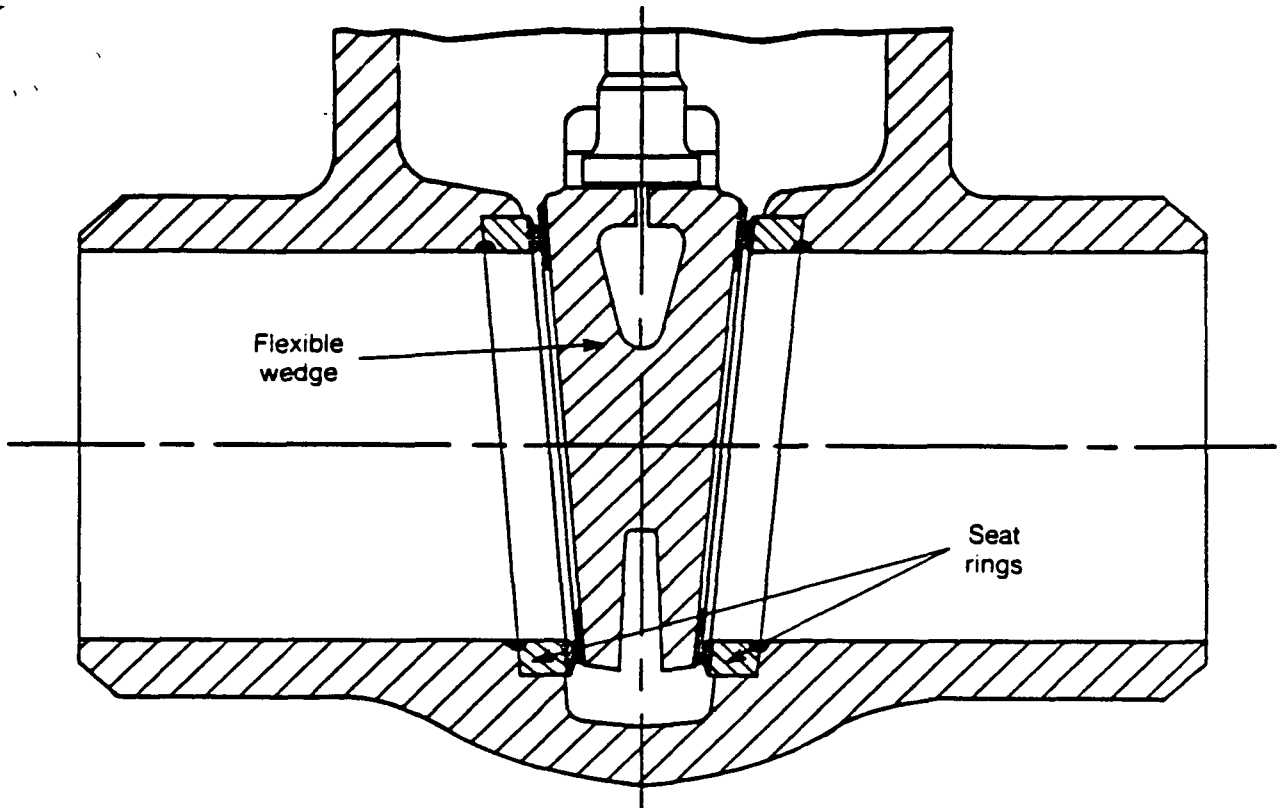
The double-disc, parallel-seat gate valve (Figure 3) is a departure from the wedge principle. As with all gate valves, upstream pressure forces the downstream seating surface against the body seat. The double-disc, parallel seat gate valve has additional seating force provided by the downward thrust of the actuator which forces the discs outward against



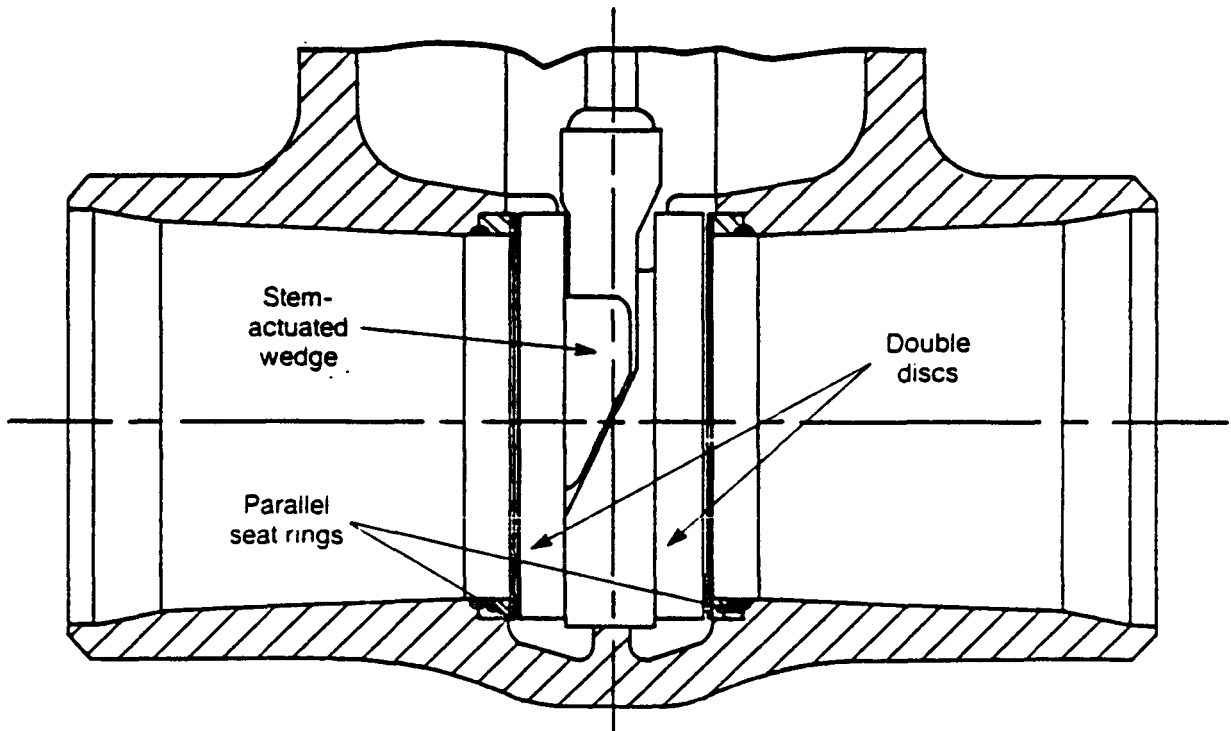
TYPICAL  
GATE  
VALVE

Source: Jenkins  
Catalogue 75BID

Figure 1



**Flexible-Wedge Gate Valve**  
**Figure 2**



**Double-Disc Parallel-Seat Gate Valve**  
**Figure 3**

their parallel body seats. Gate valves cause no change in flow direction and when fully open have little obstruction to fluid flow, thereby causing very little to no head loss. Gate valves have deep stem packing chambers that are characteristically hard to access. In comparison to other valves the gate valve requires large headroom for operation and maintenance as the valve body must accommodate the disc above the line of flow through the pipe.

### 2.1.2 Globe Valves:

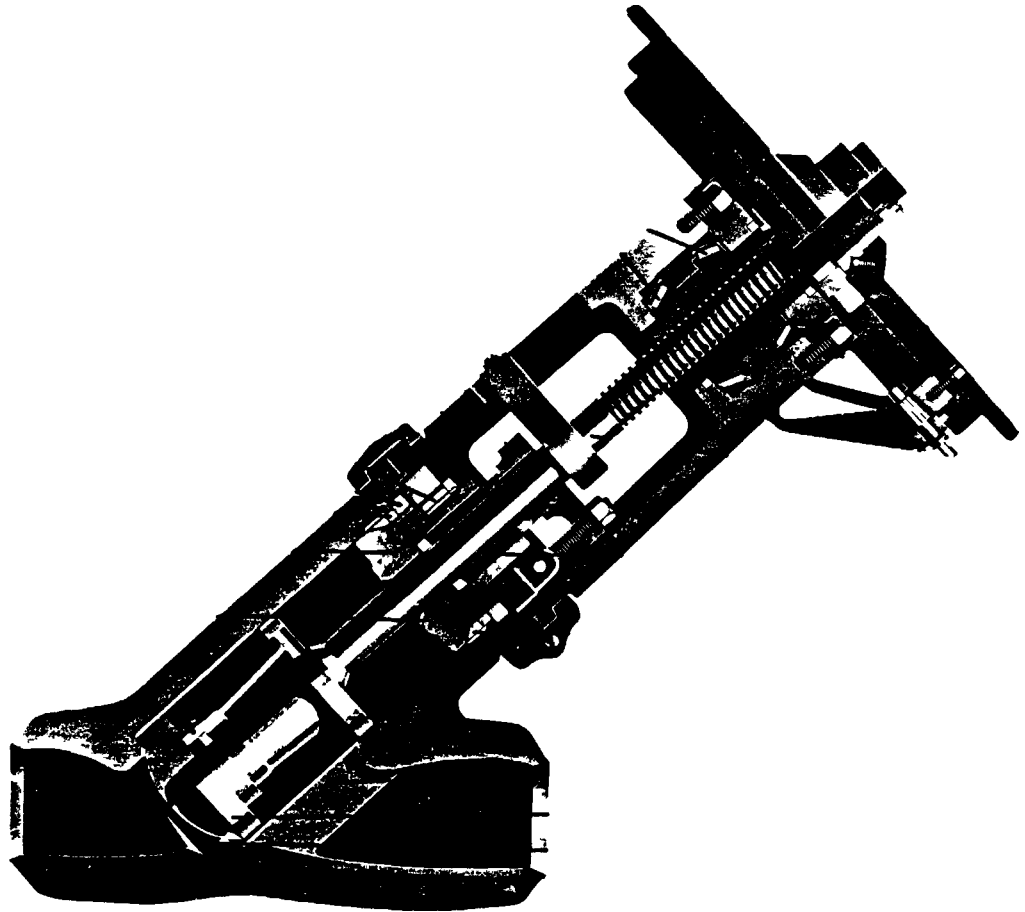
Globe valves are used for both flow isolation and throttling. The design of the valve (Figures 4 and 5) requires the fluid to make an "S" curve thereby causing head loss even in the full open position. The disc and seat arrangement is such that forces on the disc are axial to permit accurate throttling. Like the gate valve the stem packing requires a deep chamber. Wye pattern globe valves (Figure 5) reduce the head loss in the full open position by streamlining the flow path through the valve. Like the gate valve the globe valve requires substantial space above it to accommodate the rising stem and to permit access for maintenance. For throttling characteristics and corresponding trim design see Section 2.1.7.

### 2.1.3 Butterfly Valves:

Butterfly valves (Figures 6 and 7) provide good tight shut off and have minimal head loss when in the full open position. Their open design minimizes buildup of sediment and crud. Butterfly valves have two basic flange designs - the wafer type and the lug type. The wafer type (Figure 6) is designed to be held in place by compression between two flanges of the



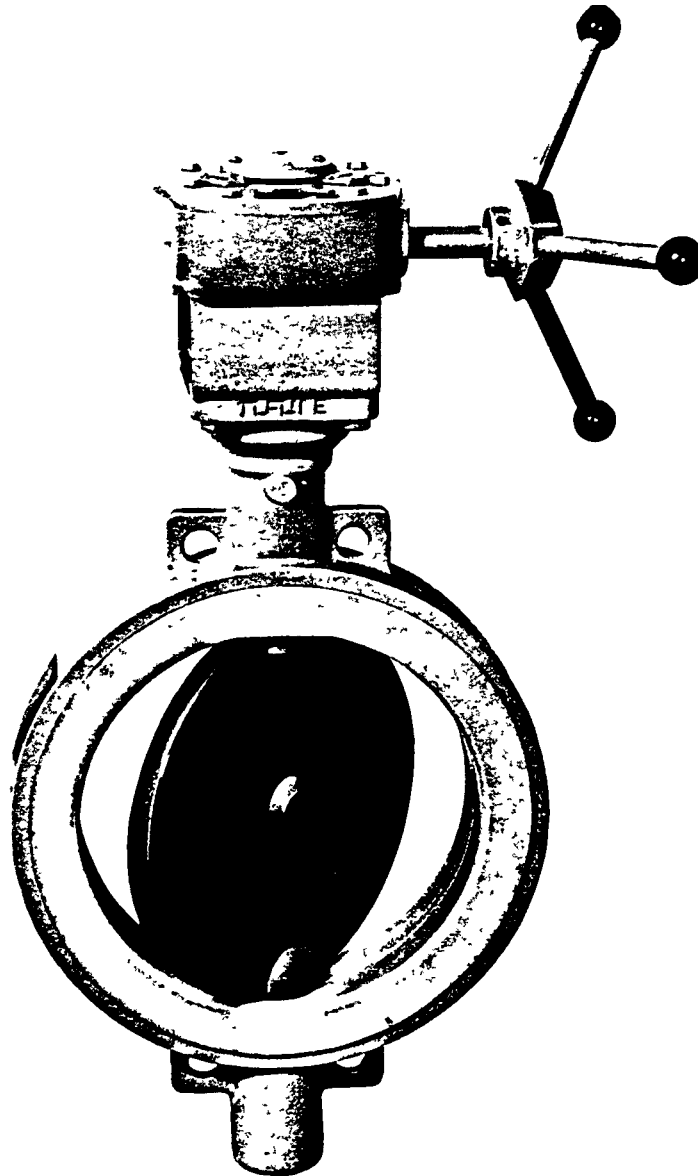
TYPICAL WYE PATTERN GLOBE VALVE



Source: Rockwell Catalogue V-5000R8

Figure 5

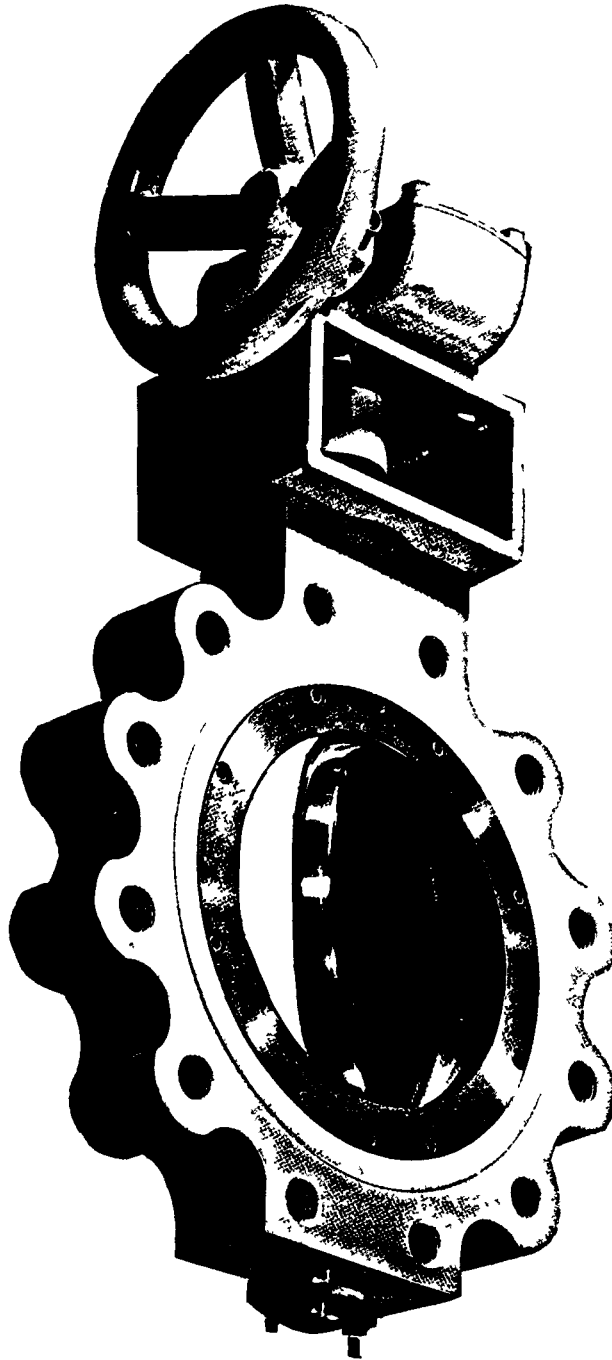
TYPICAL BUTTERFLY VALVE  
(WAFER TYPE)



Source: Tufline Catalogue 5

Figure 6

TYPICAL BUTTERFLY VALVE  
(LUG TYPE)



Source: Contromatics Catalogue 4500E

Figure 7

pipe. The lug type valve (Figure 7) is designed to act as a flange to which the piping is bolted. Historically, butterfly valves have not been used for throttling as they were unsteady between 60 degrees open and the fully open position. Modern butterfly valves have been greatly improved and are now capable of accurate throttling. Butterfly valves along with plug and ball valves have the advantage of rapid quarter turn on-off operation. Depending upon the manufacturer's design, some butterfly valves may have packing chambers as deep as gate and globe valves.

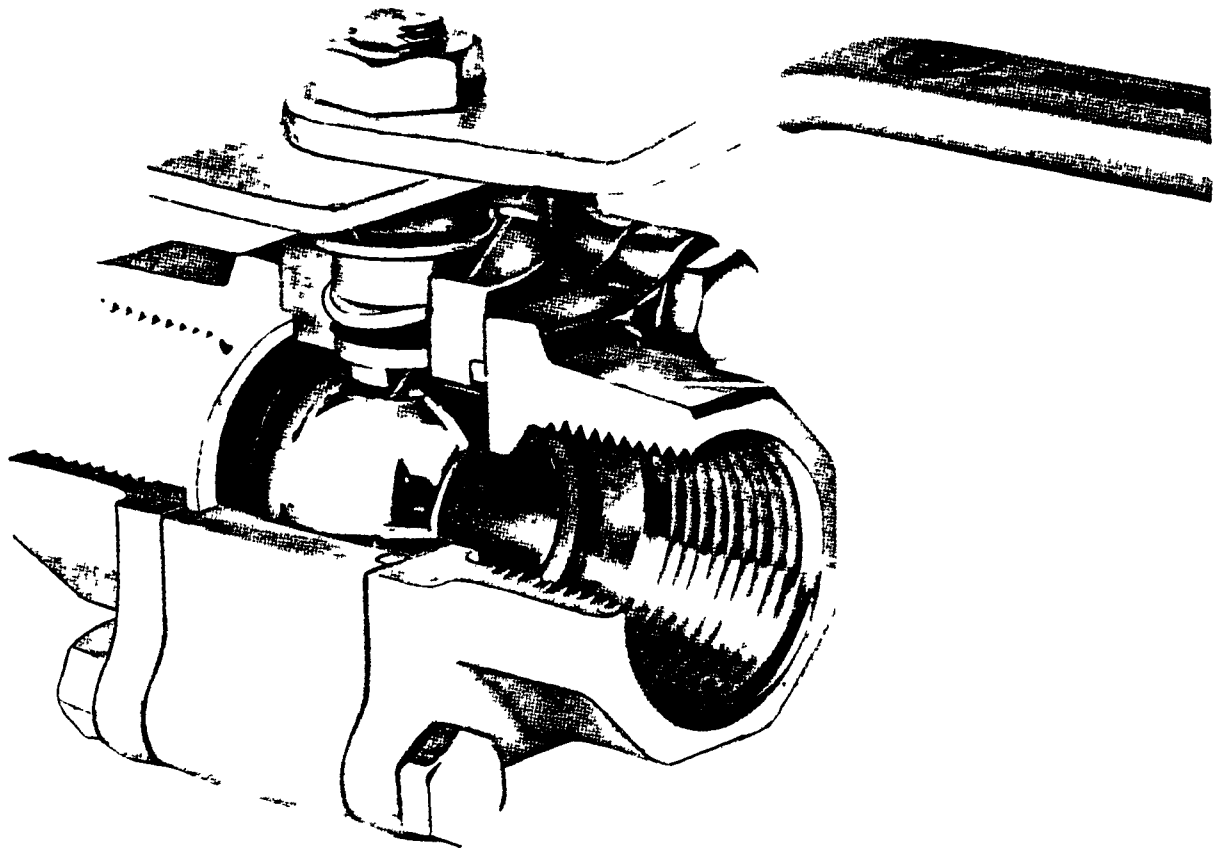
#### 2.1.4 Ball Valves:

These valves contain a sphere with a hole bored through it. The size of the hole is equal to the inside diameter of the line in which it is inserted (Figures 8 and 9). In the open position the valve is simply an extension of the pipe with effectively no head loss. In the closed position ball valves provide excellent tight shut off with seats that are self compensating for wear. Ball valves have been used successfully for a wide variety of fluids but have only recently been used for throttling control. Because the ball valve seats effectively separate the working fluid from the valve stem the stem packing usually consists of no more than a couple of O-rings or washers. Reduced port ball valves are also readily available where the ball size is smaller and hence cheaper for those instances where a full port valve is not required. The reduced port balls are normally used only when the valve is to have a throttling or control function.

#### 2.1.5 Plug Valves:

These valves (Figure 10) are a modification of the ball valve. The central element is a truncated conical shape plug with an elliptical

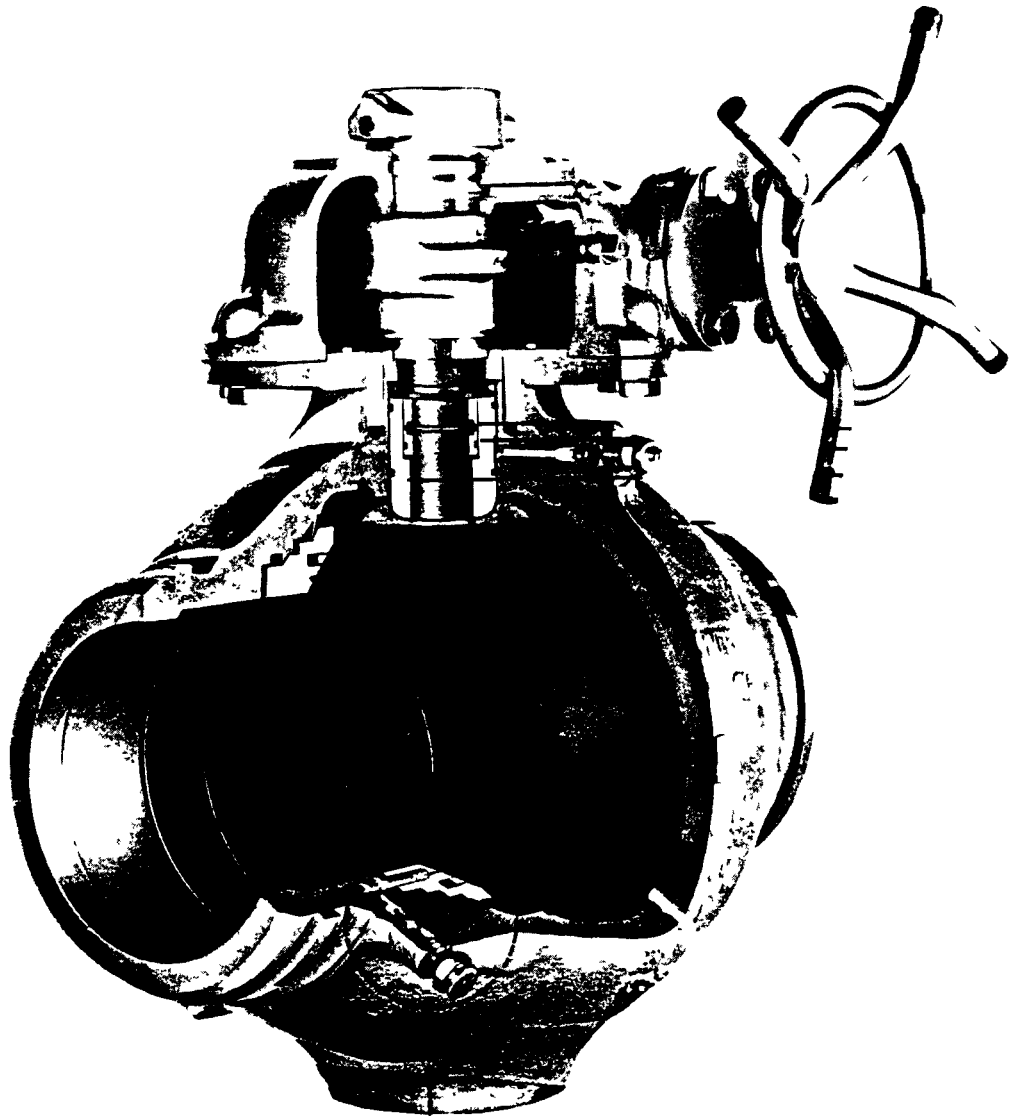
TYPICAL BALL VALVE



Source: Worcester Controls Catalogue CB-SV-2

Figure 8  
16

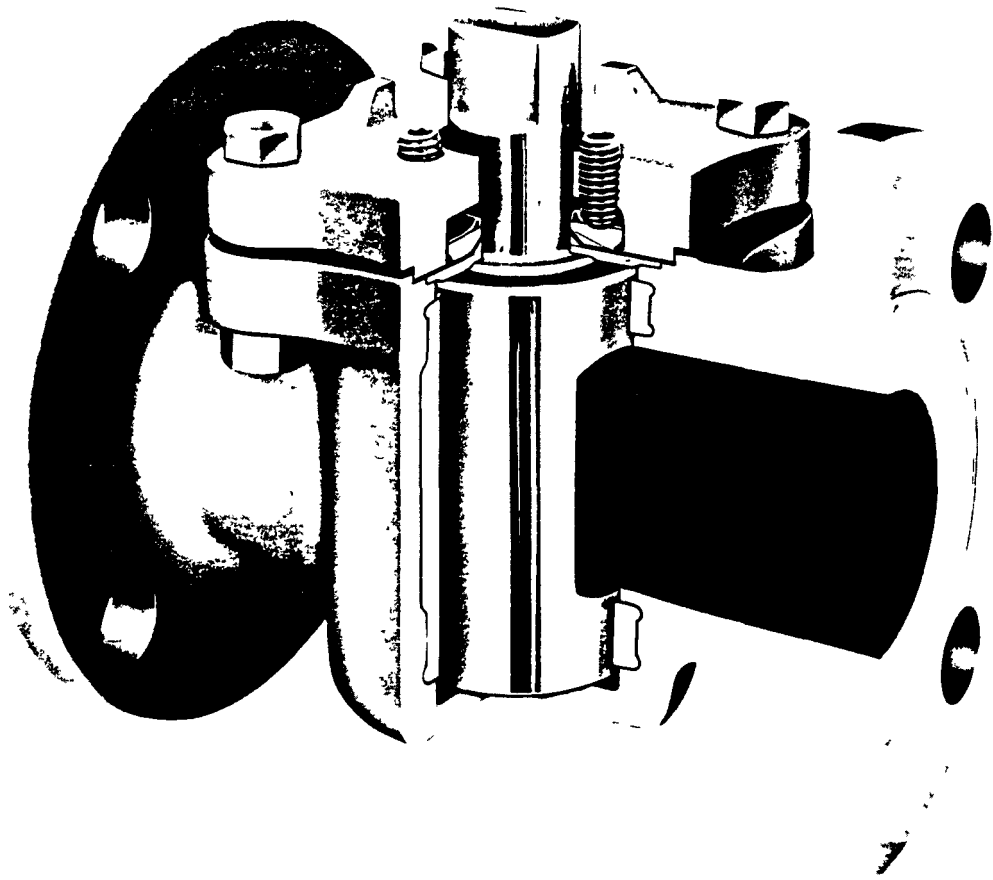
TYPICAL BALL VALVE



Source: Rockwell Catalogue V-5000R8

Figure 9

TYPICAL PLUG VALVE



Source: Tufline Catalogue 5

Figure 10

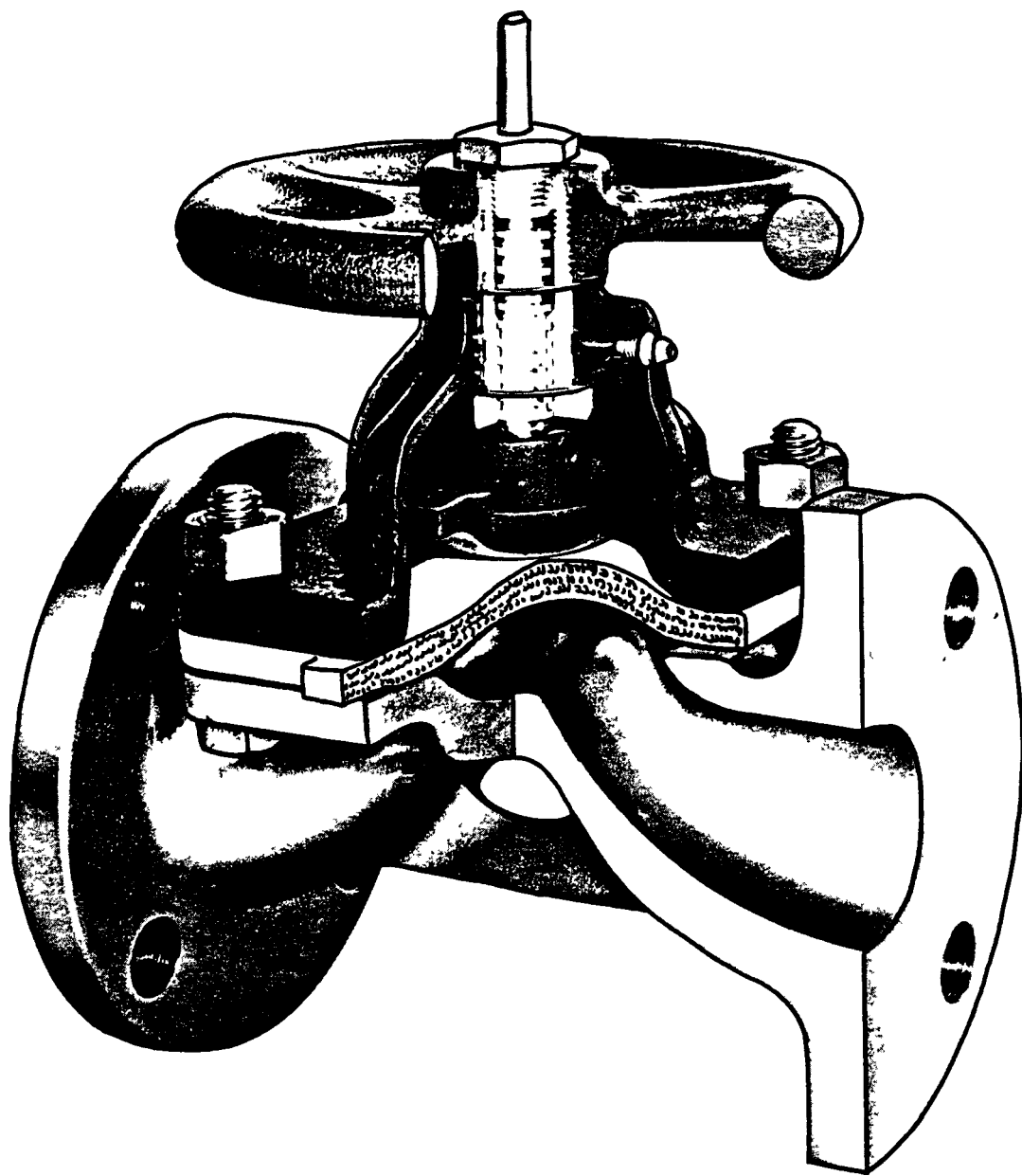
18

opening. The elliptical opening provides a minor modification to flow from a circular cross section resulting in a moderate head loss. Some plug valves are sealed via a lubricant medium which must be compatible with the process fluid. When there is insufficient lubricant, sticking or seizing of the plug may result whereas excessive lubrication may cause contamination of the process fluid. Other plug valves have a sleeve or lining, usually made of Teflon or similar elastomer. Such valves are commonly known as non-lubricated or self-lubricated plug valves. The sleeve completely surrounds the top and bottom of the plug and serves as a continuous primary seal between the plug and the body. The sleeve also acts to keep the working fluid away from the valve stem so that only a modest packing arrangement is required.

#### 2.1.6 Diaphragm Valves:

Diaphragm valves (Figure 11) have a flexible member which pinches flow between it and a weir within the valve. The advantage of this type of valve is that no stem seal is required as the working parts are separated from the working fluid by the diaphragm. The valve causes a pressure drop as a result of flow direction changes. A drawback of this valve lies in the difficulty in obtaining diaphragm material which can withstand high temperatures and pressures, which is chemically compatible with the working fluid, and able to withstand the wear to which it is subjected. No packing chamber is required for this valve as the system fluid does not act upon the valve stem.

TYPICAL DIAPHRAGM VALVE



Source: Rockwell Catalogue V-700

Figure 11

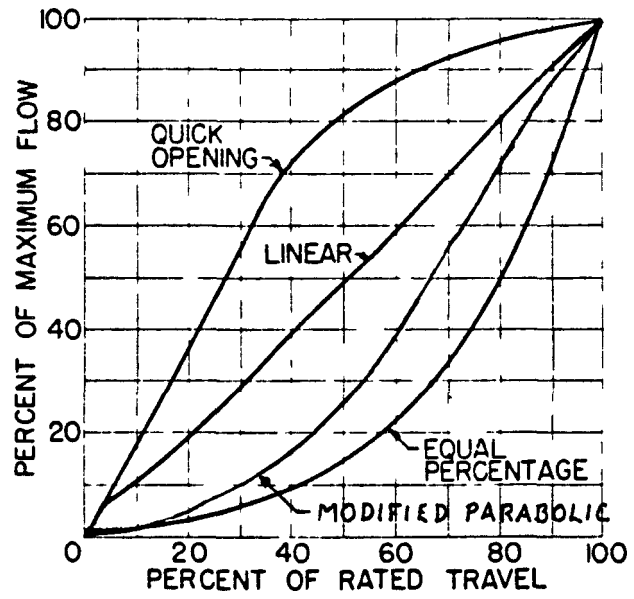
### 2.1.7 Control Valves:

Valves used in an intermediate position rather than full open or closed may be separated into two categories - throttle valves and control valves. Throttle valves are adjusted to a particular setting and remain at that setting until repositioned by an operator. In a circumstance where one has a number of components receiving flow from a common supply header, throttle valves would be used to balance the flow through the components to ensure no one component receives excessive or inadequate flow. Control valves on the other hand dynamically regulate the flow through the valve in accordance with an input signal. Control valves are used to regulate or control pressure, temperature, flowrate, level, pH, or any number of variables.

How the valve responds to a given input signal is a function of the inherent flow characteristic of the valve. The flow characteristic is the relationship between flow rate through the valve and the position of the valve plug when a constant pressure differential is maintained across the valve. The characteristic of a valve is a function of the valve plug flow area as the plug moves from open to close or the reverse. There are four flow characteristics that are normally used: linear, equal percentage, modified parabolic, and quick opening as illustrated in Figure 12. The equal percentage flow characteristic being the most common.

The valve for which flow is directly proportional to valve travel is said to have a linear characteristic. When the valve is half open the flow rate is half of the maximum. When the valve is three quarters open the flow rate is three fourths of the maximum.

# TYPICAL FLOW CHARACTERISTICS



Source: Reference 3, page 28.

Figure 12

$$\text{i.e., } Q = kL$$

where  $Q$  = flow rate;  $L$  = valve travel;  $k$  = constant of proportionality  
(Reference 3)

An equal percentage valve is one for which an incremental change in position results in an equal percentage change in flow rate. At small valve openings, the change in flow rate will be minor for an incremental change in position, whereas, when the valve is nearly open the same incremental change will result in a much larger change in flow rate. The equal percentage characteristic may be expressed as:

$$Q = Q_0 e^{nL}$$

where  $Q$  = flow rate;  $L$  = valve travel,  $Q_0$  = minimum controllable flow;  
 $n$  = constant;  $e = 2.71828$ .

A modified parabolic flow characteristic provides fine throttling control at small valve openings and a relatively linear valve characteristic at larger openings. When a valve plug is nearly closed, the change in flow rate will be small relative to valve travel whereas when the valve is more open the change in flow rate will be large and constant with respect to the valve travel.

A valve that provides the maximum change in flow rate for percentage of valve travel at small openings is said to have a quick opening characteristic. In this type of valve the characteristic is essentially linear during the first 40 percent of plug travel. Beyond this the change in flow

rate is steadily diminishing until when the the valve is fully open the change in flow rate is negligible.

Traditionally, globe valves have been used for control and, as such, a number of plug designs have been developed to produce the desired characteristics. There are single seat plugs and double seat plugs. There are smoothly tapered plugs and sharply cut angular plugs. There are single seat plugs and plugs with blades or wings. Figure 13 shows a number of globe valve plugs that are presently available and Table 1 provides the characteristics for each.

Different valve types have different characteristic curves. For example, the ball valve has an equal percentage curve. The butterfly valve has a curve that is close to a modified parabolic as one can see by comparing Figure 14 with Figure 12.

#### 2.1.8 Pressure Ratings

Pressure ratings for valves on a power plant can range from more than 2500 psi to 150 lb. The Clinch River Project had eleven separate ratings specified for its valves. The maximum pressure to which a valve may be subjected is a function of temperature. The higher the temperature the lower the maximum allowable pressure. Generally, the sealing medium is the material which limits the pressure/temperature rating of a valve in that most metal components of the valve (body, bonnet, plug or ball, etc.) may be designed to accommodate both high pressure and temperatures. The greatest problem is presented by the seat rings or stem sealing materials. Soft seated valves require a material that is non-abrasive, firm enough to

TYPICAL GLOBE TYPE CONTROL VALVE PLUGS

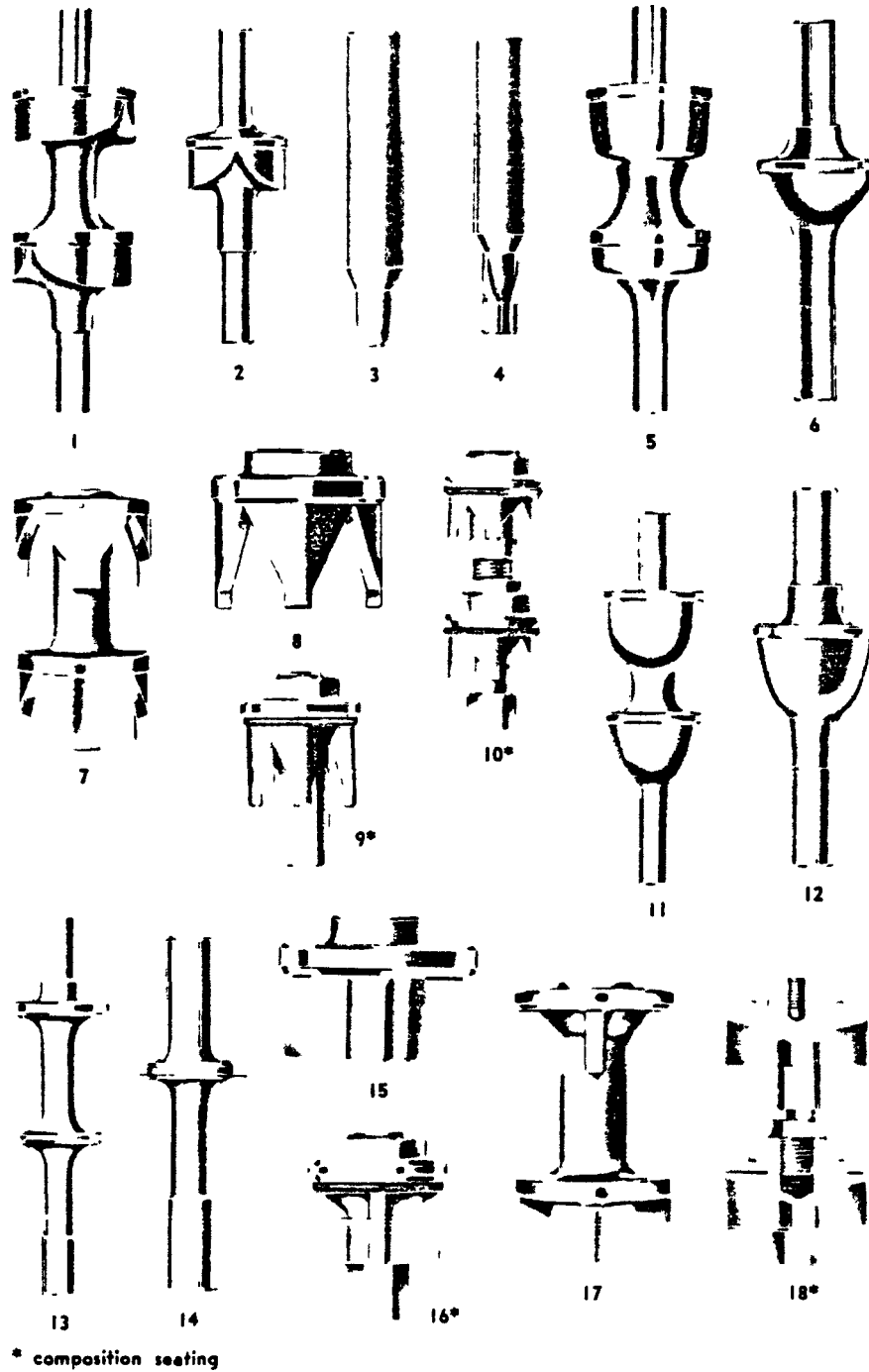


Figure 13

**TYPICAL VALVE PLUGS FOR CONTROL VALVES**

Illustration Key	Valve Plug Style	Flow Characteristic	Application	Remarks
1	V-Pop Micro-Form Micro-Flute	Equal Percentage	Used where large percentage of pressure drop is absorbed by system itself. Also used where highly varying pressure drops can be expected.	Very popular for throttling applications. Generally top or top and bottom guided.
2				
3				
4				
5	Throttle Plug	Modified Parabolic	Used on pressure and flow control applications where the major system pressure drop is available at the control valve.	Top and bottom or port guided. Metal or composition seating.
6				
7	V-Port			
8				
9				
10				
11	Linear	Linear	Flow is directly proportional to travel. Used wherever true linear relationship is desired.	Top and bottom guided.
12				
13	Quick Opening	Quick Opening	Used for two-position (on-off) service where the valve is required to be in one of two positions with no throttling of the flow.	Top and bottom or port guided. Metal or composition seating.
14				
15				
16				
17				
18				

Table 1

# FLOW CHARACTERISTIC CURVE FOR A BUTTERFLY VALVE

Source: Rockwell Catalogue V-603

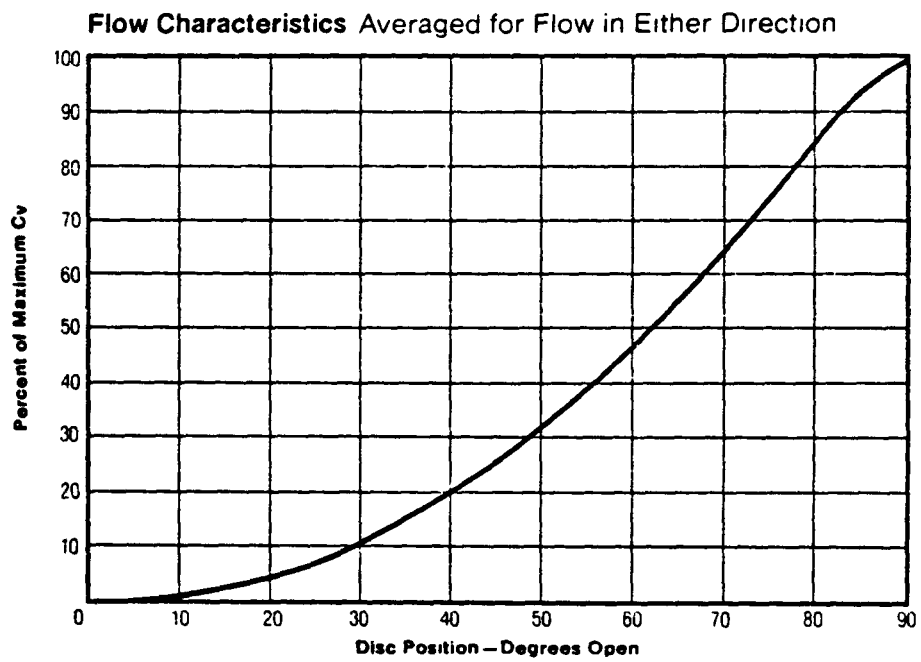


Figure 14

withstand cold drawing, and yet still resistant to high temperatures. Polytetrafluoroethylene (PTFE) or reinforced PTFE provide the best combination of these characteristics. Fortunately, most temperature/pressure applications in a nuclear plant can be accommodated by these materials.

#### 2.1.9 Materials

Valve materials are selected based upon the service requirements of the applicable system. The most common material, for valves for non-corrosive fluids at design temperatures at or below 700°F, is carbon steel. Other materials such as alloy or stainless steel, brass, bronze, cast or ductile iron, plastic, etc. are utilized as required to be compatible with the system fluid and system temperatures/pressures.

### 3.0 Survey of Other Industries

#### 3.1 Chemical and Process Industries

Numerous contacts were made in the chemical and process industries to determine what efforts had been made to standardize their systems' design. Companies approached included: Merck Pharmaceuticals, Kellogg, C. E. Lummus, Materials Research, Babcock & Wilcox, Exxon, Rockwell International, and General Electric. Where possible, copies of the company's standards were obtained for review. Generally, the standards identified acceptable materials, valve types, and fittings that the company used for different applications. Exhibits 1 and 2 are representative of these standards. No attempt has been made by these industries to restrict or limit the types, sizes, pressure ratings, or materials of valves or other components. The standards simply identify the applicable code for each item and an acceptable manufacturer's model number.

#### 3.2 Valve Manufacturers

Nearly all major valve manufacturers were contacted. Sales literature was obtained and where possible discussions were held with engineering personnel. Generally the manufacturers indicated that they produce anything for which there is a demand. The concept of limiting the selection of valves to a few types, sizes and ratings is quite divergent from their existing approach whereby different valves are produced for every conceivable application.

If an industry chooses to concentrate on certain valves or refrain from purchase of certain valves they will simply modify their production accor-

dingly. In other words, if the nuclear industry chooses to reduce the variety of valve sizes and ratings the impetus for this must come from within the industry itself, not from the manufacturers.

The manufacturers will continue their efforts to improve their designs and body/seat materials. Some manufacturers are developing valves made of plastics or other non-metallic materials. This effort is sure to continue and promises to develop valves which are extremely durable and resistant to attack by process fluids. None has yet produced a product line which is as extensive as presently available in carbon steel.

### 3.3 Naval Nuclear Program

Numerous contacts were made within the Naval Nuclear program. Early in the development of the nuclear program the Navy performed studies before deciding upon the design that was to become the Navy's standard nuclear globe valve. The Navy utilizes this standard globe valve design for both throttling and on/off service throughout the primary system. There are a few exceptions. For instance primary loop isolation valves are split disc gate valves which are designed to "leak" in one direction. That is, when shut they permit flow from the loops to pass to the reactor without permitting flow in the opposite direction. The standard globe valve is built-to-print by different manufacturers. The studies that were performed leading to the development of this valve are classified and not available for review. All inquiries resulted in referral to the DOE Engineering Data Base in Oak Ridge, Tennessee which did not have the studies in question.

### 3.4 Database Searches

A search of literature available on the subject at the DOE Energy Database was conducted. Numerous reports have been written concerning specific valve problems and some progress has been made in identifying various categories of valve malfunctions. The preponderance of these reports deals with problems of relief valves and main steam isolation valves. As stated previously, valves of this sort are not the subject of this report. Attempts were made to obtain conclusive operating experience for different valve types by accessing the Nuclear Plant Reliability Data System of INPO and the Nuclear Safety Information Center (NSIC) at Oak Ridge National Laboratory, Tennessee. When data on valve failures were obtained from these sources they were found to be too non-specific to be of any help in establishing quantitative data on the reliability of different valve types. Exhibit 3 provides examples of some of the more significant licensee event reports from the NSIC.

### 3.5 Failure Analysis

Several attempts have been made to analyze the nature of valve failures as evidenced by the number of EPRI reports issued on the subject. (References 1, 4, 5 and 6). All these studies have been inhibited by the lack of dependable data on the subject from operating plants. This, compounded by the fact that manufacturers of valves do not maintain any data on valve performance beyond overt customer complaints, little comparative data has been documented with regard to the performance of different valve types.

The best statistical information on the subject was obtained from Reference 7. This document reported the results of a preliminary study by Oak Ridge National Laboratory (ORNL) on the types of valve failures, based upon a detailed review of valve performance at two nuclear power plants. The data in Table 2 were taken from the ORNL report and indicate that rotary valves have a lower incidence of malfunction than gate and globe valves. These gates and globes had a failure rate of approximately twice that of the rotaries. This information was gleaned from historical records of corrective maintenance actions obtained directly from nuclear plant maintenance files over a five year period. The data may be misleading in that globe valves are generally used for the more severe applications and their performance may suffer accordingly. Also, the study did not identify which failures were due to the valve itself or to the operators associated with the valve.

Another study by Messrs. Reyer and Riddington (Reference 8) determined that stem packing leakage has been responsible for fully 34.5 percent of the valve failures in pressurized water reactors followed by 8.6 percent for failures of pressurizer spray valves and 6.9 percent for valve bonnet leaks. They noted particularly that packed gate and globe pressurizer spray valves had severe stem-leakage problems and that in at least one instance a rotary ball type valve had worked with considerable success in resolving that problem.

TABLE 2

MAINTENANCE FREQUENCY FOR VALVE TYPES  
(Source: Reference 7)

<u>Valve Type</u>	<u>Maintenance Frequency</u> (No. of failures*/10 <sup>6</sup> hours)
Ball	7.36
Butterfly	9.64
Check	9.65
Diaphragm	4.52
Gate	17.6
Globe	17.2
Safety/Relief	14.5
Directional Control	14.6

- \* Failures are defined as instances where the valve did not function as designed. The valve refers to the valve body and all its internal parts, the valve operator (motor, solenoid, pneumatic, etc.) and the limit and torque switches mounted on the valve or needed by the operator to make the valve function. Supply or auxiliary systems to the valve are not considered part of the valve.

#### 4.0 Developments

In the course of surveys for this report it was apparent that rotary valves are not treated with the same credibility as gate and globe valves. In spite of the advantages of lower price, smaller space requirements, ease of maintenance, and smaller less expensive operators, rotary valves have not been selected by system engineers because:

1. The gate or globe valves have traditionally been used for most applications.
2. Designers were unaware that rotary valves were effective for throttling applications.
3. Butterfly valves have had cavitation problems.
4. Early ball valves had a problem of the stem blowing out during maintenance.

The purpose of this section is to report on the developments that have been made in valve design and, in particular, to note the changes that have enabled rotary valves to overcome the problems identified above.

Rotary valves have come a long way in recent years toward gaining acceptance in other industries with Europeans being particularly receptive to their use. According to C. Cummings writing in "Canadian Controls and Instruments" North America is five years behind Europe in recognizing the versatility of ball valves. The primary advantage of rotary valves is their inherent simplicity. The primary disadvantage of rotary valves is

their inability to be used for high coincident temperatures and pressures. This is discussed further in Section 4.1.

Several articles in technical journals (References 9, 10, 11, 12, 13 and 14) have been published which recommend rotary valves or provide very favorable reports on their performance. Sections 4.1 through 4.11 discuss in greater detail the factors responsible for the emergence of rotary valves.

#### 4.1 Seat Materials

Metal has been the conventional seat material for most valves. Metal seated valves often have seats made of special alloys which in turn are screwed and/or welded into the valve body. Some valves have integral hard-faced alloy seats. Others may be surfaced with stellite, a very hard well-wearing material. A drawback of stellite is that it contains cobalt, wear particles of which may become highly radioactive and a problem in nuclear systems. The prime advantage of metal seated valves is their ability to withstand extremely high temperature and high pressure service.

The advent of polytetrafluorethylene (PTFE or Teflon) has improved the performance of rotary valves. The self-lubricating capability of this material makes it ideal for sliding contact sealing because the static coefficient of friction is slightly lower than the dynamic coefficient. Hence valves do not stick or bind with this material as they would with metal or nearly any other material. Table 3 provides the coefficient of static and dynamic friction for several PTFE compounds. Teflon itself has a relatively limited temperature/ pressure range due to its tendency to

TABLE 3  
 FRICTION COEFFICIENTS FOR  
 DIFFERENT FLUOROPOLYMER COMPOUNDS  
 Source: Reference 15

Compound	Constituents	Static Coefficient @ 33.33 psi	Dynamic Coefficient @ 33.33 psi, 1509 fpm
FC 122	90% PTFE 10% Graphite	0.05	0.07
FC 124	80% PTFE 20% Graphite	0.06	0.08
FC 169	80% PTFE 10% Glass Fiber 10% Graphite	0.06	0.11
FC 170	90% PTFE 5% Glass Fiber 5% Graphite	0.05	0.09
FC 191	75% PTFE 25% Carbon/Graphite	0.08	0.09
FC 192	65% PTFE 35% Carbon/Graphite	0.13	0.16
FC 197	85% PTFE 10% Glass Fiber 5% Carbon	0.05	0.07
FC 199	85% PTFE 5% Glass Fiber 10% Carbon	0.06	0.11

"cold flow" or deform with time upon the application of pressure. Generally the use of pure Teflon is limited to 500°F or 800 psig. The higher the temperature the lower the pressure that may be tolerated.

In order to improve the wear resistance, reduce the creep or cold flow, and increase the hardness of the material, inorganic fillers are added to the Teflon. There are any number of fillers that may be used but the most commonly used are glass fiber, carbon, graphite, bronze, or molybdenum disulphide ( $\text{MoS}_2$ ) (Reference 16). The resulting properties depend upon the type and concentration of the filler and the processing conditions.

Glass in the form of short fibers is the most commonly used filler material. It is used in compounds between 15% or 25% glass by weight. Glass filler increases the hardness, reduces the creep and dramatically increases the resistance to wear. As a result glass reinforced Teflon seats may be used for applications up to 550°F or 1300 psig pressure.

High purity coke powder is the typical carbon filler. It is often used in combination with graphite in concentrations of 25% to 35% by weight of carbon. Carbon fillers provide excellent wear resistance both when dry and when immersed in water. They are compatible with most chemicals and can withstand loads under rubbing contact.

Graphite is used alone or in combination with glass or amorphous carbon. A typical compound is 15% by weight of graphite. The addition of graphite helps reduce the wear of mating parts and improves frictional and wear properties when mixed with other fillers. Like other forms of carbon, it serves well in corrosive environments.

Round or irregularly shaped bronze particles are often used at 60% by weight of bronze. Compounds of bronze filled Teflon are creep resistant, easily machined, deliver good wear performance, and have low friction.

MoS<sub>2</sub> is used in concentrations of approximately 5% by weight of MoS<sub>2</sub> in compounds with glass or bronze. The MoS<sub>2</sub> increases surface hardness and lowers the coefficient of friction and the rate of wear.

Tables 4 and 5 (from Reference 16) provide a comparison of various properties with different filler materials. A review of the tables supports the extensive use of glass reinforced Teflon for valves.

One of the reasons that PTFE products have not gained wide acceptance in the nuclear industry is their purported sensitivity to radiation. PTFE is indeed affected by radiation, however, the threshold for this effect is on the order of 10<sup>6</sup> rads. PTFE does not experience any damage due to radiation until exposure to over 5 x 10<sup>4</sup> rads. At 10<sup>5</sup> rads the elongation is still 50 percent of its original value of 300, i.e., a specimen is able to stretch to more than twice its length without failure. Not until a total dose of 10<sup>6</sup> rads does the material experience significant loss of tensile strength. Figure 15 shows the effect of radiation exposure in air on elongation, tensile strength, flex modulus, and impact strength on pure PTFE. Without the presence of oxygen the radiation effects are reduced by a factor of 10 to 100.

There are relatively few balance of plant applications that result in 10<sup>6</sup> rads of exposure in 40 years. To achieve this dose would require an exposure of 3 rads per hour. Even in a radwaste facility the general area

PROPERTIES OF TEFLON  
Source: Reference 16

General Properties of Du Pont "Teflon" TFE Compounds

PROPERTY	FILLERS AND PERCENTAGES BY WEIGHT									
	Unfilled "Teflon" TFE	Glass Fiber, 15%	Glass Fiber, 25%	Graphite, 15%	Glass Fiber, 20% Graphite, 5%	Glass Fiber, 15% MoS <sub>2</sub> , 5%	Bronze, 60%	Bronze, 55% MoS <sub>2</sub> , 5%	Carbon, 23% Graphite, 2%	Carbon, 31% Graphite, 2%
Specific Gravity	2.18	2.21	2.24	2.16	2.18	2.28	3.74	3.66	2.07	2.04
Tensile Strength <sup>(1)</sup> psi (kg/cm <sup>2</sup> )	4 000 (280)	3,500 (250)	2,500 (175)	3,000 (210)	2,500 (175)	3,000 (210)	2,000 (140)	1,600 (110)	1,800 (125)	1,600 (110)
Elongation, % <sup>(1)</sup>	350	300	250	250	250	250	150	50	100	50
Stress at 10% <sup>(1)</sup>	1,600	1,200	1,200	1,600	1,300	1,300	2,000	1,600	1,800	1,600
Elongation, psi (kg/cm <sup>2</sup> )	(110)	(85)	(85)	(110)	(90)	(90)	(140)	(110)	(125)	(110)
Water Absorption, %	0	0.015	0.013	0	0.016	0.010	0	-	-	-
Coefficient of thermal conductivity, BTU/hr·ft <sup>2</sup> /(°F·in) [Kcal/m hr °C]	1.7 (0.21)	2.55 (0.32)	3.12 (0.39)	3.12 (0.39)	2.51 (0.31)	2.25 (0.28)	3.25 (0.4)	-	-	-

Table 4

Application Properties of Du Pont "Teflon" TFE Compounds

PROPERTY	FILLERS AND PERCENTAGES BY WEIGHT									
	Unfilled "Teflon" TFE	Glass Fiber, 15%	Glass Fiber, 25%	Graphite, 15%	Glass Fiber, 20% Graphite, 5%	Glass Fiber, 15% MoS <sub>2</sub> , 5%	Bronze, 60%	Bronze, 55% MoS <sub>2</sub> , 5%	Carbon, 23% Graphite, 2%	Carbon, 31% Graphite, 2%
Creep Modulus, <sup>(2)</sup> psi × 10 <sup>-3</sup> (kg/cm <sup>2</sup> )	28 (2)	32 (2.25)	30 (2.1)	50 (3.5)	50 (3.5)	42 (3)	90 (6.3)	120 (8.5)	75 (5.3)	80 (5.6)
Coefficient of linear thermal expansion, 10 <sup>-5</sup> in./in./°F [10 <sup>-5</sup> cm/cm/°C]										
78-200°F (25-95°C)	MD CD	8.0 (14.4) 2.9 (5.2)	7.0 (12.6) 4.2 (7.6)	7.0 (12.6) 4.4 (7.9)	7.7 (13.9) 2.6 (4.7)	8.3 (15.0) 3.5 (6.3)	5.4 (9.7) 4.4 (7.9)	- -	- -	- -
78-300°F (25-150°C)	MD CD	8.4 (15.1) 3.0 (5.4)	7.3 (13.2) 4.2 (7.6)	7.5 (13.5) 4.7 (8.5)	7.7 (13.9) 3.0 (5.4)	8.8 (15.8) 3.6 (6.5)	5.7 (10.2) 4.4 (7.9)	- -	- -	- -
78-400°F (25-205°C)	MD CD	9.1 (16.4) 3.4 (6.1)	8.0 (14.4) 4.7 (8.5)	8.1 (14.6) 5.1 (9.2)	8.1 (14.6) 3.2 (5.8)	9.6 (17.3) 3.9 (7.0)	6.4 (11.5) 5.0 (9.0)	- -	- -	- -
78-500°F (25-260°C)	MD CD	10.3 (18.5) 4.2 (7.6)	9.4 (17.0) 5.6 (10.1)	9.5 (17.6) 6.0 (10.8)	9.2 (16.6) 3.9 (7.0)	11.1 (20.0) 4.5 (8.1)	7.8 (14.1) 5.8 (10.5)	- -	- -	- -
Hardness, Shore Durometer "D"	51	54	57	61	56	57	70	-	-	-
Impact, ft. lb/in. (cm kg/cm)	2.9 (15.5)	2.7 (14.9)	2.2 (12.1)	2.6 (14.3)	2.3 (12.7)	2.9 (15.5)	2.0 (11)	-	-	-
PV Limit, <sup>(3)</sup> lb/in <sup>2</sup> × ft/min (kg × m/cm <sup>2</sup> × min)										
10 ft/min (3 m/min)	1,200 (26)	10,000 (215)	10,000 (215)	10,000 (215)	11,000 (235)	11,000 (235)	15,000 (320)	-	14,000 (300)	-
100 ft/min (30 m/min)	1,800 (39)	12,500 (270)	13,000 (280)	17,000 (365)	15,000 (320)	14,000 (300)	18,500 (400)	-	20,000 (430)	-
1000 ft/min (300 m/min)	2,500 (54)	15,000 (320)	16,000 (340)	28,000 (600)	22,000 (470)	17,500 (375)	22,000 (470)	-	30,000 (640)	-
PV for 0.005 in. (0.13mm) radial wear in 1,000 hrs (unlubricated)	20 (0.43)	3,000 (65)	5,000 (108)	1,500 (32)	3,000 (65)	5,000 (108)	8,000 (172)	-	4,000 (87)	-
Wear Factor, K <sup>(3)</sup> (in <sup>3</sup> min/ft lb hr) 10 <sup>10</sup> (cm <sup>3</sup> min/kg m hr) 10 <sup>8</sup>	2,500 (2,950)	14 (16.5)	13 (15.4)	50 (60)	12 (14)	15 (18)	6 (7)	-	12 (14)	-
Coefficient of Friction <sup>(3)</sup>										
Static, 500 psi [35 kg/cm <sup>2</sup> ] Load	0.05- 0.08	0.10- 0.13	0.10- 0.13	0.08- 0.10	0.08- 0.10	0.08- 0.10	0.08- 0.10	-	-	-
Dynamic, PV = 5,000 [105], 50 fpm [15 m/min]	0.01	0.15- 0.24	0.17- 0.24	0.15- 0.18	0.18- 0.27	0.15- 0.27	0.15- 0.22	-	0.15- 0.22	-

(1) ASTM D 1457-56T (2) Creep modulus in flexure after 100 hrs at 1000 psi (70 kg·cm<sup>-2</sup>) ASTM D 790-63 (3) Measured in air at room temperature

Table 5

# EFFECTS OF RADIATION ON "TEFLON" TFE IN AIR

Source: Reproduced from Reference 17

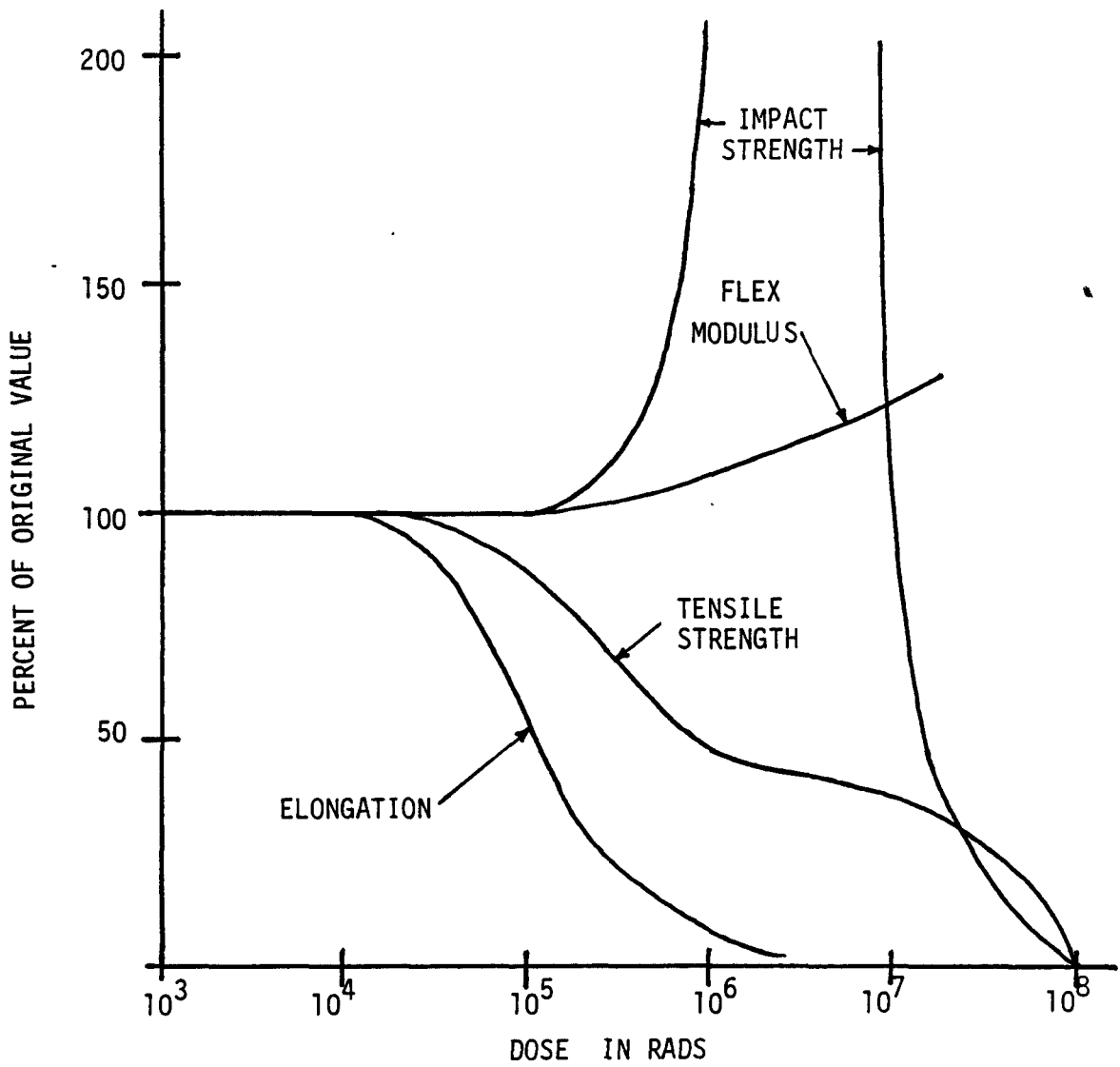


Figure 15

dose rates are measured in hundreds of millirads per hour. It is the unusual hot spot (like primary sodium) that will provide more than 3 rads per hour. In any case a valve would undoubtedly require seat/seal replacement within the forty years due to simple wear long before significant damage had been accomplished by radiation.

PTFE (Teflon) is also noteworthy in its compatibility with a multitude of substances. A chart published by Worcester Controls rates the corrosion resistance of 18 materials with nearly 600 different substances ranging from strong acids to strong caustics. For all but three of the substances listed (butadiene, coffee, and dry ethyl chloride). Teflon was rated "excellent". Only the butadiene was rated incompatible with Teflon. Not one of the other 17 materials which included steels, natural and synthetic rubber, and elastomers has anywhere near the universal compatibility of PTFE. Accordingly, it is recommended that, except for very "hot" applications such as near radwaste filters and demineralizers, PTFE be used wherever appropriate.

Another material that has also been used successfully for valve seats is a pure carbon-graphite compound. Carbon and graphite powders are blended and then compressed in a confined die. The seats are then baked in a non-oxidizing atmosphere to produce a material that can withstand temperatures up to 1000°F, which is practically inert, and unaffected by most chemical reagents. Because carbon graphite seats are nonresilient the seat design must not rely on bending or flexing to achieve proper sealing. For instance, the Rockwell McCannaseal ball valve (See Figure 16) uses a spring loaded, self-adjusting, wedge-seat design which insures tight closure under

ROCKWELL McCANNASEAL BALL VALVE

Source: Rockwell McCannaseal Catalogue V-501

McCannaseal valves are particularly suitable for remote actuation!

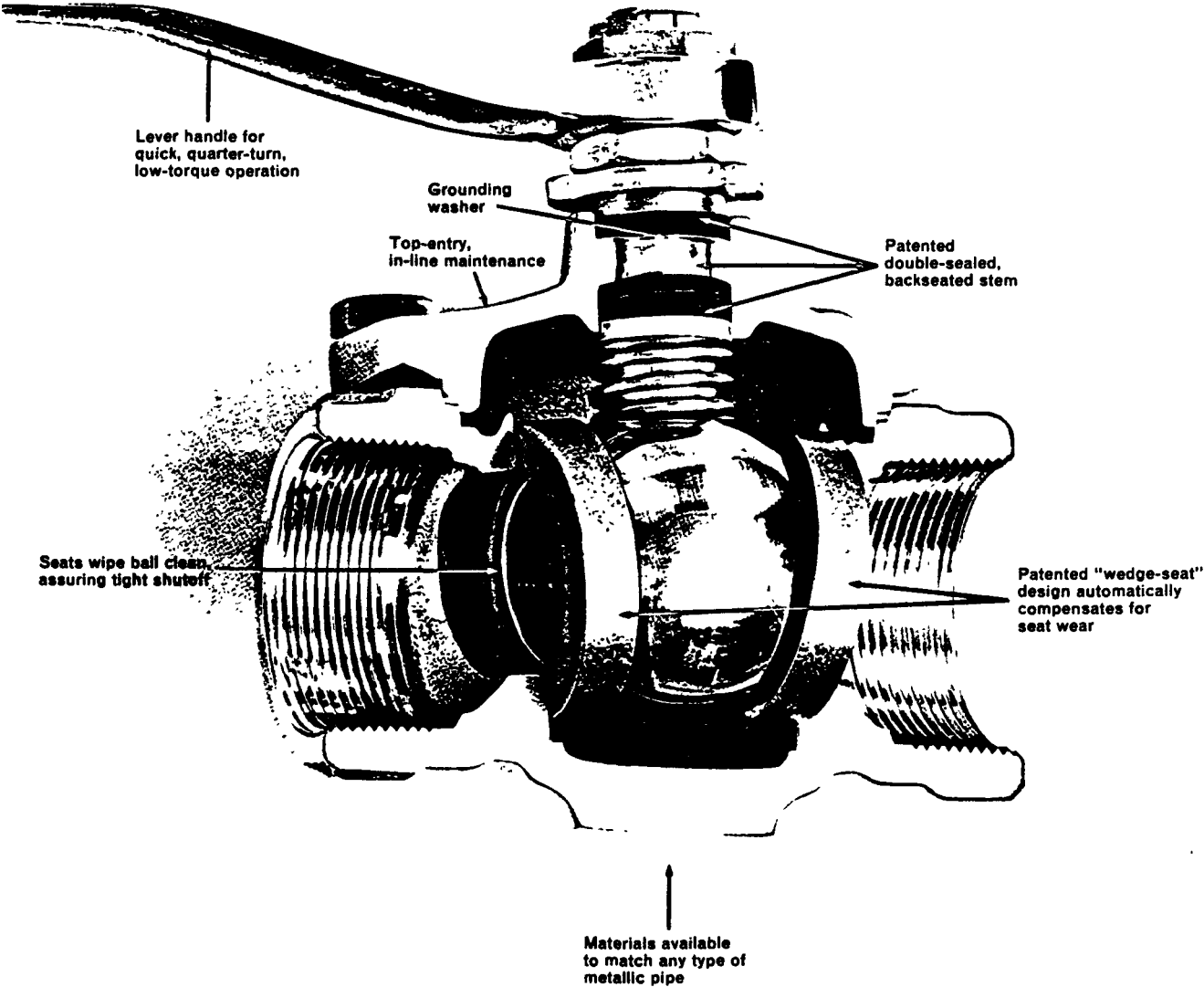


Figure 16

all operating conditions. The seats are kept in tight contact with the ball as the spring assures an even and non-binding elastic preload on the seats at all pressures, temperatures, and at all stages of seat wear.

Some manufacturers offer fire rated seats. Most fire rated seats consist of both a resilient seat and a metal back-up seat which comes into play upon destruction of the resilient seat.

Figure 17 provides representative pressure/temperature curves for different seat materials.

## 4.2 Seat Configuration

The configuration of a seating surface has much to do with the longevity of that seat. If the seat allows particles to be trapped and dragged across, or mashed into the seat, it will suffer damage. Globe valves are sealed via direct compression.

### 4.2.1 Thermal Binding

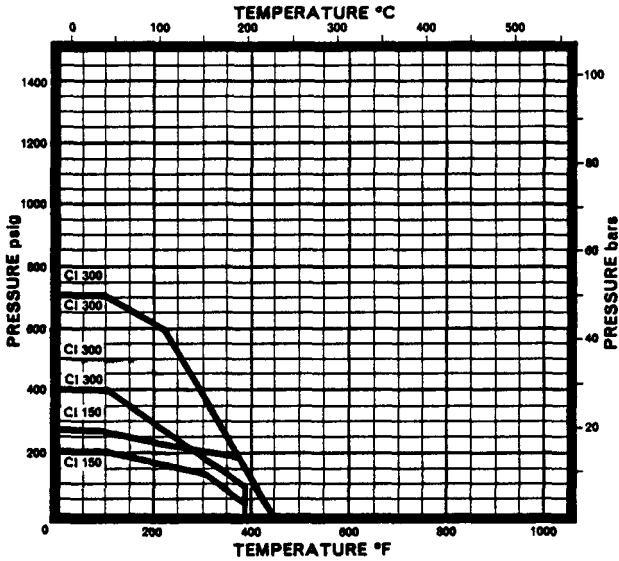
Most gate valves are sealed by the disc sliding and wedging itself in place. The binding of gate valves in the closed position due to bonnet pressurization or due to thermal binding is a significant concern. The Institute for Nuclear Power Operations (INPO) conducted a study of the problem as reported in Reference 18.

"Because of the way the body of a wedge gate valve is designed, it contracts a proportionally greater amount than the disc when the valve cools. This causes the seats, which are part of the valve body, to

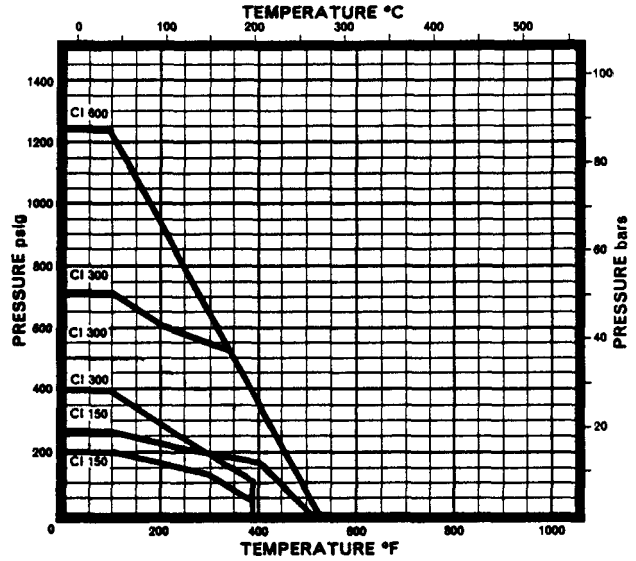
# REPRESENTATIVE PRESSURE/TEMPERATURE RELATIONSHIPS FOR DIFFERENT SEAT MATERIALS

Source: Rockwell McCannaseal Catalogue V-501

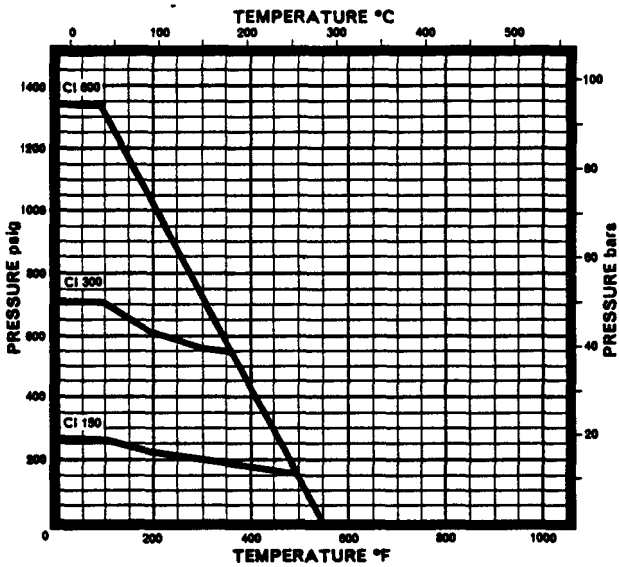
### TFE SEATS



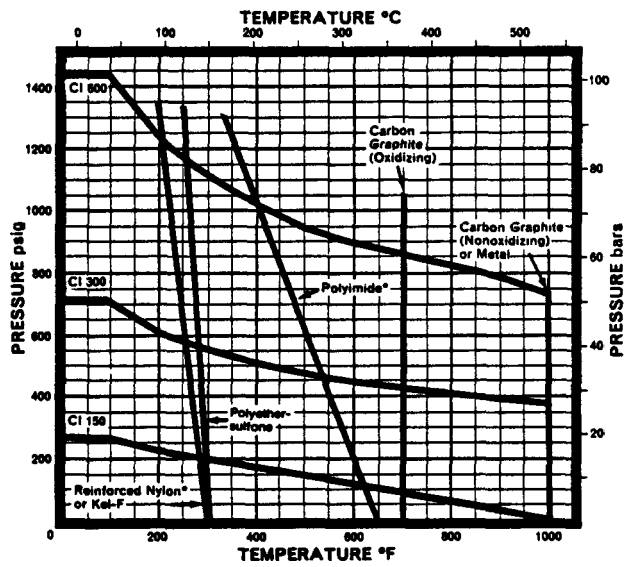
### REINFORCED TFE SEATS



### FIRE-SEAL SEATS



### CARBON-GRAPHITE, METAL, AND OTHER SEATS†



†Use of ball stops required for temperatures over 500° F

\*Limitations are lower for hot water services. Consult Rockwell

CARBON STEEL

SS316

BRONZE

ALUMINUM

Figure 17

pinch the disc tightly. Consequently, when the valve is closed hot and allowed to cool, the difference in thermal contraction can cause the seats to bind the disc so tightly that reopening is impossible until the valve is reheated. Stem and yoke failures have occurred during attempts to reopen thermally bound valves."

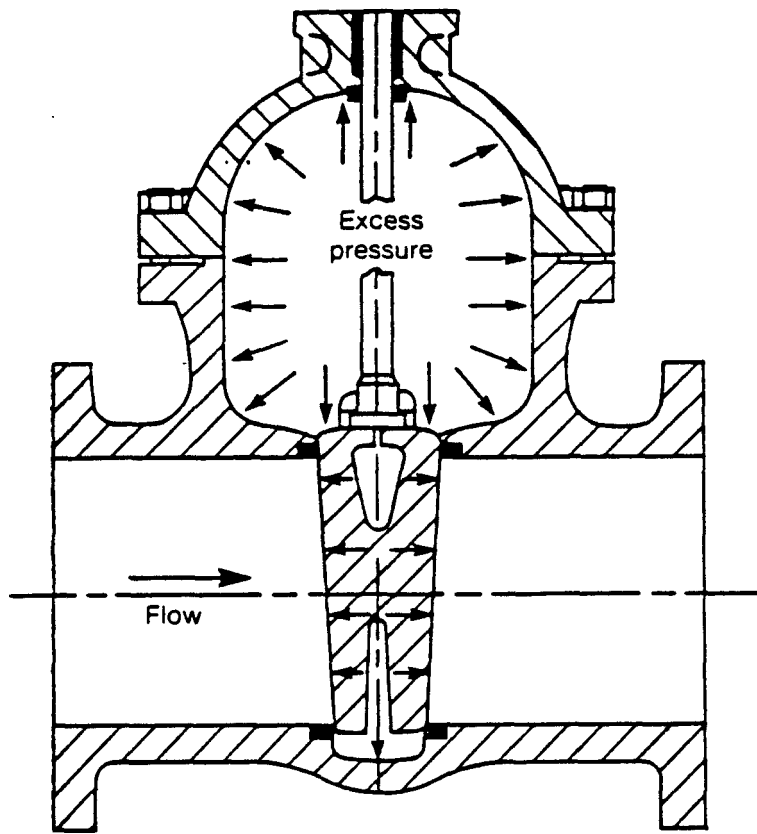
The double disc parallel seat gate valves is a solution to the thermal binding problem as the discs are able to move inwards when the actuator withdraws or moves to open the valve.

#### 4.2.2 Bonnet Pressurization

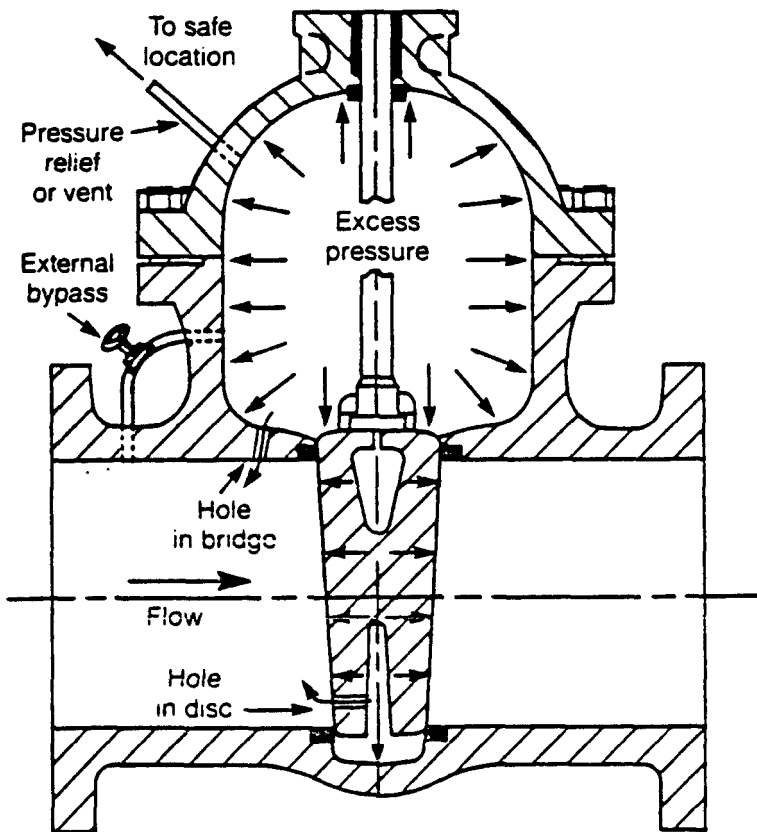
Another problem that gate valves encounter is bonnet pressurization. Liquid may become trapped in the bonnet of the valve when in the closed position. In most instances leakage past the seat into the body, or in some instances, leakage past the stem packing will relieve excessive pressure. However, occasionally the valve disc/seat and the packing seal are so tight that no leaking out of the bonnet occurs and a pressure buildup prevents the valve from opening as illustrated in Figure 18.

There are two circumstances where the valve bonnet pressure can be higher than in the system itself. One where the fluid is trapped in the bonnet after a valve closure and the system pressure is subsequently reduced. The other circumstance can develop when the fluid trapped in the bonnet is subjected to a temperature increase from the surroundings resulting in overpressurization.

This latter circumstance could lead to excessive stem leakage or even a rupture of the valve. Both mechanisms can lead to the inability to open



**Liquid Entrapment Pressure Locking**  
**Figure 18**



Source: Reference 17

**Methods of Preventing Bonnet Overpressurization**  
**Figure 19**  
 46

the valve. Figure 19 shows various methods that may be used to prevent bonnet overpressurization. All except the relief require a hole or passage between the bonnet area and the upstream line which in turn makes the valve unidirectional. It should be noted that the design of rotary valves is such that this problem cannot develop. Butterfly and plug valves do not have a fluid region that can be separated from the process system. Ball valves do have such a region between the seats external to the ball which will trap process fluid when closed, however, once a differential pressure of any significance develops the fluid simply lifts the seat of the ball and relieves itself to the region of lower pressure allowing the seat to reseal itself. Additionally, because of the rotary operation of the valve, reopening of the valve does not require overcoming this internal pressure.

#### 4.2.3 Self Wiping Seats

Butterfly valves seat via a combination of sliding and direct compression into place. Ball and plug valves have the unique self-wiping feature where the ball slides from one position to another. This self-cleaning feature extends the life of both the ball/plug and its seats by preventing the entrapment of grit and dirt on the ball/plug.

#### 4.2.4 Plug Seat Design

The seat arrangement of the plug valve has one advantage over the ball valve in that the plug is completely surrounded by the elastomer liner. This design eliminates any pockets for fluid to collect and form crud traps when the valve is used in radioactive service. Ball valves on the other hand have a void around the ball between the two seat rings that is exposed

to system fluid as the ball passes from full open to full closed. This area can become an effective crud trap. Because of this feature ball valves are not recommended for radioactive fluids. The primary drawback of the plug valve is its difficulty of operation which is caused by the friction with the surrounding liner. The laborious operation of manual plug valves is a common operator complaint. This characteristic of the valve also makes it inappropriate for use as a control valve.

#### 4.3 Stem Leakage

Valve stem leakage was identified in an EPRI study (Reference 19) as one of the most critical valve problems. This was supported in turn by studies reported in References 8 and 20 that stated valve stem leakage was responsible for over one third of the valve failures that caused orderly LWR shutdowns. This problem of valve stem leakage becomes particularly significant when one is handling radioactive or other hazardous materials. Packing gland leaks are one of the major sources of atmospheric contamination in a power plant and a cause for immediate maintenance. An EPRI study (Reference 5) was conducted to determine a solution to the problem. This study made several observations and recommendations.

1. In general, valve packing chambers are too deep.
2. Where deep packing chambers are required (five or more rings of packing) a blowout connection should be provided to facilitate removal of the lower rings.
3. Live loaded packing is effective in preventing or minimizing stem leakage.

4. Graphite packing has been demonstrated to have superior performance over the traditional asbestos packing which is still the industry standard. Graphite packing costs as much as 10 times as much as asbestos. However, the higher cost are offset by the reduced need for repacking and its associated down time. This point was reinforced by another EPRI study reported in Reference 21.

The findings of the EPRI report were also borne out by a study performed by the Electricite' de France as reported in Reference 22. In this study the French found that the surface finish of the packing box is vitally important and that even the slightest scratches can lead to future leakage. They also noted that packing-bolt relaxation and relaxation of the packing itself, decreased the pressure originally applied in the packing. Once the pressure applied to the bottom packing ring fell below the system pressure it was meant to withstand, a leak would develop. To counter this relaxation, Electricite' de France found it necessary to add to its specifications a requirement for Belleville washers under the packing bolt heads.

These findings all point to the use of ball or rotary valves in that rotary valves incorporate or obviate the need for these features.

1. Rotary valves only require shallow packing chambers and consequently a blowout connection is not required.
2. Belleville washers are often used on rotary valves to provide loaded packing.
4. Many rotary valve manufacturers offer the option of graphitic stem seals.

The quarter turn stem movement is obviously much less than one which must make several turns. This results in less wear on both the valve stem and the packing, thereby contributing to the longer packing life for rotary valves. Because of these functional differences, the packing arrangement is greatly simplified. The deep packing box is reduced to a shallow channel for one or two rings of packing in lieu of the deep channel that accommodates six or more rings.

Rising stem valves require the valve stem to pass in and out of the packing. Dirt and grit are then drawn into the packing to abrade or score the stem. The scored stem and/or packing in turn becomes a leakage path for the process fluid. In contrast, rotary valve stems move only one quarter turn and make this turn enclosed in the packing. If the stem is initially smooth and the packing has been properly installed the stem leakage will be negligible. The fact that the relative movements of stem to packing is so limited in a rotary valve results in dramatically less wear to the packing thereby extending the intervals between required packing renewal. Rotary valve packing is normally limited to one or two rings which are easily accessed. Globe and gate valves invariably have a yoke obstructing direct access to the packing and have packing boxes of much greater depth. The simpler design of the rotary valves permits the maintenance personnel to do better quality work in less time and with less effort. This factor also contributes to the longevity of rotary valve packing.

#### 4.4 Erosion

Erosion is probably the most serious problem that throttle or control valves must face. The fluid flow past sealing surfaces can erode them and damage their sealing and/or flow control capability. This problem may be further exacerbated by cavitation on valves throttling at high pressure drops.

Rotary valves, ball and plug valves in particular, have double orifice characteristics which tend to minimize this problem. When in the partially open position (see Figure 20) the ball valve has two restrictions to the flow. One as the fluid enters the ball and one as the flow exits the valve. This feature breaks the total pressure drop or head loss in two thereby reducing the tendency for erosion/cavitation at either point. Additionally, in the circumstance where cavitation does occur, its effect is minimized. Cavitation will occur just downstream of the restriction. Thus in a ball valve if cavitation does occur it falls within the ball where the effect is minimal or downstream of the ball where again the effect is not critical. The sealing surfaces avoid the brunt of the cavitation effect.

Globe valves have resolved the cavitation problem by use of various trim/plug designs so mentioned in Section 2.1.7. Butterfly valves have addressed the problem with "toothed" valves as discussed in Section 4.7 below.

DOUBLE ORIFICE FEATURE OF BALL VALVES

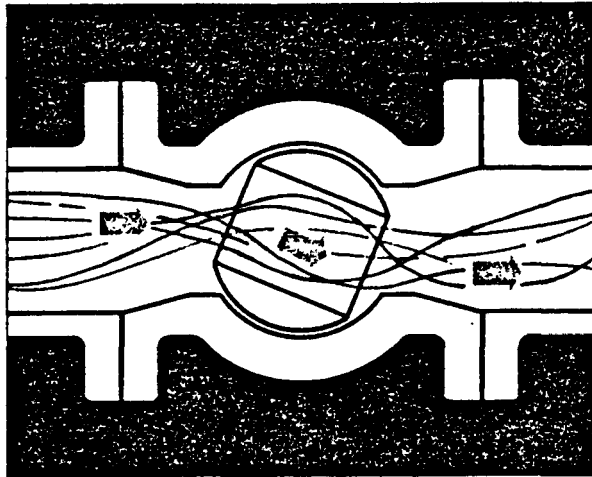


Figure 20

#### 4.5 Speed of Operation

A feature of the rotary valves that is of interest to the nuclear industry is its rapid quarter turn operation. Safety-related conventional gates and globe valves often have seating problems caused by operators overtorquing the stem. Where a system safety criterion dictates that a valve must travel from full open to closed in a short interval the operator may have to generate so much torque to meet the criterion for speed, above that needed for proper seating, that damage to the seat may result. The rotary valves may more easily meet the time-to-shut criterion as only a quarter turn is required to go from full open to shut whereas a gate or globe valve requires several complete turns. In addition, the effectiveness of the seal is not a function of the seating torque. When a pneumatic cylinder is slammed to the closed position the impact is taken by the operator stops, not by the valve's stem against the body. Most butterfly valves are torque seated which could make them susceptible to the same problem except that the overall movement of the operator is limited to preclude overtorquing. The U.S. Navy has long used ball valves for submarine hull and backup valves on seawater systems. The speed with which these valves operate is critical to preventing excessive flooding in the event of a pipe rupture.

Certainly not all applications require rapid shut off and in some instances it may be undesirable because of the effect of water hammer. In those circumstances the operator selected should have a more moderate positioning speed.

#### 4.6 Actuation Force

Another area where rotary valves have improved dramatically is in the actuation force necessary to operate the valves. Older ball valves required excessive force to operate. Newer valves, especially those with PTFE seats now require much less force to operate. Most rotary valves now require less actuating force than comparable rising stem gate and globe valves (Reference 10). Because of the small contact area, butterfly valves have particularly low break away torques. The reduced actuation force in turn permits one to utilize a smaller, less costly, actuator. The reduced size actuators reduce the loads on the piping system and thereby simplifies support. The reduced actuator torque also reduces the stress to which the valve shaft is subjected.

#### 4.7 Flow Control

As little as 10 years ago rotary valves were not considered for applications which required tight shut off or any degree of throttling. Butterfly valves in particular were avoided for any throttling service. In an article by H. D. Baumann (Reference 23) the problem of flow control and cavitation in butterfly valves was discussed. Throttling valves must convert potential energy (inlet pressure) via kinetic energy (velocity head) into turbulence (thermal or acoustic energy) to lower the upstream pressure to the required downstream pressure. Due to the simple geometry of butterfly valves there was little resistance to fluid flow. Therefore, only a portion of the kinetic energy was converted via turbulence into the desired pressure loss, or in other words, the valve exhibited "pressure recovery".

This pressure recovery was responsible for the high degree of cavitation (References 24 and 25) and the unsuitability of butterfly valves for control functions. In order to reduce this pressure recovery "toothed" vanes were developed to break up the flow and increase the turbulence through the valve. "Toothed" valves such as Worcester Controls' Gyro-Vane butterfly valve reduces the cavitation and its noise while providing precise flow control (See Figure 21). Their valve has a rangeability\* of 100:1 and also provides repeatable and predictable response over its range of travel. Developments such as this have greatly altered the picture with regard to the application of butterfly valves for flow control. According to H. D. Baumann in Reference 23 their use for this function has increased dramatically over the past decade as these butterfly valves also offer high flow capacity along with low weight and minimal space requirements.

Developments have also been made in the use of ball valves for control functions. As stated earlier the inherent characteristic curve for a ball valve is the equal percentage. One cannot change the trim in a ball valve as in a globe valve, therefore if one desires a different characteristic another means must be found. Positioners have been developed which permit one to obtain different characteristics by changing a cam wheel in the positioner. Figure 22 shows such a positioner which provides three options (equal percentage, linear, and uniform rise).

#### 4.8 Energy Consumption

The straight through feature of both the ball and butterfly valves results in a very low head loss. In a system where a number of valves cause significant head loss it must be made up in added pumping power.

\* Rangeability is defined as the ratio of maximum controllable flow to minimum controllable flow or, the ratio of the rated  $C_v$  to the minimum controllable  $C_v$ .

# "TOOTHED" DESIGN BUTTERFLY VALVE

Source: Worcester Controls Gyro-Vane Series 69 Catalogue

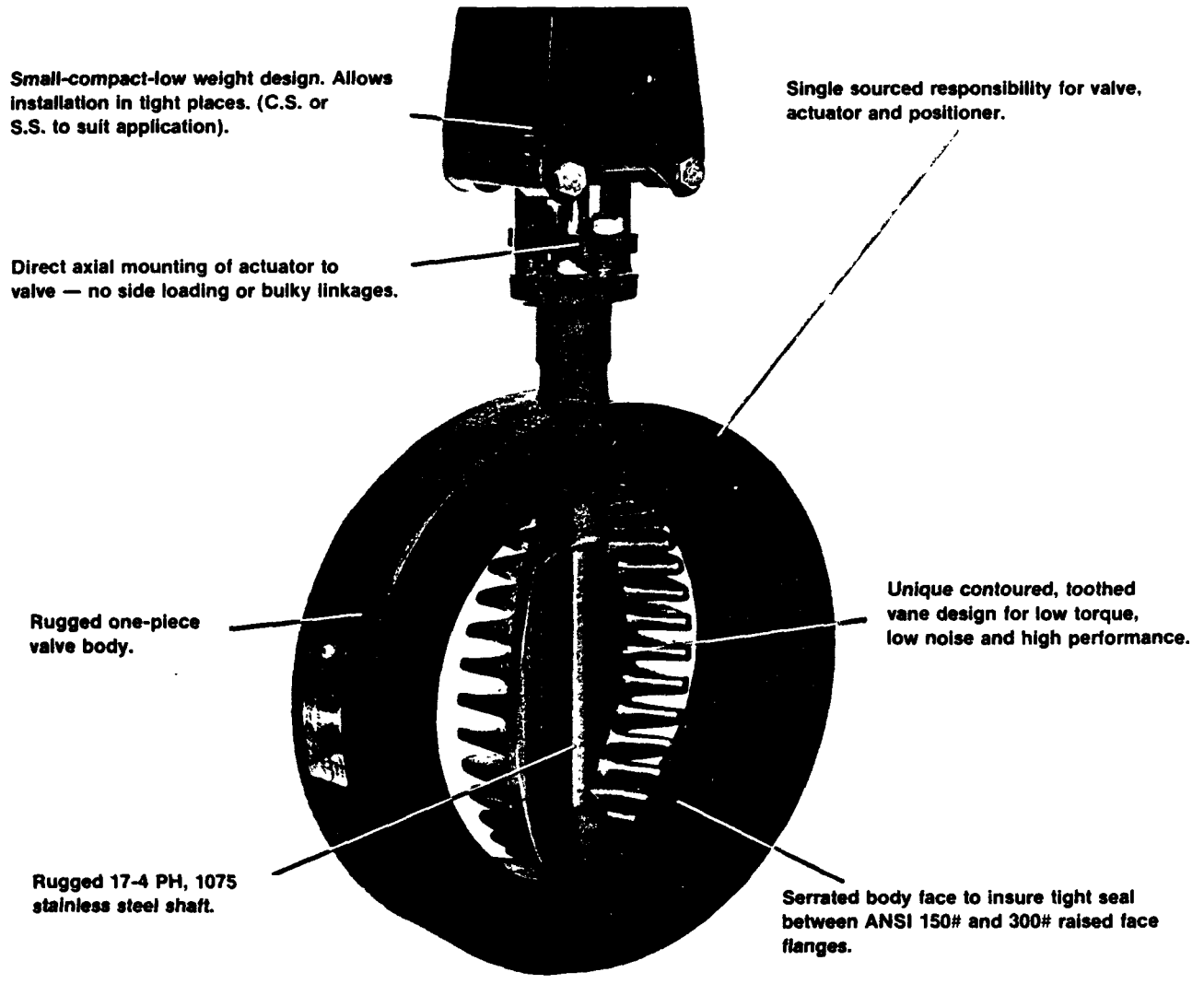


Figure 21

# MULTI CHARACTERISTIC PNEUMATIC POSITIONER

Source: Worcester Controls Catalogue CB-V15-2

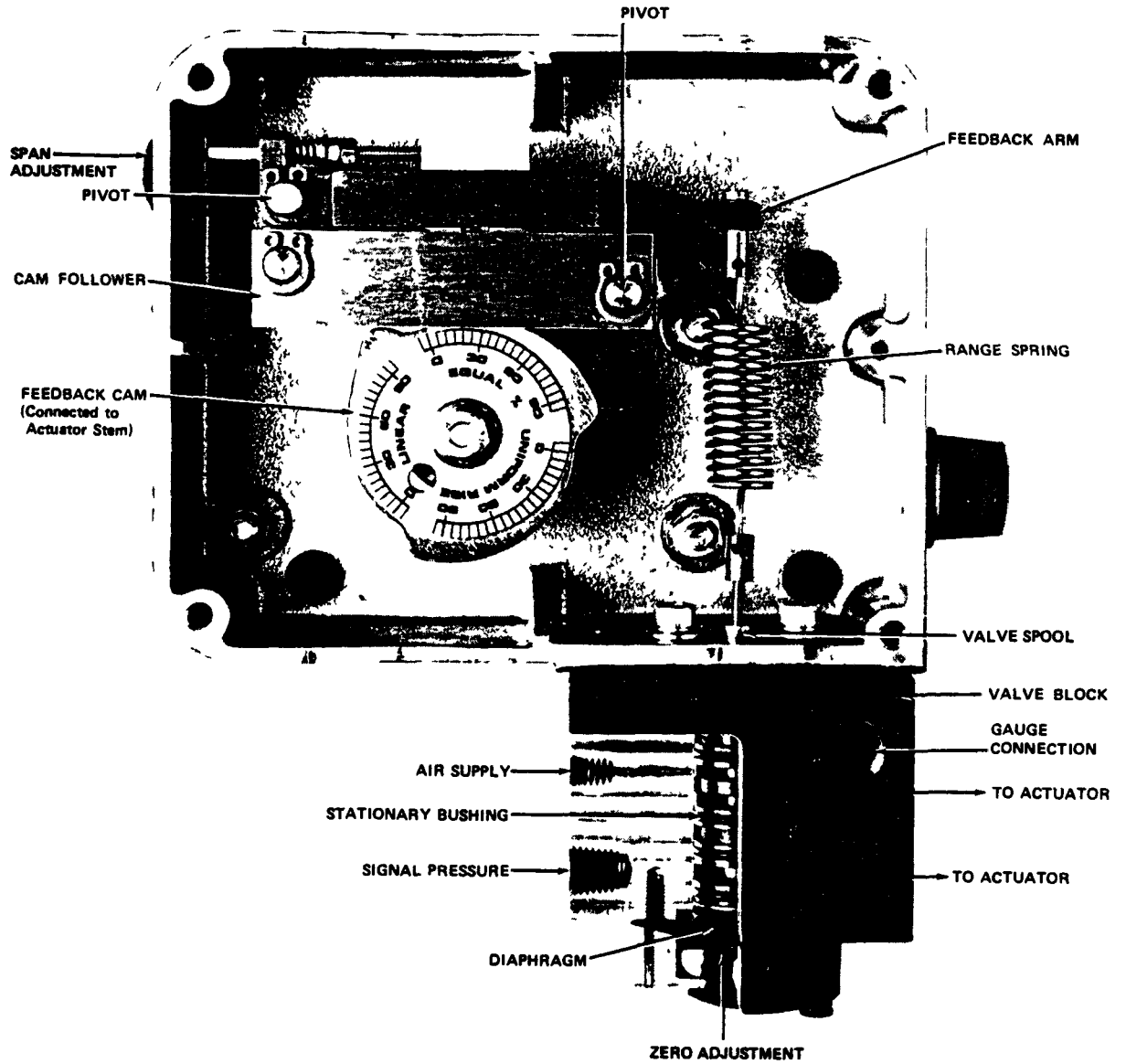


Figure 22

Beyond the added capital investment for a larger pump the energy consumption for the system is increased. J. L. Lyons and J. Wass (Reference 26) have compared consumption rates for different valve types as shown in Figure 23. It is instructive to note that for a particular flow rate (say 400 gpm) the annual energy consumption rate for a globe valve (30,000 Kwh) is over seven times that for a standard ball valve (4100 Kwh) and 24 times that for a full ported ball valve (1250 Kwh). At a standard commercial rate of 7 cents per kilowatt-hour this converts to \$2100/year for a globe valve, versus \$287/year for a standard reduced port ball valve or \$87.50/year for a full port ball valve. Clearly, the selection of valve type can have a significant effect upon the overall economics of a system.

#### 4.9 Space Requirements

Another advantage of rotary valves is their limited space requirement. Rotary valves are noticeably smaller than their counterparts of other types. Their reduced size and especially the smaller maintenance envelope requirement can contribute to reduced congestion of plant arrangements. Butterfly valves are dramatically smaller than gate or globe valves in that the body consists of little more than a ring the size of the mating line. The reduced weight of rotary valves reduces the loading on the piping and simplifies support design as discussed in Section 4.10.

#### 4.10 Support Design Effects

The mass and geometry of valves have serious impacts upon the stress analysis of piping systems and in the number, location, and design of pipe

ANNUAL ENERGY CONSUMPTION FOR PUMPING  
 VERSUS FLOW RATE FOR DIFFERENT VALVE TYPES

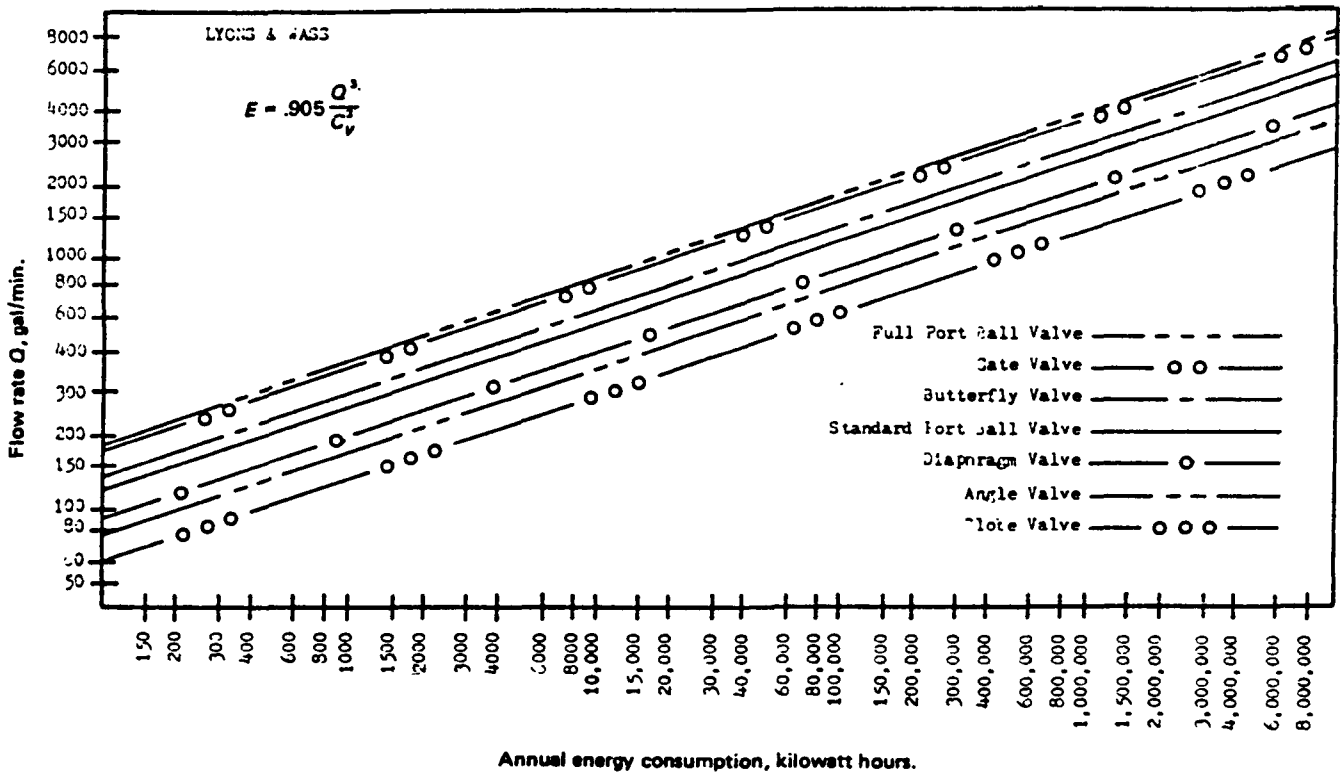


Figure 23

supporting elements. The eccentricity of the center of mass will: (1) increase the stress loads imposed on the pipe, (2) influence the response and amplitude of the pipeline under dynamic loads, and (3) affect the accelerations imposed on the valve and operator as a result of the pipeline dynamic response.

Figure 24 illustrates a typical gate/globe valve with an operator. The moment (and concomittant stress) effects on the pipe are roughly proportional to the mass of the valve ( $W$ ) and operator ( $W_{op}$ ) and the square of their radii ( $R$  and  $R_{op}$ ) from the center of mass to the centerline of the pipe. When the eccentricity and mass of a valve/operator are minimized the overall seismic stresses and the number of supports required to accommodate the stresses are reduced.

The high mass and eccentricities of valves and operators tend to lower the natural frequency of the piping system bringing it, in general, into a range of higher seismic amplification. The result is the need for stronger or additional supports to keep the stresses of the system within the allowed limits. Special seismic restraints for the operators may also be needed. The reduction of masses and eccentricities of the valve and operator masses will have an important affect in improving the conditions under seismic loads and will result in lighter and/or a reduced number of supports.

The overall geometry of rotary valves is much more compact than gate and globe valves. Rotary valves have their mass concentrated within the line of the pipe as the ball, disc, or plug simply rotate and do not significantly shift their center of gravity. In addition, the simpler stem seal

ROTARY INERTIA VALVE MODEL

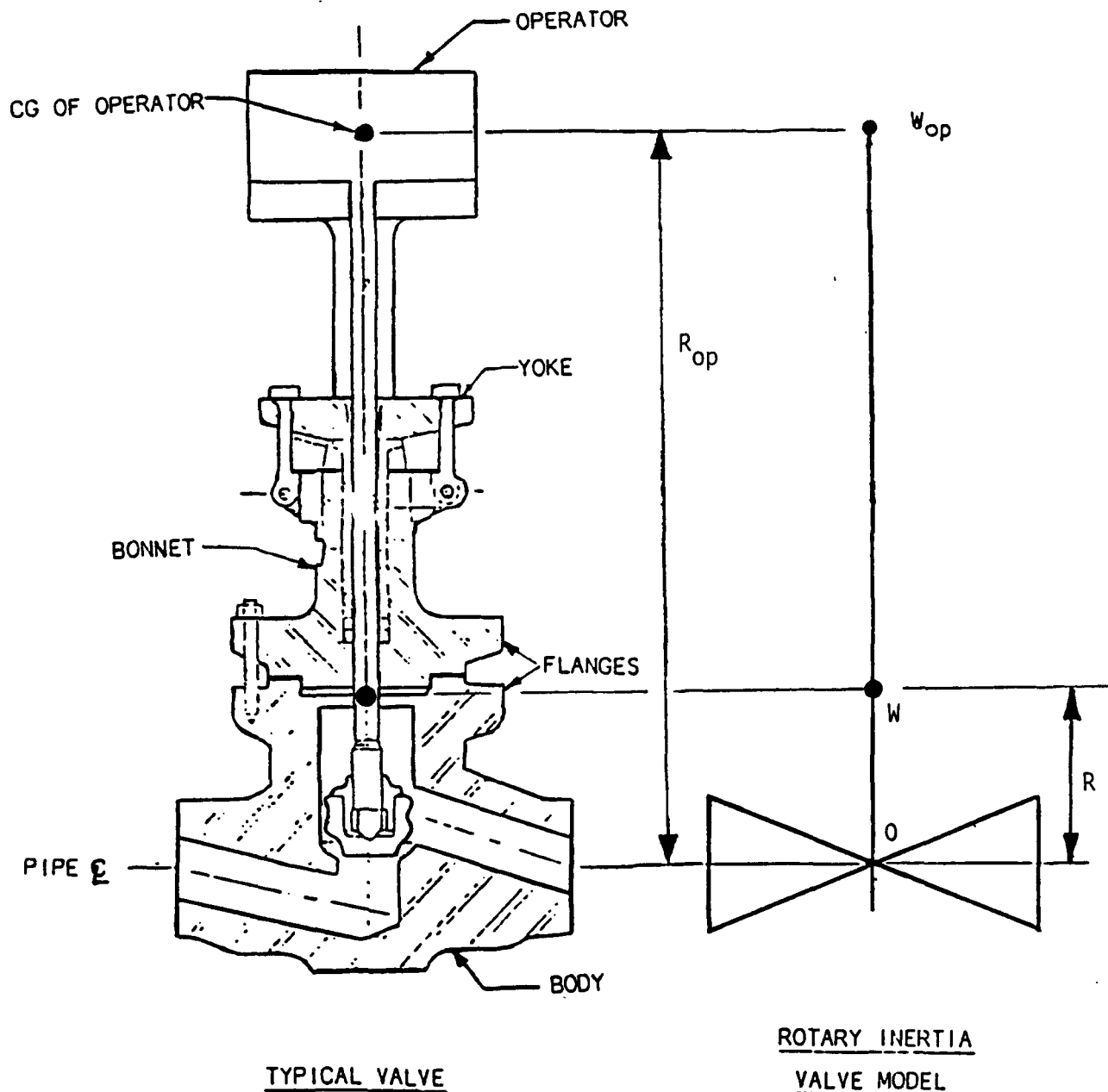


Figure 24

design of these valves makes for a smaller mass extending beyond the circumference of the pipe. Gate and globe valve bodies must accommodate movement of the disc or plug outside of the fluid flow path. This combined with the more cumbersome stem sealing apparatus for rising stem valves produces a valve where the center of mass may in fact lie beyond or outside the circumference of the pipe and impose a significant eccentric load on the pipe.

This effect is compounded when an operator is mounted on the valve. The operators for rotary valves are significantly more compact as smaller movements are required by them. These smaller operators are also closer to the centerline of the pipeline. Accordingly, use of rotary valves rather than conventional gate and globe valves will have a positive impact upon the minimization of supports and seismic restraints.

#### 4.11 Maintenance

Reference 19 identified that rotary valves require maintenance less frequently and that once required it is normally easier to perform on a rotary valve.

Valve maintenance focuses on two areas: the valve packing or stem seal and the valve seat. Rising stem valves have deep packing chambers filled with five or more rings of packing which are held in place by a packing gland. Removal of the old packing is always difficult as it is wedged in place, difficult to reach (particularly the lower rings) and difficult to grasp. The tools used to extricate the packing may easily damage the

inside surface of the packing chamber. Replacement of the new rings, although not as difficult as removal, requires considerable dexterity.

The stem seal arrangement for rotary valves, ball valves in particular, is very simple, consisting of a few elastomeric rings held in place by Belleville washers. Special tools are unnecessary and access to all parts is routine.

Beyond repacking, the most common maintenance requirement for a valve is the repair or replacement of the valve seat. This is a difficult task in gate and globe valves even when one has unlimited hands-on access. If the valve body is to remain in place, the milling or grinding operation must be done locally and the effective control of chips and debris requires considerable effort. The accomplishment of seat renewal for gates and globes by remote means would be extremely difficult.

Ball valves provide an attractive alternative in that many designs permit the valve internals to be removed through the bonnet cover. This permits replacement without disturbing the balance of the system. Also it should be noted that in most ball valve designs the internal parts fit in place directly without shrink fits, permitting the old seats to be lifted out and new ones dropped in place. This feature would lend itself well to robotics as it does for conventional hands-on maintenance.

## 5.0 Considerations for Standardization of Valve Applications

In an effort to develop a feel for the distribution of valve types, sizes, and ratings presently used in a nuclear power plant the valve lists for both the Clinch River Breeder Reactor Project (CRBRP) and the Philippines Nuclear Project were reviewed. The CRBRP valves reviewed were those procured by the architect-engineer or primarily the valves for the balance of plant systems (approximately 6000 valves). The data for the Philippines Project included valves for the entire plant except those provided with vendor packages. Approximately 11,000 valves were involved with this plant. The maximum working pressures ranged from 10 to 3335 pounds per square inch and the working temperatures from 42 to 1100°F.

Table 6 identifies the distribution of valve sizes for different pressure/temperature and fluid service combinations for CRBRP. Tables 7 and 8 show the number of valves by size for gate globe, check, ball, butterfly, plug, and diaphragm valves for both CRBRP and the Philippines Project. Tables 9 and 10 show the number of valves by pressure rating for the different valve types for the same projects. A review of these data resulted in the following observations:

- o Fully 90 percent of the valves are 8 inches or less in size.
- o Approximately 85 percent of the valves are ANSI rated 600 pounds or less.
- o Approximately 40 percent of the valves are ANSI rated 300 pounds or less.

TABLE 6

DESIGN PRESSURE/TEMPERATURE AND FLUID SERVICE COMBINATIONS FOR DIFFERENT VALVE SIZES FOR THE CLINCH RIVER PROJECT BALANCE OF PLANT VALVES

psig Press.	°F Temp.	VALVE SIZE IN INCHES																								
		1/4	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	6	8	10	12	14	16	18	20	24	30	32	36	48	72	
15	150																									
40	460				N			N	A	N		W	N	N	W		N	N	N	N	N	N				
40	1100																									
125	1100																									
150	200	W	W	W	W	W		W	W	W	N	W	W	W	W	W	W		W				W	W	W	
			A	A	A			A	A	F	N	W	W	W												
			C	C	C			C	C	C	O	O	N	N												
150	425				W						S	N				W		S		S						
180	1100																									
200	170		W	W	W	W		W	W	W	N	W	W	W	W		W									
											D	D	D	D	D											
225	125				N	N		N	N		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
250	200				W			W	W		W	W	W	W	W	W										
					D			D	D		D	D	D	D	D											
250	500				W						C					W		S								
300	420		W	W	W			W	W		W	W	W													
350	320				W	W		W	W	W	W	W	W	W	W	W				W	W			W		
435	500		W	W	W			W			W	W	W	S			W									
460	460		W	W				W			W					W										
600	110				H	H																				
					C	C																				
600	490		W	W	W			W	W	W	W	W	W	W	W	W	W					W				
			F	F	F																					
600	700		S	S	S			S	S		S	S	S	S	S	S		S	S							
1900	935				S	S		S	S	S	S	S	S		S						S	S				
2400	650				S						S	W	W	W												
3335	650				W	W		W	W		W	W	W	W	W	W		W								

Legend: W = Water  
 S = Steam  
 N = Nitrogen or Air  
 A = Acid  
 C = Caustic  
 D = Dowtherm  
 F = Diesel Fuel  
 H = Helium  
 O = Oil

Note: The pressures and temperatures are the maximum design pressures and temperatures as identified in the CRBRP valve list. The maximum temperatures do not necessarily occur coincident with the maximum pressure.

TABLE 7

DISTRIBUTION OF VALVE SIZES FOR DIFFERENT VALVE TYPES  
(Data from Clinch River Project)

Size (in)	Gate	Globe	Check	Ball	Butterfly	Plug	Diaphragm*	Total
0.25	-	-	-	-	-	-	-	0
0.375	-	-	-	-	-	-	-	0
0.5	15	65	4	1	-	11	2	96
0.75	20	2373	8	-	-	10	-	2411
1.0	11	410	43	92	-	106	20	662
1.25	2	5	-	-	-	-	-	7
1.5	25	95	29	74	-	45	-	268
2.0	27	479	32	111	-	21	-	670
2.5	17	17	1	8	-	-	-	43
3.0	185	71	95	202	4	47	-	604
4.0	169	56	51	112	1	12	-	401
6.0	79	39	33	45	21	-	-	217
8.0	72	1	1	6	15	-	-	95
10.0	31	-	6	-	32	-	-	69
12.0	26	4	11	-	47	-	-	88
14.0	20	-	-	-	12	-	-	32
16.0	12	-	2	-	24	-	-	38
18.0	5	-	-	-	11	-	-	16
20.0	3	-	-	-	21	-	-	24
24.0	4	-	-	-	33	-	-	37
30.0	1	-	-	-	30	-	-	31
36.0	-	-	2	-	6	-	-	8
48.0	-	-	-	-	3	-	-	3
72.0	-	-	-	-	6	-	-	6
78.0	-	-	-	-	-	-	-	0
96.0	-	-	-	-	-	-	-	0
Total	724 12.4%	3615 62.1%	318 5.5%	651 11.1%	266 4.6%	252 4.3%	22	5826

\* The figures for diaphragm valves are not included in the total as they were deleted on the Clinch River Project and replaced by plug valves.

TABLE 8

DISTRIBUTION OF VALVE SIZES FOR DIFFERENT VALVE TYPES  
(Data from Philippine Nuclear Power Plant Unit No. 1)

Size	Gate	Globe	Check	Ball	Butterfly	Plug	Diaphragm	Relief	Special	Total
0.25	-	109	-	-	-	-	-	4	3	116
0.375	-	197	31	-	-	-	-	-	-	228
0.5	-	210	36	2	-	-	-	-	25	273
0.75	86	2905	60	-	-	-	4	98	854	4007
1.0	174	627	76	6	-	-	17	22	115	1037
1.25	-	-	-	-	-	-	-	-	-	0
1.5	44	514	46	-	-	-	-	5	1	610
2.0	114	591	119	-	-	-	17	8	267	1116
2.5	4	76	4	-	-	-	-	-	-	84
3	263	72	90	11	15	-	27	9	180	667
4	218	89	83	2	13	-	9	7	65	486
6	281	17	50	-	25	-	-	16	21	410
8	77	12	30	-	17	-	-	-	25	161
10	101	14	27	-	24	-	-	-	14	180
12	77	3	15	-	10	-	-	-	12	117
14	17	-	4	-	1	-	-	-	-	22
16	20	2	21	-	14	-	-	-	20	77
18	3	-	2	-	-	-	-	-	-	5
20	4	-	8	-	2	-	-	-	26	40
24	-	-	-	-	-	-	-	17	-	17
30	-	2	-	-	2	-	-	-	-	4
36	-	-	-	-	-	-	-	-	-	0
48	-	-	-	-	4	-	-	-	-	4
72	-	-	-	-	-	-	-	-	-	0
78	-	-	-	-	5	-	-	-	-	5
96	-	-	-	-	8	-	-	-	-	8
TOTAL	1483 15.3%	5440 56.2%	702 7.3%	21 0.2%	140 1.5%	- 0%	74 0.7%	169 1.8%	1645 17%	9674

Valves supplied with vendor packages 1562

Total number of valves 11,236

TABLE 9

DISTRIBUTION OF VALVE PRESSURE RATINGS FOR DIFFERENT VALVE TYPES  
(Data from Clinch River Project)

ANSI Rating	Gate	Globe	Check	Ball	Butterfly	Plug	Diaphragm*	Total
2500	-	115	-	-	-	-	-	115
1500	64	410	68	-	-	-	-	542
900	0	0	0	-	-	-	-	0
600	27	2781	45	5	-	-	-	2858
300	115	38	25	219	-	-	-	397
150	411	175	164	427	266	252	22	1695
125	105	96	16	-	-	-	-	217
Gravity	2	-	-	-	-	-	-	2
<b>Total</b>	<b>724</b>	<b>3615</b>	<b>318</b>	<b>651</b>	<b>266</b>	<b>252</b>	<b>22</b>	<b>5826</b>

\* The figure for diaphragm valves is not included in the total as the diaphragm valves were deleted on the Clinch River Project and replaced by plug valves.



- o Approximately 35 percent of the valves are ANSI rated 150 pounds or less.
- o Five sizes have noticeably small populations - 0.25 inch, 0.375 inch, 0.5 inch, 1.25 inch, and 2.5 inch.
- o Nearly three fourths of the valves are gate and globe valves with globe valves constituting over 50%.
- o Approximately 35% of the valves are 0.75 inch globe valves which are used for instrument root valves as well as vent and drain valves.
- o The types of fluids encountered in a nuclear plant (excluding liquid metal) are relatively innocuous as compared to those encountered in many process industries.
- o Only water and steam are used at temperature/pressure combinations that tax the limitations of sealing materials.

#### 5.1 Recommendations

As a result of study of the above observations the following recommendations are proposed. These recommendations are discussed in further detail in Section 7.0.

1. Standardize on the use of rotary valves for all gas and liquid services except high temperature steam. Plug valves may be used for all radioactive fluids. Utilize ball valves for all non-radioactive fluid applications two inches and below. Above two inches utilize butterfly valves. The use of specialty valves such as check valves and relief valves must be retained.

2. Procure all valves presently rated 300 pounds and below as 600 pound valves.
3. Limit the selection of valve sizes below four inches to: 0.75, 1.0, 2.0, and 3.0 inches.

## 5.2 Economic Evaluation of Proposed Simplifications

If one were to remove check valves from consideration approximately 90 percent of the valves will be four inches and less in size. Table 11 shows how reducing the number of different valve types, sizes, and ratings could significantly reduce the overall procurement costs by nearly one million dollars.

Consider that there are approximately 4500\* valves that are gates, globes, balls, butterfly or plug valves in a plant and that these valves range in size from 4 inches down to 1/4 inch and are of three ANSI pressure ratings 150, 300, and 600 pounds. With five valve types, three ratings, and a range of ten sizes there are 150 possible combinations of these three parameters. Allowing that we do not have a valve for every combination it is reasonable to assume that there will be at least 100 probable combinations that must be supported with spares. By limiting the different valve types to balls, butterflys and plugs, requiring all valves to be 600 pound rated, and limiting the selection of valve sizes to 0.75, 1.0, 2.0, 3.0 and 4.0 inches the total number of different combinations that must be supported by spares is reduced to 15. If we assume that one will provide approximately 5 sets of spares per combination of valves at \$600 per set one can see that a savings of over a quarter of a million dollars may be realized.

\* To be conservative all valves rated 900 pounds and above were considered to be in this size range and were deleted from the total.

TABLE 11  
ANALYSIS OF SAVINGS AS A RESULT OF VALVE STANDARDIZATION

	<u>Present</u>	<u>Proposed</u>
Valves affected	4500	4500
Number of Different Valve Types	5	3
Number of Different Valve Ratings	3	1
Number of Different Valve Sizes	10	5
Possible Combinations	150	15
Probable Combinations	100	15
Number of Spares/Combination	5	5
Total Spares	500	75
Cost for Spares @ \$600/set	\$300K	\$45K
Cost Savings		(\$255,000)
Number of Procurement Packages @ 1 per valve type of 150/300 and 600	10	3
Cost of \$100,000/pkg	\$1,000K	\$300K
Cost Savings		(\$700,000)
Added Cost to Upgrade Ratings @ \$200/valve for 50% of valves		\$450,000
Savings in Buying Ball Valves in sizes 2" and below and butterfly valves 3" and above @ \$100/valve (300 valves already are rotary type)		(\$420,000)
Savings in Simplified Maintenance		Undefinable
<hr/>		
Total Savings		(\$925,000) plus savings in maintenance

As confirmed by recent communications not all manufacturers produce valves in pressure ratings from 150 pounds to 600 pounds. Accordingly, the experience of the Clinch River Project was to group the valves for procurement in specifications by type and two pressure rating categories (150/300 and 600). Experience has shown that a single procurement costs \$100,000 above and beyond the cost of hardware to solicit and evaluate bids, review vendor documents, resolve vendor exceptions, and surveillance. Accordingly, by standardizing the valve selection one could realize a savings of approximately \$700,000.

Because 600 pound valves are now proposed in those instances where only 150 or 300 pound valves were required the procurer will suffer a penalty. A review of valve costs in the 4 inch and below size range reveals that one would pay on the order of \$200 per valve additional. As less than 50 percent of the valves are 300 pound rated or less this will result in a penalty of about one half million dollars.

The cost of ball and butterfly valves are generally less than their equivalent gate and globe valves. As the cost differential will be approximately \$100 per valve the savings realized will be over \$400,000.

Of course, the reduction in the number of different valve types, sizes, and ratings are expected to greatly reduce the cost of maintenance by making it simple to perform, easier to train personnel, and reducing the warehousing requirements. These factors, however real, are impossible to quantify and are part of the indirect benefits to standardization. By referring to Table 11 one can see that the overall savings would be significant in spite of the fact that one would be buying higher rated valves.

## 6.0 Suggested Specification Simplifications for Non-Nuclear Components

As mentioned in the introduction, the Clinch River Project attempted to upgrade the quality of secondary plant equipment by including many design and fabrication requirements over and beyond those specified in industry codes in the specifications. This approach proved to be counter productive and resulted in products of greater expense without a corresponding increase in quality. The added requirements also intimidated some vendors and discouraged them from submitting proposals.

- 1) Vendors already had well established techniques and procedures that they were loath to alter, especially for small quantities.
- 2) The paper work or documentation required by procedures was often component specific thereby requiring the vendor to track the parts through its manufacturing process. This required the manufacturer to disrupt his manufacturing process to provide the necessary segregation.
- 3) The procedures often required the vendor to provide documentation concerning suppliers over whom he had little or no control.
- 4) As most vendors intended to provide their standard product with minimal modification if any, most ancillary requirements served no purpose other than to give the purchaser a false sense of quality.

Rather than providing a specification which attempts to dictate every facet of design, material selection, and manufacture, it is considered that a specification which simply defines the acceptable performance criteria would be more successful in obtaining a quality product at a more reason-

nable price. The existing specifications call for additional requirements in four major categories - welding, materials, painting and coating, electrical, packaging, storage and handling much of which could be eliminated without a loss of quality.

Exhibit 6 is a markup of a specification suggested for ball valve procurement. Exhibit 7 is a compilation of items that are often included in such a specification but which are considered to unnecessarily add to the cost of the procurement. The following sections discuss the nature of the changes that have been made in the Exhibit 6 markup.

### 6.1 Welding

Design and fabrication is required in accordance with ANSI B31.1. Specifying the chapter and paragraph is unnecessarily limiting. The ancillary requirements for low hydrogen electrodes, filler metals, electrode storage, etc. are beyond the requirements of the code. All the detailed requirements for cleaning, welding procedures, heat treatment, welding qualifications, and records are redundant with the ANSI B31.1 standard and could be deleted.

### 6.2 Materials

Materials should be the manufacturer's standard materials that are used for his stocked items. Where the purchaser has a particular material requirement it should be identified in the specification. The purchaser should request and review the materials used and require changes in only those instances where a particular material is known to be unacceptable. The intent of this approach is to avoid forcing the manufacturer to make

changes to his standard product to accommodate changes for which there is not a sound basis or for preference only.

### 6.3 Painting and Coating

It has been the practice to define extensive details concerning coatings and their application. A more practical approach would be to specify a particular coating system and to require that the valve vendor follow the coating manufacturer's written instructions. Exhibits 4 and 5 show typical instruction sheets for manufacturer's products. The instructions provide all the necessary details concerning surface preparations, mixing, application temperatures, application equipment, and procedures. The approach of citing the coating manufacturer's instructions has a number of benefits:

1. It simplifies the specification thereby making it more attractive to the bidder.
2. It eliminates the possibility of conflict between the specification and a coating manufacturer's instructions.
3. It eliminates the difficulty of preparing instructions that accommodate the requirements of different manufacturers which may be mutually conflicting.

### 6.4 Electrical Requirements

The requirements for limit switches should be defined without specifying a particular manufacturer. Terminal box enclosures for all

valves and operator types should be standardized on NEMA ICS-6, type 4 except for those rare instances where Type 6 (submersible) are required. This exception could be addressed as a special requirement in the valve list.

#### 6.5 Packaging and Packing, Storage and Handling

Delineating the specific requirements for packaging, packing, storage and handling at the same time as referencing ANSI N45.2.2 is redundant. The ANSI standard is complete and only requires one to specify the level to be applied to particular equipment. As cited in the attached markup (Exhibit 6) Level B is appropriate for valves with motor operators. All other valves could be assigned Level C or one could appropriately specify the manufacturer's standard procedures.

#### 6.6 Testing Requirements

By careful scrutiny of the various tests and examinations one can still ensure that one is receiving a quality product. The testing requirements presently defined in CRBRP specifications are sufficient to evaluate the quality of the delivered products and no major changes are suggested.

## 7.0 Conclusions

The diversity of valve sizes, types, and ratings is by no means limited to the breeder reactor program. Power plants in general, be they liquid metal fast breeders, pressurized water, or fossil fueled, utilize a host of different valves and experience similar difficulties with procurement, maintenance, and spare parts support. It follows, therefore, that the power industry in general would benefit from increased standardization of valves and the conclusions of this report which was produced for the breeder program are indeed applicable to the power industry as a whole.

The power industry has been slow to standardize upon plant designs, system designs, or even component selection because it is not governed by a single body but consists of a multitude autonomous utilities. The U.S. Navy has been able to establish a standard valve design for use on all its nuclear plants because it is a single organization and is not subject to the forces of the marketplace. Similarly, the French are able to achieve a high degree of standardization because their nuclear industry is nationalized and is able to unilaterally decree that particular designs be used for all plants. The restriction of designs is possible in an organization such as the military, however, in the open marketplace such restrictions and limitations are not practicable. As the restriction or limitations cannot originate from a central authority any steps toward standardization must be initiated by individual power plant designers.

There are steps that can be taken which would improve the commonality of power plant valves without favoring a specific manufacturer. The

industry has for years favored the use of gate and globe valves over other valve types. This tradition is firmly entrenched and was quite properly based upon the fact that these valves served their purposes better than other valve types that were available. However, over the years as rotary valves were developed and improved, the industry has been reluctant to accept them. The past decade has seen many significant improvements in rotary valves and the modern rotary should not be judged on the performance of older models.

Approximately 50 percent of the valves in a nuclear power plant are non-safety class or balance of plant valves. These valves have the greatest potential for standardization and were the focus of this study. The conclusion of this study is that significant strides could be made toward standardization in instituting the following changes:

1. Standardize on the use of rotary valves for all gas and liquid services except high temperature steam. Plug valves should be used for all radioactive fluids. Utilize ball valves for all non-radioactive fluid applications two inches and below within the pressure/temperature range shown on Figure 22 such as chilled water, service water, demineralized water, fire protection (with fire rated seals), instrument air, service air, and nitrogen. Above two inches, butterfly valves may be used in the same systems because they are much less expensive. Where other considerations warrant the additional expense, ball valves should be used. Such a consideration might be the greater ease of maintenance of ball valves and the subsequent reduced personnel radiation exposure in a radiation area. For high temperature steam applications the use of globe valves should continue.

2. Eliminate all pressure ratings below ANSI 600 for all valves. Valves in this size range are readily available in the 600 pound rating for an additional cost of 25 percent or less and the added expense would not be significant compared to the savings from supporting fewer valve types. It should be noted that this step would require all piping to be procured with 600 pound flanges or end preparations.
3. For valves below four inches in size, limit the choice of sizes to 3/4 inch, 1 inch, 2 inches, and 3 inches. The other sizes (1/4 inch, 3/8 inch, 1/2 inch, 1-1/4 inch, 1-1/2 inch and 2-1/2 inch) are not used sufficiently to warrant the expense of spare parts support. The use of the next higher valve size will not restrict system designers or add significantly to the capital cost.

The second phase of this study dealt with the procurement specifications with the intent of making them more biddable. It is suggested that the specifications be written to specify fewer details of design. Excessive ancillary requirements above and beyond those contained in standard engineering and industry codes should be avoided. In addition, it is recommended that the documentation requirements be kept as a minimum to those that are needed to verify the adequacy or quality of the delivered product. Exhibit 6 is provided as a representative specification for the procurement of ball valves which would fulfill the above requirements.

It is hoped that the implementation of the recommendations put forth in this report will assist in reducing the overall costs for nuclear power plants and contribute thereby to their continued development.

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ENGINEERING DIVISION			SPEC. SP-29C
STANDARD SPECIFICATIONS- PIPING MATERIAL			SHEET 1 OF 2
DESCRIPTION	CARBON STEEL (CS) SOCKET WELDED AND FLANGED		ISSUED 10/8/79 REV. 2/24/82
1. <u>MAX. DESIGN RATING:</u>	650 psig @ 750°F		
2. <u>PIPE:</u> All sizes	Black CS IPS seamless pressure pipe, ASTM A106 Gr. B, Sch. 80		
3. <u>FITTINGS:</u> 2" and under	Forged black CS, ASTM A-105, socketwelding, ANSI B36.11, 3000 lb.		
2½" and over	Black CS buttwelding, ASTM A234 Gr. WPB, seamless, ANSI B16.9, Sch. 80.		
4. <u>FLANGES:</u> 2" and under	600 lb. forged CS, ASTM A105, socketweld ends bored for Sch. 80 pipe, raised face		
2½" and over	600 lb. forged CS, ASTM A105, weld neck type, bored for Sch. 80 pipe, raised face		
5. <u>GASKETS:</u>	Ring type 316 SS inserted Grafoil gaskets, Union Carbide Gr. GHE, 1/16" thick (Finishing Areas), spiral wound asbestos & 304 SS, Flexitallic type CG, 1/8" thick, elsewhere.		2
6. <u>BOLTING:</u>	Alloy steel stud bolts, ASTM A193, Gr.B-7, threaded full length, with two heavy semi-finished hex nuts, ASTM A194, Gr.2H, with Class 2A fit on studs, and 2B fit on nuts.		
7. <u>PIPE JOINTS:</u> 2" and under	Sch. 80 socketweld couplings		
2½" and over	Buttwelding		
8. <u>BRANCH CONNECTIONS:</u> 2" and under	Full size and reducing-use Sch.80 socketwelding tees.		
2½" and over	Reducing - use XH weldolets* or sockolets* Full size - use buttwelding Sch. 80 tees.		
9. <u>VALVES - SHUTOFF:</u> (See Note 1, page 2) 2" and under Tag: G-1203	Forged CS gate valve, 2000 lb.CWP, SS trim, bolted bonnet, O.S.&Y., socket weld ends, Vogt Fig.SW-12111 or approved equal.		
2½" and over Tag: G-1509	Cast CS gate valve, Class 600, hard faced seats, bolted bonnet, O.S.&Y., buttwelding ends, Crane Fig.76½XU or approved equal.		
*Bonney Forge or	approved equal.		

ENGINEERING DIVISION		SPEC. SP-29C
STANDARD SPECIFICATIONS- PIPING MATERIAL		SHEET 2 OF 2
DESCRIPTION	CARBON STEEL (CS) SOCKETWELDED AND FLANGED	ISSUED 10/8/79 REV. 2/24/82
10. <u>VALVES - THROTTLING:</u> (See Note 1, below)		
2" and under Tag: GL-1203	Forged CS globe valve, 2000 lb.CWP, SS trim, bolted bonnet, O.S.&Y., hard faced seats, socket weld ends, Vogt Fig.SW-12141 or approved equal	
2½" and over Tag: GL-1514	Cast CS globe valve, 600 lb, SS seat and disc, bolted bonnet, O.S.&Y., buttwelding ends, Powell Fig.6031WE or approved equal.	
11. <u>VALVES - CHECK:</u>		
2" and under Tag: C-1210	Forged CS swing check valve, 2000 lb.CWP, no bonnet joint, socket weld ends, Vogt Fig.SWS-74 or approved equal.	
2½" and over Tag: C-6005	Cast CS swing check valve, Class 600, bolted bonnet, buttwelding ends, Crane Fig.175½XU or approved equal	
NOTE: (1) Valves shall have grafoil packing. (2) Where chain operators are required for elevated steam gate & globe valves, they shall be the "Hammer-Blow" type as manufactured by the Roto Hammer Co., Tulsa, Oklahoma, or approved equal. Units shall include handwheel replacement adapter, anvil, rotary hammer, chain guide, and set collar. Units shall be sized in accordance with manufacturer's recommendations.		

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PIPING MATERIAL SPECIFICATIONS - CLASS CA

JOB NO. 6411

SERVICE: Steam, Condensate and Boiler Feed Water  
 MATERIAL: Carbon Steel  
 RATING & FACING: 300# RF  
 PRESS-TEMP. RANGE: 555# @ 600°F. - 720# @ 100°F.  
 CORROSION ALLOWANCE: 0.125"

GATE VALVES

TAG NO.

1/2" - 3/4" (Note 3)	800# THD	CV-83Q	Vogt 12111	R2
1/2" thru 1-1/2" 2" only	300# RF Flg'd. 300# RF Flg'd.	CV-30Q CV*30FQ	Vogt #363 Walworth #5206F- HF	R2 R2
3" thru 14" 16" thru 24"	300# RF Flg'd. 300# RF Flgd.	CV-30FQ CV-30FGQ	Pacific #2355-7 Pacific 2355-7BG	R2 R2

GLOBE VALVES

1/4" (Note 4)	800# THD	CG-83Q	Vogt 12141	R2
1/2" thru 2" 3" thru 8"	300# RF Flg'd. 300# RF Flg'd.	CG-30Q CG*30Q	Vogt #483 Pacific 360-7	R2 R2

CHECK VALVES

1/2" thru 2" (Horiz. only)	300# RF Flg'd.	CE-30HQ	Vogt #583	R2
3" thru 12"	300# RF Flg'd.	CC-30Q	Pacific 380-7	R2

PIPE

1/2" thru 1-1/2"	XS, Smls Steel P.E.	ASTM A106 Gr. B
2"	XS, Smls Steel P.E.	ASTM A53 Gr. B
3" thru 10"	Std. Smls Steel BE	ASTM A53 Gr. B
12" thru 16"	XS, Smls Steel BE	ASTM A53 Gr. B
18" thru 24"	Sch. 40, Smls Steel BE	ASTM A53 Gr. B

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PIPING MATERIAL SPECIFICATIONS - CLASS CA

JOB NO. 6411

FITTINGS

1/2" thru 2"	3000# Socketweld	ASTM A105
3" thru 10"	Std. Smls Buttweld	ASTM A234 Gr.WPB
12" thru 16"	XS, Smls Buttweld	ASTM A234 Gr.WPB
18" thru 24"	Sch. 40, Smls Buttweld	ASTM A234 Gr.WPB

UNIONS

Use flanges

SWAGE NIPPLES

XS, Smls Steel

ASTM A106 Gr. B

PIPE NIPPLES

1/2" thru 1-1/2"	XS, Smls Steel	ASTM A106 Gr. B
1/2" only (Note 5)	Sch. 160, Smls Steel	ASTM A106 Gr. B

FLANGES

1-1/2" (Note 6)	300# Long welding neck	ASTM A105	R2
1/2" thru 2"	300# RF Socketweld	ASTM A105	
3" thru 24"	300# RF, Welding Neck (Bore to match pipe)	ASTM A105	
1" only (Note 2)	300# Long welding neck, Blind	ASTM A105	

ORIFICE FLANGES

1-1/2" thru 24"	300# RF Welding Neck (Bore to match pipe)	ASTM A105
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GASKETS

Flexitallic Style "CG"	Type 4DF1
Type 304 SS, Asbestos Filled	MWK Eng. Std. 18-1S-68

BOLTS-STUD

Length to be in accordance with Eng. Standard 895.1	Type AB7	R2
Alloy Steel Stud Bolts	MWK Eng. Std. 17-1S-80	
w/2 SF Heavy Hex Nuts each		

EQUIPMENT;FAILURE, OPERATOR ERROR;NONLICENSED OPERATOR

9/0/0000001-0000442// 25  
 ACCESSION NO. 0020162030  
 TITLE STEAM GENERATOR LEVEL CHANNEL INOPERABLE AT NORTH ANNA 1  
 CORPAUTH VIRGINIA ELECTRIC & POWER CO.  
 DATE 1980  
 TYPE Q  
 MEMO LTR W/LEX 80-100 TO U.S. NRC, REGION 2, DEC 22, 1980, DOCKET  
 50-338, TYPE--PWR, MFG--WEST, AE--SEW, DCS NO.--8012510316  
 AVAIL AVAILABILITY - NRC PUBLIC DOCUMENT ROOM, 1717 H STREET,  
 WASHINGTON, D. C. 20555 (05 CENTS/PAGE -- MINIMUM CHARGE  
 \$2.00)  
 CATEGORY 170000;090000  
 EDITION 0121  
 CORP CODE ARX  
 COUNTRY A  
 LER NO 80-100  
 ABSTRACT DATE OF EVENT - 120180. POWER LEVEL - 077%. CAUSE - HIGH  
 TRANSMITTER OUTPUT DUE TO VALVE LEAK. LI-1474 STEAM GENERATOR  
 A LEVEL CHANNEL I INDICATED HIGHER THAN THE AVERAGE OF THE  
 THREE CHANNELS. THE CAUSE IS A HIGH TRANSMITTER OUTPUT DUE TO  
 A LEAKING ROOT ISOLATION VALVE. BECAUSE THE UNIT IS NEARING A  
 REFUELING OUTAGE THE CHANNEL WILL BE LEFT IN TRIP UNTIL THE  
 OUTAGE WHEN THE LEAKING VALVE WILL BE REPAIRED. THE NEXT  
 SCHEDULED FUNCTIONAL TEST ON THIS CHANNEL IS NOT SCHEDULED TO  
 OCCUR PRIOR TO THE UNIT 1 REFUELING OUTAGE.  
 COMPONENT CODE INSTRUMENTATION AND CONTROLS  
 SYSTEM CODE IA-REACTOR TRIP SYSTEMS  
 KEYWORDS FAILURE;REACTOR, PWR;NORTH ANNA 1 (PWR);REACTOR PROTECTION  
 SYSTEM;FAILURE, INSTRUMENT;FAILURE, INHERENT;SENSORS, LEVEL;  
 STEAM GENERATOR;VALVES;LEAK

9/0/0000001-0000442// 26  
 ACCESSION NO. 0020162028  
 TITLE SERVICE WATER VALVE FAILS TO OPEN AT ZION 2  
 CORPAUTH COMMONWEALTH EDISON CO.  
 DATE 1980  
 TYPE Q  
 MEMO LTR W/LEX 80-030 TO U.S. NRC, REGION 3, DEC 24, 1980, DOCKET  
 50-304, TYPE--PWR, MFG--WEST, AE--SEL, DCS NO.--8101050340  
 AVAIL AVAILABILITY - NRC PUBLIC DOCUMENT ROOM, 1717 H STREET,  
 WASHINGTON, D. C. 20555 (05 CENTS/PAGE -- MINIMUM CHARGE  
 \$2.00)  
 CATEGORY 170000;120000  
 EDITION 0121  
 CORP CODE DKS  
 COUNTRY A  
 LER NO 80-030  
 ABSTRACT DATE OF EVENT - 112430. POWER LEVEL - 092%. CAUSE - VALVE  
 OPERATOR FAILURE. WHILE TESTING, ONE OF THE SERVICE WATER  
 INLET VALVES TO THE RCFC'S, 2MOV-SW0002, FAILED TO STROKE TO  
 THE FULL OPEN POSITION. ELECTRICIANS INSPECTED AND REPAIRED  
 THE VALVE OPERATOR AND CONTROL CIRCUIT. THE VALVE WAS STROKED  
 BY SAFEGUARDS ACTUATION WITH NO PROBLEM.  
 COMPONENT CODE VALVOP-VALVE OPERATORS  
 SYSTEM CODE WA-STATION SERV WATER SYS & CONT  
 KEYWORDS FAILURE;REACTOR, PWR;ZION 2 (PWR);TEST, SYSTEM OPERABILITY;  
 SERVICE WATER SYSTEM;VALVE OPERATORS;FAILURE, EQUIPMENT;  
 FAILURE, INHERENT;VALVES

9/0/0000001-0000442// 27  
 ACCESSION NO. 0020162002  
 TITLE RCS LEAKAGE EXCEEDS LIMIT AT BEAVER VALLEY 1  
 CORPAUTH DUQUESNE LIGHT CO.  
 DATE 1980  
 TYPE Q  
 MEMO LTR W/LEX 80-100 TO U.S. NRC, REGION 1, DEC 18, 1980, DOCKET  
 50-334, TYPE--PWR, MFG--WEST, AE--SEW, DCS NO.--8012300659  
 AVAIL AVAILABILITY - NRC PUBLIC DOCUMENT ROOM, 1717 H STREET,  
 WASHINGTON, D. C. 20555 (05 CENTS/PAGE -- MINIMUM CHARGE  
 \$2.00)  
 CATEGORY 170000;110000  
 EDITION 0121

CORP CODE DUQ  
 COUNTRY A  
 LER NO 80-107  
 ABSTRACT DATE OF EVENT - 112580. POWER LEVEL - 046%. CAUSE - LEAKY SEAL INJECTION DRAIN VALVES. THE MEASURED UNIDENTIFIED REACTOR COOLANT SYSTEM LEAKAGE EXCEEDED THE T.S. LIMIT OF 1 GPM. THE EXCESSIVE LEAK WAS IDENTIFIED, REDUCED, AND MEASURED. THE MEASURED UNIDENTIFIED LEAKAGE WAS DETERMINED TO BE WITHIN THE T.S. LIMIT. THE SEAL WATER INJECTION FILTERS, CH-FL-4A AND 4B, DRAIN VALVES 1CH-308 AND 1CH-309 LEAK BY. THE VALVES WERE TIGHTENED CLOSED TO REDUCE LEAKAGE AND A TEMPORARY HOSE WAS INSTALLED TO DIRECT LEAKAGE TO THE AUXILIARY BUILDING SUMP. THE VALVES ARE BEING REPLACED WITH IDENTICAL VALVES. A BACKUP VALVE IS ALSO BEING INSTALLED IN-SERIES.

COMPONENT CODE VALVEX-VALVES  
 SYSTEM CODE CG-REAC COOL CLEANUP SYS & CONT  
 KEYWORDS FAILURE;REACTOR, PWR;BEAVER VALLEY 1 (PWR);TEST, SYSTEM OPERABILITY;VALVES;LEAK;COOLANT PURIFICATION SYSTEM;FAILURE, EQUIPMENT;FAILURE, INHERENT;REACTOR COOLANT

9/0/0000001-0000442// 28

ACCESSION NO. 0020161498  
 TITLE MAIN STEAM FLOW INDICATOR INOPERABLE AT BEAVER VALLEY 1  
 CORPAUTH DUQUESNE LIGHT CO.  
 DATE 1980  
 TYPE Q  
 MEMO LTR W/LER 80-098 TO U.S. NRC, REGION 1, DEC 18, 1980, DOCKET 50-334, TYPE--PWR, MFG--WEST, AE--SEW, DCS NO.--8012300659  
 AVAIL AVAILABILITY - NRC PUBLIC DOCUMENT ROOM, 1717 H STREET, WASHINGTON, D. C. 20555 (05 CENTS/PAGE -- MINIMUM CHARGE \$2.00)

CATEGORY 170000;090000  
 EDITION 0121  
 CORP CODE DUQ  
 COUNTRY A  
 LER NO 80-098  
 ABSTRACT DATE OF EVENT - 112280. POWER LEVEL - 030%. CAUSE - TRANSMITTER BYPASS VALVE NOT FULLY CLOSED. OPERATOR SURVEILLANCE OF THE BOARD REVEALED THAT MAIN STEAM FLOW INDICATOR FI-MS-484 WAS PEGGED LOW. ACTUAL STEAM FLOW WAS ABOUT 1 MILLION LBM/HR. THE TRANSMITTER, FT-MS-484, BYPASS VALVE WAS NOT FULLY CLOSED. THE VALVE WAS FULLY CLOSED AND THE CHANNEL CHECKED FOR PROPER INDICATION.

COMPONENT CODE INSTRU-INSTRUMENTATION AND CONTROLS  
 SYSTEM CODE IA-REACTOR TRIP SYSTEMS  
 KEYWORDS FAILURE;REACTOR, PWR;BEAVER VALLEY 1 (PWR);REACTOR PROTECTION SYSTEM;FAILURE, INSTRUMENT;FAILURE, MAINTENANCE ERROR; MAINTENANCE PERSONNEL;SENSORS, FLOW;VALVES;STEAM;BYPASS;TEST, SYSTEM OPERABILITY

9/0/0000001-0000442// 29

ACCESSION NO. 0020161943  
 TITLE BIT BORON CONCENTRATION BELOW LIMIT AT BEAVER VALLEY 1  
 CORPAUTH DUQUESNE LIGHT CO.  
 DATE 1980  
 TYPE Q  
 MEMO LTR W/LER 80-091 TO U.S. NRC, REGION 1, DEC 12, 1980, DOCKET 50-334, TYPE--PWR, MFG--WEST, AE--SEW, DCS NO.--8012190587  
 AVAIL AVAILABILITY - NRC PUBLIC DOCUMENT ROOM, 1717 H STREET, WASHINGTON, D. C. 20555 (05 CENTS/PAGE -- MINIMUM CHARGE \$2.00)

CATEGORY 170000;120000  
 EDITION 0121  
 CORP CODE DUQ  
 COUNTRY A  
 LER NO 80-091  
 ABSTRACT DATE OF EVENT - 111380. POWER LEVEL - 000%. CAUSE - WATER INLEAKAGE THROUGH ISOLATION VALVES. ROUTINE SAMPLING OF THE BORON INJECTION TANK (BIT) INDICATED A LOW BORON CONCENTRATION IN THE TANK. A SECOND SAMPLE ALSO READ LOW. AFTER ADDING 100 POUNDS OF BORON, SAMPLES INDICATED A HIGH CONCENTRATION. A DILUTION WAS BEGUN, BRINGING THE BIT BACK INTO SPECIFICATION AT 2010 HOURS. THE CAUSE FOR THE LOW BORON CONCENTRATION IN THE BIT IS THOUGHT TO BE DUE TO INLEAKAGE THROUGH THE ISOLATION



# CARBOLINE 191 PRIMER AND FINISH (APR\*)

350 HANLEY INDUSTRIAL COURT • ST. LOUIS, MO. 63144 • 314-644-1000

## SELECTION DATA

**GENERIC TYPE:** Epoxy-polyamide. Part and Part B mixed prior to application.

**GENERAL PROPERTIES:** A tank lining system for fresh water, including potable water service, and for contact with food products.\* Carboline 191 Primer and Finish are not photochemically reactive as defined by Regulation 8, Rule 4 of the Bay Area Air Quality Management District.

**RECOMMENDED USES:** Carboline 191 Primer and Finish is recommended for use as a tank lining and heavy duty service system for protection of steel and concrete in water and food products service. Carboline 191 Finish, colors White C800, and Gray C703 and C705, may be used in contact with food products in accordance with Food and Drug Administration Regulation 175.300. Extraction tests on the material were far below the limits set by the agency. Excellent lining for sugar solutions, meat products, etc.

**NOT RECOMMENDED FOR:** Immersion in water over 130°F (54°C), strong mineral and organic acids, or solvents.

### CHEMICAL RESISTANCE GUIDE:

Exposure	Immersion	Splash and Spillage
Acids	NR	NR
Alkalies	Excellent to 150°F (66°C)	Excellent
Solvents	NR	Poor-Fair
Salt	Excellent to 150°F (66°C)	Excellent
Water	Excellent to 130°F (54°C)	Excellent
Sugar Solutions	Excellent to 150°F (66°C)	Excellent

**TEMPERATURE RESISTANCE:** Not affected by steam cleaning. See specific exposure for temperature resistance.

**FLEXIBILITY:** Good

**WEATHERING:** Very Good (chalks)

**ABRASION RESISTANCE:** Very Good

**SUBSTRATES:** Carboline 191 Primer may be applied over properly prepared steel or concrete.

**TOPCOAT REQUIRED:** The most recommended system is Carboline 191 Primer with two coats of Carboline 191 Finish or two coats of Carboline 191 HB. Carboline 191 Primer may be topcoated with catalyzed epoxies, vinyls, modified phenolics, or others as recommended.

**COMPATIBILITY WITH OTHER COATINGS:** May be applied over Carbo Zinc® 11, or others as recommended. When applied over inorganic zincs such as Carbo Zinc 11, a mist coat may be required to minimize bubbling.

April 83 Replaces Oct. 82

## SPECIFICATION DATA

### THEORETICAL SOLIDS CONTENT OF MIXED MATERIAL:

	By Volume
Carboline 191 Primer	71% ± 2%
Carboline 191 Finish	69% ± 2%

### RECOMMENDED SYSTEM:

One coat Carboline 191 Primer at 5 mils (125 microns) dry film thickness. Two coats Carboline 191 Finish at 5 mils (125 microns) dry film thickness each. An alternate system is one or two coats Carboline 191 Finish over Carbo Zinc 11.

### THEORETICAL COVERAGE PER MIXED KIT\*: (1½ Gal. Kit)

Carboline 191 Primer	1708 mil sq. ft. (28.4 sq. m/l at 25 microns)
	342 sq. ft. at 5 mils (5.7 sq. m/l at 125 microns)
Carboline 191 Finish	1660 mil sq. ft. (27.6 sq. m/l at 25 microns)
	332 sq. ft. at 5 mils (5.5 sq. m/l at 125 microns)

\*NOTE: Material losses during mixing and application will vary and must be taken into consideration when estimating job requirements.

**SHELF LIFE:** 24 months minimum.

**COLORS:** Carboline 191 Primer – Brick Red only.  
Carboline 191 Finish – White S800 and Gray C703 and C705 are standard colors for food contact. Other colors are available on special order.

**GLOSS:** Finish – Semi-Gloss

## ORDERING INFORMATION

Prices may be obtained from Carboline sales representative or main office.

### APPROXIMATE SHIPPING WEIGHT:

	1½ Gal. Kit	7½ Gal. Kit
Carboline 191 Primer	20 lbs. (9.1 kg)	94 lbs. (42.7 kg)
Carboline 191 Finish	20 lbs. (9.1 kg)	94 lbs. (42.7 kg)
Carboline Thinner #76	8 lbs. (3.6 kg)	37 lbs. (16.8 kg)
	in 1's	in 5's

### FLASH POINT: (Pensky-Martens Closed Cup)

Carboline 191 Primer Part A	68°F (20°C)
Carboline 191 Finish Part A	67°F (19°C)
Carboline 191 Part B	70°F (21°C)
Carboline Thinner #76	21°F (-6°C)

To the best of our knowledge the technical data contained herein are true and accurate at the date of issuance and are subject to change without prior notice. User must contact Carboline to verify correctness before specifying or ordering. No guarantee of accuracy is given or implied. We guarantee our products to conform to Carboline quality control. We assume no responsibility for coverage, performance or injuries resulting from use. Liability, if any, is limited to replacement of products. Prices and cost data if shown, are subject to change without prior notice. NO OTHER WARRANTY OR GUARANTEE OF ANY KIND IS MADE BY THE SELLER, EXPRESS OR IMPLIED, STATUTORY, BY OPERATION OR LAW, OR OTHERWISE, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

# APPLICATION INSTRUCTIONS

These instructions are not intended to show product recommendations for specific service. They are issued as an aid in determining correct surface preparation, mixing instructions, and application procedure. It is assumed that the proper product recommendations have been made. These instructions should be followed closely to obtain the maximum service from the materials.

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**SURFACE PREPARATION:** Remove any oil or grease from surface to be coated with clean rags soaked in Carboline Thinner #76 or methyl ethyl ketone in accordance with SSPC-SP 1.

**Steel:** Dry abrasive blast to a White Metal Finish in accordance with SSPC-SP 5 to a degree of cleanliness in accordance with NACE #1 to obtain a 1-2 mil (25-50 micron) blast profile.

**Concrete:** Do not coat concrete treated with hardening solutions unless test patch indicates satisfactory adhesion. Do not apply coating unless concrete has cured at least 28 days at 70°F (21°C) and 50% R.H. or equivalent time. Apply to properly prepared concrete that was acid etched or sweep sandblasted.

**MIXING:** Mix separately, then combine and mix in the following proportions:

	<u>1½ Gal. Kit</u>	<u>7½ Gal. Kit</u>
Carboline 191 Primer Part A		
or		
Carboline 191 Finish Part A	1 Gal.	5 Gal.
Carboline 191 Part B	½ Gal.	2½ Gal.

Thin up to 20% by volume with Carboline Thinner #76.

**POT LIFE:** Two hours at 75°F (24°C) and less at higher temperatures. Pot life ends when coating loses body and begins to sag.

**APPLICATION TEMPERATURES:**

	<u>Material</u>	<u>Surfaces</u>
Normal	65-85°F (18-29°C)	65-85°F (18-29°C)
Minimum	55°F (23°C)	50°F (10°C)
Maximum	90°F (32°C)	110°F (43°C)

	<u>Ambient</u>	<u>Humidity</u>
Normal	65-85°F (18-29°C)	50%
Minimum	50°F (10°C)	0%
Maximum	110°F (43°C)	90%

Do not apply when the surface temperature is less than 5°F (2°C) above the dew point.

Special thinning and application techniques may be required above or below normal conditions.

**SPRAY:** Use sufficient air volume for correct operation.

Use a 50% overlap with each pass of the gun. On irregular surfaces, coat the edges first, making an extra pass later.

**NOTE:** The following equipment has been found suitable, however, equivalent equipment may be substituted.

**Conventional:** Use a 3/8" minimum I.D. material hose. Hold gun approximately 12-14 inches from the surface and at a right angle to the surface.

<u>Mfr. &amp; Gun</u>	<u>Fluid Tip</u>	<u>Air Cap</u>
Binks #18 or #62	66	63PB
DeVilbiss P-MBC or JGA	E	704

Approx. .070" I.D.

**Airless:** Use a 3/8" minimum I.D. material hose. Hold gun approximately 18-20 inches from the surface and at a right angle to the surface.

<u>Mfr. &amp; Gun</u>	<u>Pump*</u>
DeVilbiss JGA-507	QFA-514 or QFA-519
Graco 205-591	President or Bulldog 30:1
Binks Model 700	Mercury 5C or B8-36 37:1

\*Teflon packings are recommended and are available from manufacturer.

Use a .017-.021" tip with 2400 psi.

**BRUSH OR ROLLER:** For touch-up or small areas only. Use a natural bristle brush applying with full strokes. Avoid rebrushing. If rolled, use a short nap mohair roller with phenolic core. Avoid rerolling.

**DRYING TIMES:**

	<u>Carboline 191 Primer</u>	<u>Carboline 191 Finish</u>
<b>Between coats:</b>		
50°F (10°C)	5 days	5 days
60°F (16°C)	2 days	2 days
75°F (24°C)	18 hours	18 hours
90°F (32°C)	12 hours	12 hours
<b>Final cure:</b>		
60°F (16°C)	3 weeks	3 weeks
75°F (24°C)	10 days	10 days
90°F (32°C)	7 days	7 days

Force curing at 150°F (66°C) is recommended for all tank lining service.

**CLEAN UP:** Use Carboline Thinner #76 or methyl ethyl ketone.

**STORAGE CONDITIONS:**

Temperature: 45-110°F (7-43°C) Humidity: 0-100%

**CAUTION: CONTAINS FLAMMABLE SOLVENTS. KEEP AWAY FROM SPARKS AND OPEN FLAMES. IN CONFINED AREAS WORKMEN MUST WEAR FRESH AIRLINE RESPIRATORS. HYPERSENSITIVE PERSONS SHOULD WEAR GLOVES OR USE PROTECTIVE CREAM. ALL ELECTRIC EQUIPMENT AND INSTALLATIONS SHOULD BE MADE AND GROUNDED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE. IN AREAS WHERE EXPLOSION HAZARDS EXIST, WORKMEN SHOULD BE REQUIRED TO USE NONFERROUS TOOLS AND TO WEAR CONDUCTIVE AND NONSPARKING SHOES.**



# Amercoat® 90

High-performance epoxy



**Excellent protection against corrosive chemical and weather environments**

**Economical water tank lining; requires only 2 coats**

**Withstands continuous immersion in water up to 140°F**

**Meets requirement for nuclear radiation tolerance and decontamination in nuclear power plants**

### Typical Uses

Protection of steel and concrete surfaces exposed to splash, spillage and fumes of corrosive chemical and weather conditions. Also used as a water tank lining to protect steel and concrete surfaces exposed to immersion in water. Used in nuclear power plants for protection against radiation.

### Outstanding Characteristics

Amercoat 90 provides excellent protection against corrosive chemical and weather environments. As a water tank lining, it requires only 2 coats without a primer to protect surfaces exposed to immersion in water. Amercoat 90 is resistant to cumulative radiation of  $7.8 \times 10^9$  rads and has a decontamination

factor greater than 20 (95% removed) when tested according to ANSI N5.12-1974, American National Standard—Protective Coatings (Paints) for the Nuclear Industry. Also meets requirements for design basis accident conditions for pressurized water reactors and boiling water reactors of ANSI N101.2-1972, American National Standard—Protective Coatings (Paints) for Light Water Nuclear Reactor Containment Facilities.

### Application Data Summary

For complete information on surface preparation, application equipment and procedure and safety precautions, refer to Amercoat 90 Application Instructions.

### Physical Data

- Finish ..... Flat
- Color ..... Pearl gray, white
- Surface ..... Steel or concrete
- Components ..... 2
- Cure ..... Solvent release and chemical reaction between components
- Volume solids ..... 56% (from formula)
- Dry film thickness ..... 4 mils (100  $\mu$ ) per coat
- Coats ..... 2
- Calculated coverage at
  - 1 mil (25  $\mu$ ) ..... 900 sq ft/gal (22 sq m/ltr)
  - 4 mils (100  $\mu$ ) ..... 225 sq ft/gal (5.5 sq m/ltr)
- Allow for application losses and surface irregularities.
- Application ..... Airless or conventional spray
- Pot life ..... 4 hrs @ 70°F (21°C)
- Drying time to recoat ..... 24 hrs @ 70°F (21°C)
- Curing time for immersion service ..... 5 days @ 70°F (21°C)
- Pot life and drying times are dependent on temperature.
- Mixing ratio (by volume) .. 4 parts resin solution to 1 part curing solution
- Flash point (ASTM D 93) .. 82°F (28°C)
- Temperature resistance .. 140°F (60°C) immersion 250°F (121°C) dry
- Thinner ..... Amercoat 6
- Cleaner ..... Amercoat 12
- Packaging
  - Resin solution ..... 0.8 gal in 1-gal can
  - Curing solution ..... 0.2 gal in 1-qt can
  - Resin solution ..... 4.0 gals in 5-gal pail
  - Curing solution ..... 1.0 gal in 1-gal can
- Shipping weight (approximate)
  - 1-gal unit ..... 13 lbs (5.90 kg)
  - 5-gal unit ..... 58 lbs (26.3 kg)
- Shelf life ..... 1 year from shipment date when stored indoors at 40 to 100°F (5 to 38°C)

### Systems Using Amercoat 90

	Immersion	Nonimmersion
Amercoat 90	Yes	Yes
Amercoat 71/Amercoat 90	No	Yes
*Dimetcote®/Amercoat 90	No	Yes
*Dimetcote/Amercoat 71/Amercoat 90	No	Yes

### Chemical Resistance Guide

	Fume	Splash and Spillage	Immersion
Acid	Excellent	Limited	Not recommended
Alkali	Excellent	Excellent	Limited
Solvent	Excellent	Excellent	Limited
Salt	Excellent	Excellent	Excellent
Water	Excellent	Excellent	Excellent

This resistance guide only shows typical recommendations for Amercoat 90. For specific exposures and recommendations, please contact your Ameron representative who will help you evaluate your particular corrosion protection needs.

\*A "mist coat" may be required to prevent application bubbling

# Amercoat® 90

## Surface Preparation

Steel—Dry abrasive blast

Concrete—Acid etch or abrasive blast

## Equipment

Standard industrial spray equipment, airless or conventional.

## Safety

Since improper use and handling of Amercoat 90 can be hazardous to health and cause fire or explosion, safety precautions included with the Application Instructions must be observed during all storage, handling, use and drying periods.

## Warranty

Ameron's products are warranted to be free of defects in material or workmanship. If a product does not conform with this Warranty, Buyer must notify Ameron within five days of discovery of the defect, but in no event later than one year after delivery date or after expiration of the applicable shelf life, whichever is shorter. Ameron's sole obligation under

this Warranty shall be at its option, to credit Buyer's account, or to supply replacement material or repair. Failure to notify Ameron of nonconforming goods under this Warranty, within the time specified above, shall bar Buyer from recovery hereunder.

It is expressly understood that Ameron makes no other warranties concerning the goods, and the sole remedy of the Buyer and the sole liability of Ameron for product defect shall be as set forth above. No other warranties, express or implied, whether of merchantability or of fitness for any particular use shall apply. Ameron shall not be responsible for consequential damages.

Any recommendation or suggestion relating to the use of the products made by Ameron either in technical literature or in response to specific inquiry is given in good faith, but it is for Buyer to satisfy itself of the suitability of the goods for its own particular purpose and it will be deemed to have done so.

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Exhibit 5  
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Protective Coatings  
Division

# Application Instructions

## Amercoat® 90

### High-performance epoxy

Amercoat 90 is designed for protection of steel and concrete surfaces. Refer to Amercoat 90 Product Data Sheet for properties and uses. To obtain the maximum performance for which Amercoat 90 is formulated, strict adherence to all application instructions, precautions, conditions and limitations is necessary.

#### Surface Preparation

##### Steel

**Immersion**—Blast all steel in accordance with SSPC-SP5\* White Blast to achieve a 1.5 mil (37.5  $\mu$ ) minimum as determined with a Keane-Tator Surface Profile Comparator or similar device. Remove abrasive residue or dust from surface.

**Non-Immersion**—New steel without pits or depressions. Blast in accordance with SSPC-SP10\* Near White. Previously painted or pitted steel, blast in accordance with SSPC-SP10\* Near White.

Apply Amercoat 90 as soon as possible to prevent rusting. Keep moisture, oil, grease or other organic matter off surface before coating. Spot reblast to remove any contamination, solvent wiping is not adequate.

##### Concrete

All surfaces to be coated must contain no additives or hardeners, and should not be treated with sealers or conventional curing compounds containing waxes, silicones or silicates. Do not use form release agents based on oils, which will deposit a residue on the concrete.

When cured, surface must either be abrasive-blasted using 16-30 mesh

\* Steel Structures Painting Council Specification

sand or acid-etched according to the following procedure.

Flood the surface with muriatic acid, using equal parts of acid to water (by volume). Allow the acid to remain in contact with the concrete until bubbling stops then flush with clean water and scrub using a stiff bristle broom to remove acid salts and loose deposits.

A suitably finished, acid-etched or abrasive-blasted surface must have a uniform surface texture exposing fine aggregate resembling coarse sandpaper. If required, repeat acid etching or abrasive blasting until the surface texture is uniform.

Concrete surfaces which have been previously coated, or cured with conventional curing compounds or are contaminated with form oils must be completely cleaned by abrasive blasting. Acid etching is not acceptable, as it will not normally remove these contaminants.

After surface is properly prepared, small holes or voids in concrete wall or overhead surfaces should be filled with a suitable material such as Nu-Klad® 114 filler compound before applying Amercoat 90.

See Application Instructions for appropriate primer.

#### Environmental Conditions

**Air temperature**—50°F to 100°F (10 to 38°C)

**Surface temperature**—50°F to 120°F (10 to 49°C)

The surface temperature must be at least 5°F (3°C) above the dew point to prevent moisture condensation.

#### Application Equipment

The following equipment is listed as a partial guide and suitable equipment from other manufacturers may be used.

Adjustments of pressures and change of tip size may be needed to achieve the proper spray characteristics.

**Airless spray**—Standard airless spray equipment, such as Graco Bulldog Hydra-Spray, or larger with a 0.017- to 0.023-inch orifice.

**Conventional spray**—Industrial equipment, such as DeVilbiss MBC or JGA spray gun, and a pressure material pot with mechanical agitator. A moisture and oil trap in the main air supply line and separate regulators for air and fluid pressure are required.

#### Application Procedure

1. Flush all equipment with Amercoat 12 cleaner before use.
2. Stir each component thoroughly, then add the curing solution into the resin solution and mix until uniform. Amercoat 90 is packaged in the proper mixing proportions of resin and curing solutions.

##### 1-gallon unit

Resin solution—0.8 gal in 1-gal can  
Curing solution—0.2 gal in 1-qt can

##### 5-gallon unit

Resin solution—4 gals in 5-gal pail  
Curing solution—1 gal in 1-gal can

3. If thinning is necessary for workability, thin with no more than 1 pint of Amercoat 6 thinner per gallon of Amercoat 90 for airless or conventional equipment. Use only Amercoat 6.
4. When applying by conventional spray, use adequate air pressure and volume to ensure proper atomization.
5. Apply a wet coat in even parallel passes with 50% overlap to avoid holidays, bare areas and pinholes and to achieve a dry film thickness of 4 mils (100  $\mu$ ). When applying coating directly over inorganic zincs at full thickness, bubbling may occur under certain

conditions. A test patch is recommended and if bubbling occurs, a "mist coat" should be applied first. Consult your Ameron Representative for further information.

6. Check dry film thickness using a nondestructive dry film thickness gauge such as Mikrotest or Elcometer. If less than 8 mils (200  $\mu$ ) total, apply additional material. Total dry thickness must not exceed 18 mils (45  $\mu$ ).

7. When a pinhole-free coating is required, check continuity of dry but uncured coating with a nondestructive holiday detector such as Tinker and Razor Model M-1. Apply additional coats of Amercoat 90 to areas requiring touchup.

#### Drying and Curing Time for Amercoat 90 (at 5 mils thickness) (ASTM D 1640)

Dry hard—9 hours at 70°F (21°C)

Dry through—12 hours at 70°F (21°C)

Dry to recoat—24 hours at 70°F (21°C)

Curing time for immersion service—5 days at 70°F (21°C)

8. Clean equipment immediately with Amercoat 12 after use.

#### Safety Precautions

**Amercoat 90 resin**—Warning! Flammable. Contains xylol, liquid epoxy resin and glycol ethers. May cause skin, eye and mucous membrane irritation on prolonged or repeated contact. Inhalation of high concentrations of vapors could cause headache, nausea, dizziness or asphyxiation. **May be harmful or fatal if swallowed.**

**Amercoat 90 curing solution**—Warning! Flammable. Contains xylol, liquid epoxy resin and amine adduct. May cause eye irritation or skin irritation on prolonged or repeated contact. Inhalation of high concentrations of vapors may lead to asphyxiation. May

be harmful or fatal if swallowed. The following precautions apply to both resin and curing solutions. Keep away from heat, open flame, sparks or strong oxidizing materials. Avoid prolonged or repeated skin contact and excessive inhalation of vapors. Store in cool, well ventilated area and keep container closed and upright when not in use to prevent leakage. Use with adequate ventilation. Wear approved respirator protection equipment and other protective equipment as necessary to prevent skin and eye contact. Remove contaminated clothing and launder before reuse.

**First aid**—For excessive inhalation, remove to fresh air. Apply artificial respiration if breathing is labored. In case of skin contact, wash skin with soap and water, for eye contact, flush immediately with water for at least 15 minutes and get medical attention immediately.

**In case of fire**—blanket flames with dry chemical, carbon dioxide or foam. Wear self-contained breathing apparatus.

**In case of spillage**—extinguish all sources of ignition. Use absorbent clean up materials and dispose of in separate closed metal container in accordance with all applicable regulations.

**Important**—Read precautions of resin solution before mixing. Mixed material has hazards of both components.

Improper use and handling of this product can be hazardous to health and cause fire or explosion. Consult Code of Federal Regulations Title 29, Labor, parts 1910 and 1916 concerning occupational safety and health standards and regulations, as well as any applicable state and local regulations on safe practices in coating operations. Necessary safety

equipment must be used and ventilation requirements carefully observed, especially in confined or enclosed spaces.

If you do not fully understand these warnings and instructions, or if you cannot strictly comply with them, do not use the product.

**Notice**—This product is for industrial use only.

#### Warranty

Ameron's products are warranted to be free of defects in material or workmanship. If a product does not conform with this Warranty, Buyer must notify Ameron within five days of discovery of the defect, but in no event later than one year after delivery date or after expiration of the applicable shelf life, whichever is shorter. Ameron's sole obligation under this Warranty shall be at its option, to credit Buyer's account or to supply replacement material or repair. Failure to notify Ameron of nonconforming goods under this Warranty, within the time specified above, shall bar Buyer from recovery hereunder.

It is expressly understood that Ameron makes no other warranties concerning the goods, and the sole remedy of the Buyer and the sole liability of Ameron for product defect shall be as set forth above. No other warranties, express or implied, whether of merchantability or of fitness for any particular use shall apply. Ameron shall not be responsible for consequential damages.

Any recommendation or suggestion relating to the use of the products made by Ameron either in technical literature or in response to specific inquiry is given in good faith, but it is for Buyer to satisfy itself of the suitability of the goods for its own particular purpose and it will be deemed to have done so.

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Exhibit 5  
4 of 4

SUGGESTED TECHNICAL SPECIFICATION FOR

BALL VALVES TO ANSI B31.1

October, 1985

DESIGN PHASE: Reference

Prepared by: \_\_\_\_\_  
Project Engineer

Approved by: \_\_\_\_\_  
Project Manager

Approved by: \_\_\_\_\_  
Quality Assurance Manager

BURNS AND ROE, INC.  
BREEDER REACTOR DIVISION

EXHIBIT 6

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TECHNICAL SPECIFICATION FOR BALL VALVES TO ANSI B31.1

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1. SCOPE

This technical specification covers the requirements for the design, manufacture, testing, packaging and delivery of ball valves complete with operators and associated accessories in accordance with this specification.

1.1 Classification.

1.1.1 Owner's Classification

All valves, operators and accessories furnished shall be non safety-related in accordance with this specification and are classified as Category II, Permanent Plant-Operationally significant, unless otherwise classified in APPENDIX A, Valve List, hereinafter referred to as APPENDIX A. This information is for the convenience of Purchaser.

1.1.2 Seismic Category and cleanliness class shall be as specified in APPENDIX A.

1.2 Components and Services to be Provided

All components and services to be provided by Contractor shall be as specified in paragraph 6.1, Items to be Provided by Contractor, of this specification.

## 2. APPLICABLE DOCUMENTS

The edition and addenda of the following publications are a part of this specification and are applicable to the extent indicated by the specific reference.

### 2.1 American Society of Mechanical Engineers (ASME)

ASME Boiler and Pressure Vessel Code, Section IX Welding and Brazing Qualifications, (Edition and addenda in effect at time of qualification).

### 2.2 American Society for Testing and Materials (ASTM)

A105-81	Forgings, Carbon Steel, for Piping Components
A182-81a	Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
A193-81a	Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
A194-81	Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
A216-77	Carbon-Steel Castings Suitable for Fusion Welding for High-Temperature Service

- A240-80b Heat Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Fusion Welded Unfired Pressure Vessels
- A276-81 Stainless and Heat-Resisting Steel Bars and Shapes
- A351-81 Austenitic Steel Castings for High Temperature Service
- A479-81 Stainless and Heat-Resisting Steel Wire, Bars and Shapes for Use in Boilers and Other Pressure Vessels
- A564-80a Hot-Rolled and Cold-Finished Age-Hardening Stainless and Heat Resisting Steel Bars and Shapes
- A743-82 Corrosion-Resistant Iron-Chromium, Iron-Chromium-Nickel, and Nickel-Base Alloy Castings for General Application
- B68-80 Seamless Copper Tube, Bright Annealed
- B462-79 Forged or Rolled-Chromium-Nickel-Iron-Molybdenum-Copper-Columbium Stabilized Alloy Pipe Flanges, Forged Fittings, and Valves and Parts for Corrosive High Temperature Service
- B463-81 Chromium-Nickel-Iron-Molybdenum-Copper-Columbium Stabilized Alloy Plate, Sheet and Strip

B473-79 Chromium-Nickel-Iron-Molybdenum-Copper-Columbium Stabilized Alloy Bar and Wire

2.3 American National Standards Institute (ANSI)

B16.10-73 Face-to-Face and End-to-End Dimensions of Ferrous Valves

B16.25-81 Fittings, Flanges and Valves

B16.34-81 Steel Valves, Flanged and Butt-Welding End

B31.1-80 Power Piping (Summer 81 Addenda)

N45.2.2-78 Packaging, Shipping, Receiving, Storage and Handling of Items for Nuclear Power Plants

2.4 Institute of Electrical and Electronics Engineers (IEEE)

112-78 Test Procedure for Polyphase Induction Motors and Generators

383-74 Standard for Type Test of Class 1E Electrical Cables, Field Splices and Connections for Nuclear Power Generating Stations.

2.5 National Electrical Manufacturers Association (NEMA)

MG 1-78          Motors and Generators  
(R1980)

ICS 1-78          General Standards for Industrial Equipment Control and  
(R1980)          Systems

ICS 2-78          Standards for Industrial Control Devices, Controllers and  
(R1980)          Assemblies

ICS 4-77          Terminal Blocks for Industrial Control Equipment and Systems  
(R1978)

ICS 6-78          Enclosures for Industrial Controls and Systems  
(R1980)

2.6 National Fire Protection Association (NFPA)

70-81            National Electrical Code

2.7 Steel Structures Painting Council (SSPC)

Steel Structures Painting Manual, Volume 2, Systems and Specifications  
(1976).

- Vis 1-67T Pictorial Surface Preparation Standards for Painting Steel Surfaces (Editorial Changes 1971)
- PA 1-64 Shop, Field and Maintenance Painting
- PA 2-73T Measurement of Dry Paint Thickness with Magnetic Gauges
- SP 1-63 Solvent Cleaning (Editorial Changes 1971)
- SP 10-63T Near White Blast Cleaning, including Appendix A (Editorial Changes 1971)
- PS 8.01-64T Rust Preventive Compounds (Thick Film)

## 2.8 American Welding Society (AWS)

- A5.1-78 Carbon Steel Covered Arc-Welding Electrodes
- A5.4-78 Corrosion-Resisting Chromium and Chromium-Nickel Steel Covered Welding Electrodes
- A5.5-81 Low-Alloy Steel Covered Arc-Welding Electrodes
- A5.9-77 Corrosion-Resisting Chromium and Chromium-Nickel Steel Bare and Composite Metal Cored Standard Arc Welding Electrodes and Welding Rods

- A5.11-76 Nickel and Nickel-Alloy Covered Welding Electrodes
- A5.12-80 Tungsten Arc Welding Electrodes
- A5.14-76 Nickel and Nickel-Alloy Bare Welding Rods and Electrodes

2.9 Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)

- SP 25-78 Standard Marking System for Valves, Fittings, Flanges and Unions
- SP 53-80 Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components (Dry Powder Magnetic Particle Inspection Method)
- SP 54-80 Quality Standard for Steel Castings-Radiographic Inspection Method for Valves, Flanges, Fittings and Other Piping Components
- SP 61-77 Pressure Testing of Steel Valves
- SP 84-78 Steel Valves - Socket Welding and Threaded Ends

## 2.10 Federal Standard

595a Colors (Volume 1) Jan. 1968 Edition including Revision 6  
(Feb. 1980)

## 2.11 Association of American Railroads

The Rules Governing the Loading of Commodities on Open Top Cars and Trailers (Revised to October, 1981)

## 2.12 Westinghouse Document

WARD-D-0037 Seismic Design Criteria for Clinch River Breeder Reactor Plant, Rev. 1.

## 3. TECHNICAL REQUIREMENTS

### 3.1 General.

The design, fabrication, inspection, testing and delivery of all valves, operators and accessories furnished shall be in accordance with ANSI B31.1, Power Piping; ANSI B16.34, Steel Valves, and the requirements of this specification.

### 3.2 Design and Performance Requirements.

3.2.1 The service conditions and ratings for the equipment specified herein shall be as specified in APPENDIX A.

3.2.2 The Valve Number (Equipment Identification Number, EIN) and size of each valve to be provided are specified in APPENDIX A.

3.2.3 The schedule of the pipe to be connected to each valve is given in APPENDIX A.

3.2.4 The minimum corrosion allowance for carbon steel valve bodies shall be 0.060 inch.

3.2.5 Valves with flanged or welding ends shall have face-to-face or end-to-end dimensions in accordance with ANSI B16.10. For any valves that are not in compliance with ANSI B16.10, Contractor shall provide on certified drawings the face-to-face and end-to-end dimensions, weld details and a statement that such dimensions are at variance with the applicable requirements of ANSI B16.10.

3.2.6 The radiation zone for each valve is given in APPENDIX A. Environmental design conditions are defined in TABLE II, Environmental Conditions, hereinafter referred to as TABLE II. Valves will be designed to tolerate a radiation zone II as a minimum.

3.2.7 All valves, operators and accessories shall be designed to meet the requirements specified, irrespective of orientation or installed position.

3.2.8 A service life of 30 years shall be used as a basis for design. Components for which a 30 year life expectancy cannot be reasonably assured shall be designed and installed to permit safe and convenient replacement. Parts that are replaceable during normal maintenance, such as packing and gaskets, shall have a minimum life of 5 years. Contractor shall provide a list identifying the design life of all such items in accordance with TABLE I, Document Submittal Table, hereinafter referred to as TABLE I.

### 3.3 Documents

3.3.1 Contractor shall prepare and submit to Purchaser in accordance with TABLE I, drawings and data as follows:

3.3.1.1 Initial and final certified copies of outline and assembly drawings. The information shown on or submitted with the drawings shall include, but not be limited to, two views of the valve assembly with dimensions, bill of material with ASME/ASTM specifications, weight and center of gravity of the valve assembly, preferred mounting orientation, critical dimensions (such as end-to-end), Purchaser order number, pressure rating, fail position, actuator closing/opening speed, maintenance and disassembly space envelopes, list of manufacturers of purchased accessories, model or catalog number, electrical wiring diagram, schematic diagram of actuator control system, description of operation of the valve, Purchaser's

Equipment Identification Number, (EIN; Valve Number in APPENDIX A) and all weld end preparation details.

3.3.1.2 A special tools list, if required. If special tools are not required for installation or maintenance, Contractor shall include a statement to that effect in the instructions manuals.

### 3.4 Materials

3.4.1 APPENDIX A identifies individual valves as ferritic carbon steel, nickel alloy steel or austenitic stainless steel. The allowable materials for individual components of these valves are specified in TABLE III, Valve Classification Sheets, hereinafter referred to as TABLE III. Any material substitution shall be subject to Purchaser's approval. Where materials are not specified, they shall be selected by Contractor subject to Purchaser's approval.

3.4.2 Certificates of Conformance for all ASTM (ASME) materials shall be kept by Contractor and shall be made available for Purchaser's inspection upon request.

3.4.3 All materials shall be new and shall conform to the requirements of the applicable codes and standards.

3.4.4 Contractor shall provide measures in the shop practice procedures to prevent contamination harmful to materials. Particular attention shall be

given to the prevention of piping or components coming in contact with materials containing more than trace amounts of low melting point elements such as sulfur, lead, zinc, copper, cadmium, or mercury. In addition, attention shall be given to the prevention of austenitic steel or nickel base alloy piping and components coming in contact with any halide compound or halogen element in a manner not previously approved by the Purchaser. Caution shall be used to prevent stainless steel piping and components from coming in contact with carbon steel materials.

3.4.5 Brushing shall be performed with clean austenitic stainless steel brushes. Carbon steel brushes shall not be used on stainless steel surfaces. Adequate controls shall be imposed on tools used in abrasive work (grinding, sanding or chipping). Tools which contain materials that could contribute to intergranular cracking or stress corrosion cracking, or tools which may have become contaminated by such materials during previous usage shall not be used on surfaces or corrosion resistant alloys.

#### 3.4.6 Protective Coating Material Requirements

Coating materials shall be in accordance with manufacturer's standard.

### 3.5 Design and Construction Features

#### 3.5.1 General.

3.5.1.1 All welded valves shall be of the top entry or swing out type and shall be designed in accordance with the requirements of ANSI B31.1 and ANSI B16.34.

3.5.1.2 Valves shall be designed so that normal maintenance can be performed without removing the valve from the piping system.

3.5.1.3 Live loading shall be maintained on stem packing by Belleville springs or equivalent means.

3.5.1.4 Except for drains, the design of all valves shall minimize crevices or retention pockets which could permit the accumulation of corrosion products.

3.5.1.5 Where indicated in APPENDIX A, valves shall be provided with a locking device. Padlocks and keys will be furnished by Purchaser.

3.5.1.6 Any air sets complete with a gauge required for the regulation of the valve operating air supply as well as solenoid pilot valves shall be integrally assembled to the valve.

3.5.1.7 Identification plates shall be provided and permanently attached to each valve. Identification plates shall be austenitic stainless steel

and have black identification figures stamped or etched thereon. The attachment of identification plates shall be done in such a manner that will not produce or induce cracking. Direct attachment of the plate to a pressure retaining part of the valve, if absolutely necessary, shall be approved by Purchaser.

3.5.1.8 All valves shall be provided with open and closed position stops.

3.5.1.9 Unless otherwise specified, valves shall be lever actuated. The valves shall have a provision for mechanical position indication.

3.5.1.10 Unless otherwise specified in APPENDIX A, all valves two (2) inches nominal size and smaller shall have socket weld ends in accordance with MSS SP 84. Socket welds may be performed with gas tungsten arc or manual shielded metal arc processes depending upon the specific job requirements.

3.5.1.11 All valves 2-1/2 inches nominal size and larger shall have butt weld end connections or flanged end connections as specified in APPENDIX A. Unless otherwise specified, the butt weld end preparation for the field welding of piping, fittings, nozzles and accessories shall be in accordance with B16.25.

3.5.1.12 Weld end valves shall be designed so that the installation, welding and post weld heat treatment, if applicable, will not deteriorate the valve leak tightness. Contractor shall advise if precaution should be taken.

3.5.1.13 Valves shall be designed to accept extension stems when specified in APPENDIX A.

3.5.1.14 Contractor shall submit in accordance with TABLE I the completed TABLE VI, Valve Technical Data, hereinafter referred to as TABLE VI.

### 3.5.2 Valve Operators - General

3.5.2.1 Valve operators shall be as specified in APPENDIX A. Each operator shall be designed for the service and conditions of the operated valve in accordance with APPENDIX A.

3.5.2.2 Valve operators shall be equipped with continuous indication of the ball position.

3.5.2.3 The pneumatic operator design shall include a fail safe operating mode arranged to fail on loss of valve external motive power in the mode indicated in APPENDIX A. Contractor shall supply all equipment and accessories necessary to perform this requirement.

3.5.2.4 All motor and terminal block enclosures shall be NEMA ICS-6, Type 4, unless otherwise specified in Appendix A.

3.5.2.4 A valve position element shall be provided where specified in APPENDIX A. Position elements shall be totally enclosed and shall be positively indexed to the valve position regardless of the type of valve opera-

tor. The position element shall be of the slide wire type, 3-wire, 0-10K ohms, pre-wired to terminal blocks in the limit switch enclosure. The element will be connected to Purchaser's transmitter.

### 3.5.3 Motor Operators.

3.5.3.1 Electric motor operators, where specified in APPENDIX A, shall be furnished complete with high starting torque motor, reduction gear, adjustable limit switches, adjustable torque switches, a handwheel for manual operation, an integrally mounted mechanical position indicator and miscellaneous accessories as required.

3.5.3.2 Motor operator-valve assembly shall be designed in such a way that neither operator nor valve will self-destruct in case of a limit switch failure.

3.5.3.3 Each motor operator shall include an auxiliary manual handwheel. The handwheel shall be automatically declutched whenever the drive motor is energized. A lever shall be provided to engage the clutch for manual operation. Operator clutches that are always engaged may be employed as long as they have a manual override that prevents the manual handwheel from rotating. Handwheels shall be sized to permit operation up to 150 percent of the maximum operating torque without causing damage to the motor operator or the valve.

3.5.3.4 The motor operators shall operate from fully open to fully closed against the maximum differential pressure indicated in APPENDIX A within 60 seconds, unless otherwise indicated.

3.5.3.5 Each motor operator shall have one terminal box for motor leads and one terminal box for control leads, both mounted on the operator. In lieu of the above, one compartmentalized box divided into motor and control compartments is acceptable. Nameplates shall be provided identifying individual connection boxes or compartments.

3.5.3.6 Gear trains shall impart a positive locking action to the stem such that the stem position will be held under any imposed forces other than those applied by the motor or by the manual operator.

3.5.3.7 The transmission and coupling shall allow the motor to attain full speed before the stem load is encountered in both the opening and closing directions.

3.5.3.8 Provision for mounting the operator shall be provided on the valve body. The unit shall be designed so that the operator location may be oriented at 90 degree increments above the valve stem. The operator shall be mounted on the valve body so that it can be removed from the valve for maintenance without dismantling the valve.

3.5.3.9 Each motor operator shall be provided with a mechanical valve position indicator. It shall provide continuous indication of valve position throughout its entire rotation.

3.5.3.10 All motor operators shall be equipped with two adjust-able torque switches (one for each direction of operation). These switches shall be

closed while the valve is operating and shall open when resistance exceeding safe torque is encountered.

3.5.3.11 The torque switch and operator design shall prevent any creeping of the ball or relaxation of torque when the operator is deenergized.

3.5.3.12 Torque switches shall respond to both magnitude and direction of torque, i.e., the close (open) torque switch shall operate only when excessive torque is sensed during the closing (opening) cycle and shall not operate for excessive torque during the opening (closing) cycle.

3.5.3.13 Where torque switches occupy a compartment separate from the limit switches, they shall be wired into the limit switch compartment for Purchaser's external connections. Torque switches shall comply with the same electrical characteristics as limit switches.

3.5.3.14 All motor operators shall be equipped with limit switches directly geared to the operator reduction gearing and adjusted in accordance with this specification.

3.5.3.15 Limit switches shall consist of a minimum of four adjustable actuators. Two actuators shall be factory adjusted to operate at limits of valve travel. Two actuators shall be available for field adjustment, each capable of independent adjustment to operate at any position between the limits of valve travel.

3.5.3.16 The operation of the limit switches shall be repeatable within plus or minus two (2) percent of the set point. The means of adjustment shall be vibration and shock proof.

3.5.3.17 Limit switches shall have 600 volt insulation and the contacts shall be rated for 10 Amp. continuous for 120 V AC and 125 V DC application. The making and interrupting ratings shall be in accordance with NEMA ICS 2-125.

3.5.3.18 Limit switch enclosures shall be NEMA ICS 6 Type 4 and shall be provided with a 115 Volt AC, single phase space heater, unless otherwise specified in Appendix A.

3.5.3.19 Limit and torque switches shall be wired and adjusted in accordance with TABLE IV, Typical Wiring Diagram and Limit and Torque Switch Contact Development for Motor Operated Valves, hereinafter referred to as TABLE IV.

#### 3.5.4 Motors

3.5.4.1 Electric motors shall be of high starting torque, low starting current type. Motors shall be rated for a power supply of 460 volts, 3 phase, 60 Hertz and an ambient temperature of 40°C, unless otherwise specified in APPENDIX A.

3.5.4.2 Motors shall be capable of starting fully loaded and accelerating the driven load to the rated speed with 80 percent of the rated voltage at

the motor terminals. Motors shall be capable of providing satisfactory performance when starting under load with the motor terminal voltage at 110 percent of the rated voltage and a maximum ambient temperature as shown in TABLE II.

3.5.4.3 DC motors shall not be used unless specified.

3.5.4.4 Where specified, DC motors one (1) hp and smaller shall be rated at 120 volts and suitable for operation at any voltage from 100 through 140 volts. DC motors larger than one (1) hp shall be rated at 240 volts and shall be suitable for operation at any voltage from 200 through 280 volts.

3.5.4.5 Bearings shall be of the cartridge mount ball/roller type, designed to facilitate removal and replacement and sealed to prevent escape of lubricant or entrance of foreign materials. Bearings shall be capable of being lubricated without removal of the bearing caps or sealed if permanently lubricated bearings are to be provided.

3.5.4.6 Space heaters shall be provided for all motors except those in NEMA ICS 6 Type 6 enclosures. Space heaters shall be rated at 115 volts AC, single phase. The design of the motors in regard to temperature shall be predicated on the fact that space heaters will operate continuously.

3.5.4.7 All motors shall have a nameplate containing information in accordance with NEMA MG 1, Part 10, Paragraphs 38A and 65.

3.5.4.8 Motor terminals shall be provided with ring tongue conductor terminals.

3.4.5.9 Terminal boxes, where mounted on the motor, shall be weather-tight. Gaskets of neoprene shall be provided at cover joints and at the joint between box and motor frame unless these joints are otherwise weathertight. Conduit boxes shall be corrosion resistant. All motor terminal boxes shall be rotatable in 90 degree increments.

3.5.4.10 As a minimum, motor windings shall have Class B insulation with a temperature rise of 80°C measured by resistance; this rise shall not be exceeded with the valve operated through three (3) open-close-open cycles. Motors shall have a minimum rating of 15 minutes at full load.

3.5.4.11 The stalled torque rating of the motor shall be sufficient to provide the required operating torque with 90 percent of the rated voltage at the motor terminals.

3.5.4.12 The motor locked rotor current shall be the lowest value consistent with satisfactory performance and economical design for the torque-current class and shall not exceed 800 percent of rated full load current.

3.5.4.13 Contractor shall furnish Electrical Motor Operator Data as required by TABLE VI in accordance with TABLE I:

### 3.5.5 Manual Gear Operators

3.5.5.1 Manual gear operators, where specified in APPENDIX A, shall transmit the torque required to turn the valve against the design pressure specified. A rim pull of not more than 100 pounds shall be required to provide sufficient torque to turn the valve stem against rated pressure. For valves where the operational force is over 100 pounds, an alternate of a manual gear operator shall be used.

3.5.5.2 The gear shall be of the self-locking type to hold a fixed position for extended periods of time.

3.5.5.3 A mechanical type position indicator shall be integrally mounted on each operator.

3.5.5.4 Operator limit switches, where specified in APPENDIX A, shall be mounted on the position indicator and shall be as specified in paragraph

### 3.5.6 Remote Manual Operators.

3.5.6.1 Appurtenances as listed in paragraph 3.5.6.2 for remote manual operation shall be furnished for valves as required in APPENDIX A.

3.5.6.2 Remote manual operation shall be by means of extension stems, floor mounted valve pedestals or chainwheels as indicated in APPENDIX A. Extension stems shall have two universal joints.

3.5.6.3 Operator limit switches, where specified in APPENDIX A, shall be mounted on the position indicator and shall be as specified in paragraph 3.5.7.6. Remote indication shall be provided to indicate the direction of rotation and the position of the valve.

### 3.5.7 Pneumatic Operators - General.

3.5.7.1 Pneumatic operators shall be as specified in APPENDIX A and shall meet the requirements specified in paragraphs 3.5.8 and 3.5.9 of this specification as applicable.

3.5.7.2 Instrument air will be available at  $165 \pm 15$  psig. The pneumatic operators shall be sized to the lower limit of the expected header pressure to ensure a conservative design margin.

3.5.7.3 Air sets (filter - regulators), solenoid valves, limit switches and actuators shall be mounted on the valves and piped to form an assembly ready for installation. Solenoid pilot valves shall be supplied for rack mounting, when specified in APPENDIX A.

3.5.7.4 Each pneumatic operator shall be furnished with an auxiliary handwheel for manual operation on loss of air. Handwheels shall have positive position locking. Handwheels shall meet the following additional requirements:

- (a) Auxiliary handwheels shall have a weatherproof mechanism housing packed with lubricant and shall be capable of operating the valve in an open

or closed position independent of the instrument or control air pressure.

- (b) Auxiliary handwheels shall be of commercial design and shall be sized so that a total tangential force of not more than 100 pounds is required on the handwheel rim to affect the maximum thrust required for the most severe valve operation. Abnormal handwheel tangential forces 50 percent in excess of normal shall not result in damage to valve parts.
- (c) Handwheels shall not interfere with the automatic operation of the valve, but may be used to take over manually at any time.

3.5.7.5 Contractor shall furnish a solenoid valve in the air supply line to the valve operator. The solenoid valve shall be supplied complete with interconnecting tubing and shall meet the requirements of paragraph 3.5.10.

3.5.7.6 Each valve shall be equipped with two limit switches integrally mounted on the valve. Switches shall meet the following requirements:

- (a) Switches shall be mounted on the valve in such a manner that one switch shall actuate when the valve ball reaches the fully closed position and the other switch shall actuate when the ball reaches the fully open position as shown in TABLE V, Typical Wiring Diagram and Limit Switch Contact Development for Air Operated Valves, hereinafter referred to as TABLE V. Each switch shall be double pole, double throw, form "Z" contacts, snap action type.

- (b) Limit switch contact ratings shall be as specified in paragraph 3.5.3.20.
- (c) All limit switches shall be mounted in an enclosure with 3/4 inch threaded conduit opening. Ring-tongue terminals with insulated ferrules shall be used for termination of all wiring.
- (d) The limit switch configuration and wiring shall be in accordance with TABLE V.

### 3.5.8 Cylinder Operators.

3.5.8.1 Actuators shall be sized to close (or open) the valve against 120 percent of the maximum differential pressure shown in APPENDIX A.

3.5.8.2 Where specified, cylinder operators shall be provided with positioners. Positive positioners shall be pneumatic bellows type or electro-pneumatic type as specified in APPENDIX A. The actuator shall be spring-loaded and single acting unless otherwise specified. The actuator shall be arranged to fail, on the loss of air pressure, in the mode indicated in APPENDIX A.

3.5.9 Diaphragm Operators.

3.5.9.1 The spring and diaphragm combination shall be selected to provide the correct stroking speed in accordance with the closing and opening times as specified in paragraph 3.5.3.7 of this specification.

3.5.9.2 Diaphragm material shall be reinforced nylon, neoprene, Buna N, or Purchaser approved equal and shall be suitable for applicable environmental conditions.

3.5.9.3 Diaphragm cases shall be bolted pressed steel and shall be designed to withstand the maximum air supply pressure. Suitable pressure relief protection shall be provided for each actuator.

3.5.10 Solenoid Operated Air Pilot Valves.

3.5.10.1 All pneumatic operated valves shall be provided with solenoid operated three-way air pilot valves, where specified in APPENDIX A, that admit control air to the valve operator when energized. The solenoid coil shall have NEMA MG 1, Class H insulation, NEMA ICS 6 Type 4 enclosure and a 3/4 inch threaded conduit opening. The solenoid coil shall be capable of being continuously energized without exceeding a temperature rise of 80°C over ambient.

3.5.10.2 Solenoid coil voltage rating shall be 120 volt AC, single phase, 60 Hz or 125 volt DC, as specified in APPENDIX A.

3.5.10.3 Solenoid operators shall operate satisfactorily throughout the following voltage ranges:

<u>Voltage Rating</u>	<u>Range</u>
120 Volts, 60 Hz	108-132 Volts
125 Volts, DC	100-140 Volts

3.5.10.4 All solenoid valves shall be tubed so that deenergization or solenoid failure moves the main valve operator to the failure mode position indicated in APPENDIX A.

3.5.10.5 The pilot valve shall be mounted on the valve operator, unless otherwise specified, and all tubing and fittings shall be completely installed. The pilot valve shall be located in the air tubing to the valve operator.

3.5.10.6 All solenoid supply leads and limit switch contacts on each valve shall be wired to a terminal block installed in a NEMA ICS 6 Type 4 terminal box mounted on the valve operator as shown in TABLE V. The terminal box shall have a threaded hub and be conveniently located to receive a rigid steel conduit for all outgoing conductors.

### 3.5.11 Instrument Tubing and Valves.

3.5.11.1 All interconnecting instrument tubing shall be furnished and pre-piped. All tubing shall be seamless copper (ASTM B-68), 1/4 inch O.D. minimum.

3.5.11.2 Instrument tubing fittings shall be brass tube ends, Parker CPI, "Swagelok" or Purchaser approved equal.

### 3.5.12 Wiring.

3.5.12.1 Equipment mounted on each valve shall be furnished completely assembled, piped, wired and tested at the factory. Terminal blocks shall have two (2) or 20 percent spare terminals, whichever is greater.

3.5.12.2 Wiring between devices and outgoing terminal blocks shall be installed in rigid steel conduit. Conduit shall be hot-dipped galvanized inside and out. Non-stationary devices, such as motors and limit switches, shall be connected with flexible conduits. Flexible conduit may be used for wire runs up to and including 6 feet in length.

3.5.12.3 The continuity of the "ground" shall be maintained across all flexible conduit connections.

3.5.12.4 All wiring methods shall be in accordance with NFPA 70.

3.5.12.5 All control wiring shall be brought to terminal blocks. Connections made on terminal blocks and internal devices shall be by means of ring-tongue type insulation-gripping insulated terminals. On internal devices which do not permit the use of insulated terminals, control wiring shall be held by screw type compression connectors. Wiring shall have no splices. Not more than two wires shall be terminated on one terminal point. A permanent identification label shall be attached to each wire at the point of connection.

3.5.12.6 Wire stripping shall be accomplished with a tool that assures that the wire will not be nicked. Terminals shall be attached to the stripped wire by means of a ratchet type crimping tool which makes a full crimp to the specified pressure before allowing the wire with the terminal to be released.

3.5.12.7 All control wiring shall be stranded copper or stranded tinned copper conductor, No. 14 AWG minimum with 90°C temperature and 600 volt rated insulation. The insulation shall be moisture and oil resistant, flame retardant and shall not support combustion. All wire used by Contractor shall be qualified by the flame test requirements specified in Paragraph 2.5 of IEEE 383. The use of PVC insulated wire shall be minimized. PVC shall only be used if substitute materials are not available and if the PVC insulated wire is a standard part of the design of a commercial piece of equipment. When used, the PVC insulated wire must be located within an enclosure. Purchaser approval shall be obtained for the use of PVC insulated wire.

3.5.12.8 Terminal blocks shall be 600 volt, front connected barrier type with marker strips identifying all internal and external wiring.

### 3.5.13 Grounding.

3.5.13.1 Noncurrent-carrying metallic parts of electrical equipment and other metallic equipment which may come in contact with energized conductors shall be grounded.

3.5.13.2 All equipment requiring grounding shall be provided with means for the attachment of a grounding cable to the enclosure. The grounding means shall be a tapped hole in the enclosure with a matching bolt and a Burndy Hydent lug for copper cable suitable for No. 2 through 6 AWG conductor sizes, or Purchaser approved equal.

### 3.5.14 Special Tools

A complete set of all special tools, if required, for the installation and maintenance of the valves shall be provided by Contractor. If special tools are not required for installation or maintenance, Contractor shall include a statement to that effect in the instruction manuals.

### 3.6 Fabrication Welding Requirements.

All shop welding, including repair welds shall be performed in accordance with ANSI Code B31.1.

### 3.7 Marking and Identification of Valves

A corrosion resistant nameplate shall be permanently attached to each valve in a clearly visible, easily accessible location. Marking on plates shall be in accordance with ANSI B16.34 and MSS SP 25. A blank space of sufficient size shall be provided to permit the stamping of a 12 character number prior to shipping. This space shall be labeled "Equipment Identification Number". Accessories shall be similarly identified. Rotation arrows for open and close shall be marked on all handwheels.

### 3.8 Cleaning, Cleanliness and Protection

The cleanliness of the equipment furnished shall be in accordance with Manufacturer's standard.

### 3.9 Painting

All external steel surfaces (except stainless steel) shall be primed and topcoated in accordance with the coating manufacturer's instructions.

#### 3.9.2 Application of Coating.

3.9.2.1 The coating manufacturer's instructions and recommendations shall be followed for the application of coatings.

3.9.2.2 Appurtenances such as handwheels, operators, etc. shall be given a minimum of two (2) coats of Manufacturer's standard coating to a minimum

dry film thickness of 3 mils. This coating shall be capable of withstanding temperatures to design temperature plus 50°F without loss of its protective integrity.

3.9.2.3 Bolts, stainless steel, nonferrous and galvanized steel surfaces need not be shop coated.

### 3.10 Installation

The ball valves will be installed and field tested by Purchaser. Contractor shall shop assemble the ball valves before shipment to minimize field installation efforts.

### 3.11 Seismic Requirements

The seismic category is given in APPENDIX A. Those valves requiring seismic qualification are listed in APPENDIX C, Seismic Category III Requirements, hereinafter referred to as APPENDIX C.

## 4. QUALITY ASSURANCE REQUIREMENTS

### 4.1 Quality Assurance Program

4.1.1 Contractor shall implement and maintain its standard Quality Assurance/Quality Control program to assure that the valves and accessories including subcontracted items are designed, manufactured, inspected,

tested, documented and delivered in accordance with the requirements of this technical specification and Contractor's documented instructions and procedures. The program shall be submitted to Purchaser in accordance with TABLE I. Contractor shall notify Purchaser in writing of any intended change to its program that would affect the quality of the delivered items.

#### 4.1.2 Purchaser's Surveillance

4.1.2.1 All manufacturing, processing, assembly, testing, inspection and shipping operations shall be preplanned, documented and subject to surveillance by Purchaser, Owner, the Government or their designated representatives.

4.1.2.2 Contractor shall not proceed beyond final inspection prior to preparation for shipment until Purchaser performs its surveillance or provides a formal waiver.

#### 4.2 Tests and Examination

In addition to Contractor's standard examinations, shop tests, inspections, the test requirements of NEMA MG 1 and IEEE 112 for motors and NEMA ICS 1 for all solenoids and miscellaneous electrical equipment, the following examinations and tests shall be performed:

4.2.1 All tests and examinations shall be in accordance with ANSI B31.1, Chapter VI.

4.2.2 All valves shall be visually inspected in accordance with ANSI B31.1, Paragraph 136.4.2.

4.2.3 All valves shall be subjected to hydrostatic and seat leakage tests in accordance with MSS SP 61. The acceptance criteria shall be in accordance with MSS SP 61.

4.2.3.1 Main seat leakage shall not exceed 2cc/hr per inch of nominal valve size, unless otherwise specified in APPENDIX A. Leakage shall not exceed 0.02 standard cubic feet of air per inch of nominal valve size for gas service valves, if applicable.

4.2.3.2 The seat leakage test shall be performed after the hydrostatic test.

4.2.3.3 Prior to testing, the valve internals shall be thoroughly flushed with demineralized water. The test medium shall be demineralized water. Water used for hydrostatic testing of stainless steel shall not exceed one (1) ppm total halogen content.

4.2.4 Nondestructive examination and acceptance criteria requirements for the valves shall be in accordance with ANSI B31.1, Section 136, except that the radiography shall be in accordance with the requirements of MSS SP 54.

4.2.5 A stroke test to verify functional operation shall be performed on each valve after final assembly with appurtenances. The test shall be per-

formed in accordance with Contractor's standard procedures and shall meet the requirements of paragraph 3.5.3.7.

4.2.6 Prior to shipment, the assembled units shall be functionally tested. The wiring shall be tested for proper connections and grounds. The wiring and connections shall be subjected to and shall withstand a dielectric test consisting of twice the rated potential plus 1000 volts applied continuously for one minute.

4.2.7 Contractor shall submit copies of certified reports of all examinations and tests to Purchaser in accordance with TABLE I. Each test report shall include test results, a discussion of test procedures, calibration data for instruments and equipment, and a complete set of test data backup calculations. Certified shop test reports for all motors and solenoid electrical equipment shall be in accordance with NEMA MG 1, ICS 1, IEEE 112 and TABLE I of this specification.

4.2.8 The ANSI, MSS and/or other standards followed for the tests or inspections, together with a listing of valve areas inspected, shall be referenced in all test and inspection reports.

#### 4.3 Seismic Qualification

Contractor shall submit the documentation indicated in TABLE I which demonstrates that the qualification of the Seismic Category III equipment (which requires qualification) is in accordance with the Seismic Data Appendix (APPENDIX C) of this specification.

### 5. PREPARATION FOR DELIVERY

#### 5.1 Packaging and Packing

5.1.1 Packaging for valves shipped with motor operators shall be in accordance with ANSI N45.2.2, Section 3, consistent with Level B as described therein. Packaging for all other valves shall be in accordance with Manufacturer's standard.

5.1.2 All valves furnished shall be packaged and shipped completely assembled to the extent possible including operators, junction or control boxes, all interconnecting tubing and wiring, and accessories. Packages shall be labeled and numbered so that each section or assembly may be identified before being uncrated. Any items not fully assembled shall be packaged separately.

5.2 Marking of Shipment

5.2.1 All items shall be clearly marked to preserve the identity of the equipment shipped. Marking of all shipments shall include the following information:

a. Contract Data

Purchaser's P.O. Number  
Name and Address of Contractor  
Quantity and Description  
Gross Weight  
Valve Number (E.I.N.)  
Packing List

b. Destination

c. Return Address

d. Handling Instructions

e. Weight of Package

f. Special Instructions

### 5.3 Shipping

5.3.1 Where equipment must be separated for shipment, all materials and equipment required to facilitate re-assembly and reconnection of inter-connecting cabling, conduit, and wiring in the field shall be furnished.

5.3.2 Shipping methods shall be in accordance with ANSI N45.2.2, Section 4.

### 5.4 Receiving, Handling, Storage and Maintenance.

5.4.1 Receiving and Handling on-site will be in accordance with ANSI N45.2.2, Section 5 and Section 7.

5.4.2 For Contractor's information, valves with motor operators attached will be stored at Level B and the Section 6 (Storage) requirements in accordance with ANSI N45.2.2 for a period of at least two (2) years.

5.4.3 All other valves will be stored at level C and the Section 6 (Storage) requirements in accordance with ANSI N45.2.2 for a period of at least two (2) years.

5.4.4 Contractor shall supply, in accordance with TABLE I, any instructions for handling, and repacking of items supplied. Contractor shall also provide special or supplemental storage and maintenance instructions if the length of time in storage and conditions described will allow degradation of the material.

## 6. NOTES AND ORDERING DATA

### 6.1 Items to be Provided by Contractor

The equipment and services to be provided by Contractor under this specification shall include the following:

6.1.1 The design, fabrication, inspection, testing, documentation, packaging and delivery of all valves, operators and accessories.

6.1.2 All documents listed in paragraph 3.3 of this specification.

6.1.3 Shop testing and inspection.

6.1.4 Shop painting of all valve assemblies and accessories.

6.1.5 Shipment to job site of all valves and accessories.

6.1.6 One gallon of topcoat paint of each color for touch-up.

6.1.7 A complete set of all special tools, if required.

6.1.8 Contractor is responsible for all items implicit in the above list and covered in the technical specification.

## 6.2 Items to be Provided by Purchaser

The following equipment and services will be provided by Purchaser.

6.2.1 Receiving, handling and site storage of the equipment furnished by Contractor.

6.2.2 Installation of the equipment and hook-up to connecting piping and utilities.

6.2.4 Valve actuating signal equipment.

6.2.5 All external wiring from single terminal locations.

6.2.6 Valve control signal and supply tubing.

6.2.7 Electric-to-pneumatic signal converters.

6.2.8 Field touch-up painting labor.

## 6.3 Ordering Data

The following detailed requirements and conditions necessary to design, fabricate and test the valves and accessories are part of this technical specification:

TABLE I - Document Submittal Table

TABLE II - Environmental Conditions

TABLE III - Valve Classification

TABLE IV - Typical Wiring Diagram and Limit and Torque Switch Contact Development for Motor Operated Valves

TABLE V - Typical Wiring Diagram and Limit Switch Contact Development for Air Operated Valves

TABLE VI - Valve Technical Data

APPENDIX A - Valve List

APPENDIX B - Legend to Valve List Abbreviations

APPENDIX C - Seismic Category III Requirements

#### 6.4 Information to be Submitted

All information listed in TABLE I shall be submitted within the time specified for Purchaser's approval or information in accordance with the applicable administrative instructions made part of the Contract.

TABLE I  
DOCUMENT SUBMITTAL TABLE

Item No.	Spec. Para. No.	Name, No. & Para. of Code or Std. being invoked	Document Description	Approval Level* (Data Type)	Required Submittal Date	Submitted for: Approval/Info.
1	3.5.1.14 & 3.5.4.13	-	Valve Technical Data (including Electric Motor Operator Data) and Motor Heating Capability Curve	3	210 Days After Contract Award	X
2	4.1.1	-	Quality Assurance/Quality Control Program	3	30 Days After Contract Award	X
3	3.3.1.2	-	Special Tools List (If Applicable)	4	120 Days After Contract Award	X
4	3.3.1.1	-	Valve Outline and Assembly Drawings including Electrical Diagrams and Design Data	3	180 Days After Contract Award	X
5	4.3	APPENDIX C	Seismic Design and Analysis Calculations	3	240 Days After Contract Award	X
6	4.3.7	NEMA MG 1 ICS 1 IEEE 112	Copies of Certified Reports of all Tests and Examinations	4	10 Working Days After Completion of Tests	X

NOTE: Reference administrative instructions for number of documents required.

\*This information is for the convenience of Purchaser. Contractor shall place this information above the title block of a drawing and in the top right hand corner of the title page of other documents.

TABLE I  
DOCUMENT SUBMITTAL TABLE

Item No.	Spec. Para. No.	Name, No. & Para. of Code or Std. being invoked	Document Description	Approval Level* (Data Type)	Required Submittal Date	Submitted for: Approval/Info.
7	4.3	APPENDIX C	Seismic Analysis Procedures	3	90 Days Prior to Use	X
8	-	Contract administrative instructions	Deviation Reports/Waiver Requests	3	As Generated	X
9	5.4.4	-	Storage and Handling Procedures	4	150 Days Prior to Shipment	X
10	-	Contract administrative instructions	Shipping Plan	4	150 Days Prior to Shipment	X
11	-	Contract administrative instructions	Site Receiving Documentation	4	150 Days Prior to Shipment	X
12	-	Contract administrative instructions	Installation Documentation	4	150 Days Prior to Shipment	X
13	3.2.8	Contract administrative instructions	Spare Parts List, Final Maintenance and Instruction Manuals	3	180 Days Prior to Shipment	X
14	-	Contract administrative instructions	Certificate of Compliance	4	Upon Shipment	X

TABLE II

Environmental Conditions

Atmosphere	Pressure	Temperature (°F)		Max. Relative Humidity %
		Min	Max	
Air	Atm	9	110	100

TABLE III

VALVE CLASSIFICATION NO. 48

Carbon Steel Ball Valves

ANSI Pressure-Temperature Rating Class: 150 to 300, Standard

Type: Ball

Size Range: 1" to 8"

Service: Water, Air, Gas, and Chemical

Materials: Body and bonnet cover - Cast carbon steel, ASTM A 216 Grade WCB or forged carbon steel, ASTM A 105

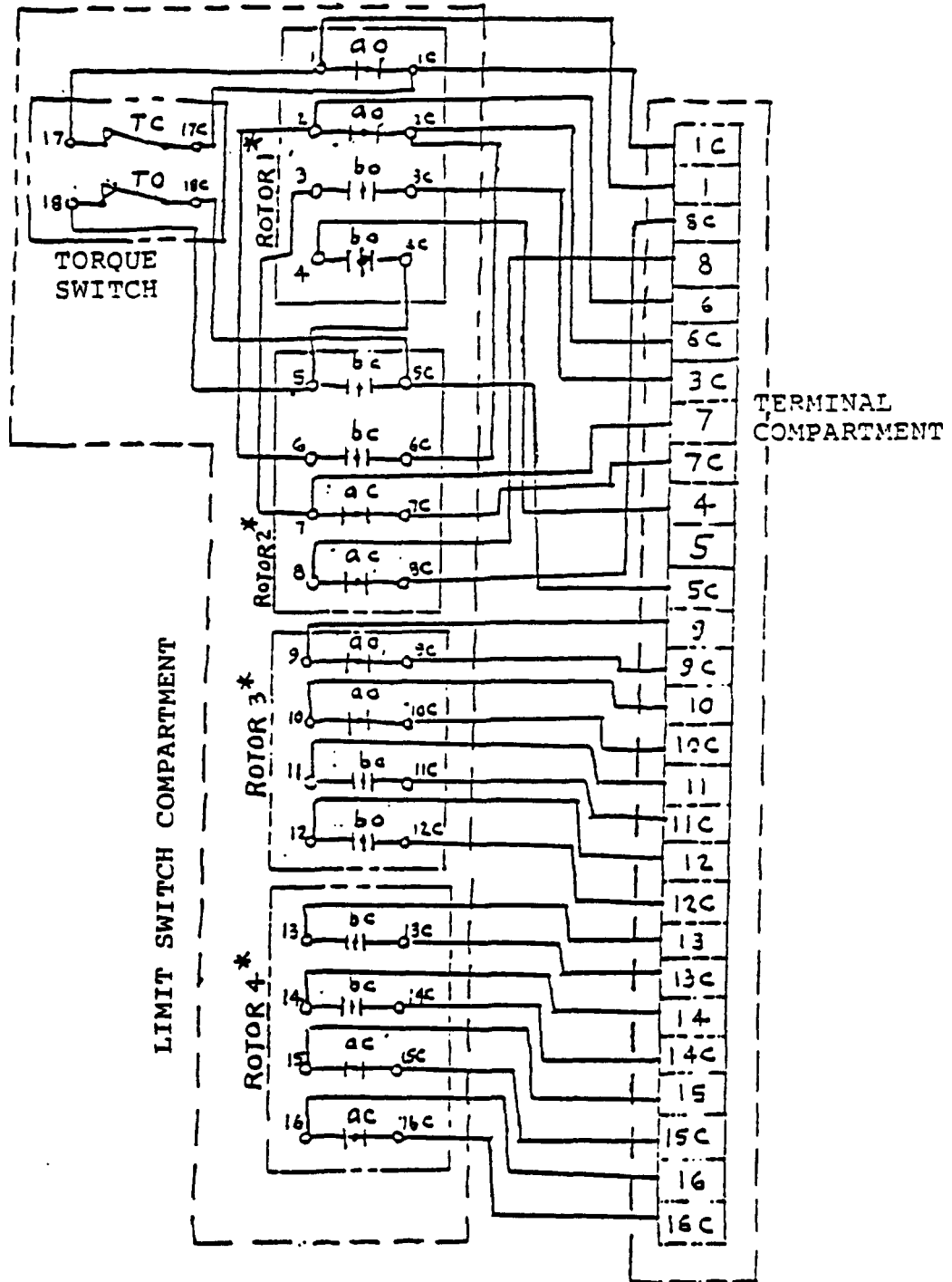
Ball - Cast stainless steel, ASTM A 351 Grade CF8M (316), ASTM A 240 Type 316\*, ASTM A 276 Type 316 Condition A, or ASTM A479 Gr. 316\*\*\*\*\*

Stem - Forged carbon steel, ASTM A 105 or stainless steel, ASTM A 564 Type 630

Seat Ring and Body Seals\*\* - UHMW Polyethylene, Polyimide, Polyurethane, EPDR (EPDM),\*\*\* Polysulfone (e.g. Udel), Polyethersulfone (e.g. Victrex), Polyphenylene Sulfide (e.g. Ryton) or reinforced Polytetrafluoroethylene (PTFE)\*\*\*\*

TABLE IV

TYPICAL WIRING DIAGRAM AND LIMIT AND TORQUE SWITCH CONTACT DEVELOPMENT FOR MOTOR OPERATED VALVES



\* Contacts shown for valve in fully open position.

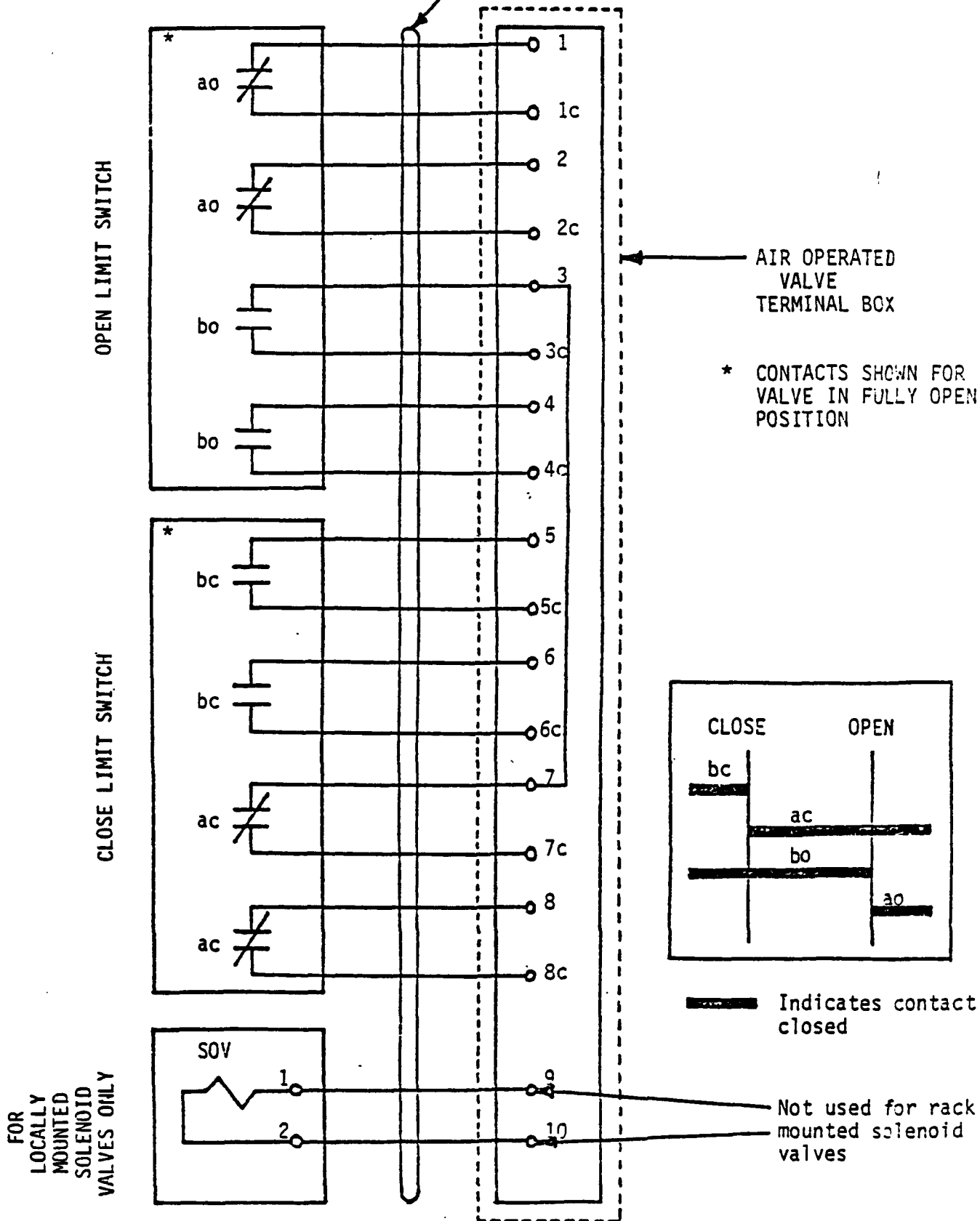
TABLE IV (Cont'd)  
TYPICAL WIRING DIAGRAM AND  
LIMIT & TORQUE SWITCH CONTACT DEVELOPMENT  
FOR MOTOR OPERATED VALVES

ROTOR	CONTACT NO.	VALVE POSITIONS				CONTACT DESCRIPTION
		FULL OPEN	A	B	FULL CLOSED	
1	1	█				ao
	2	█				ao
	3		█	█	█	bo
	4		█	█	█	bo
2	5				█	bc
	6				█	bc
	7	█	█	█		ac
	8	█	█	█		ac
3	9	█				ao
	10	█				ao
	11		█	█	█	bo
	12		█	█	█	bo
4	13				█	bc
	14				█	bc
	15	█	█	█		ac
	16	█	█	█		ac
	17	Close torque switch, contact opens when valve is fully closed or if mechanical overload occurs during closing cycle				tc
	18	Open torque switch, contact opens if mechanical overload occurs during opening cycle				to

- NOTES: 1) █ Indicates contact closed  
2) Rotors 3 & 4 can be set at valve position fully open, fully closed or any position in between as indicated by points A & B

TABLE V  
TYPICAL WIRING DIAGRAM  
AND LIMIT SWITCH CONTACT DEVELOPMENT  
FOR AIR OPERATED VALVES

BY VENDOR



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TABLE VI  
Valve Technical Data

The following technical data shall be prepared by Contractor for each Manufacturer's Figure. Number as applicable, and submitted to Purchaser in accordance with TABLE I:

A. Valve Data

Manufacturer

Name: \_\_\_\_\_

Location: \_\_\_\_\_

Manufacturer's Figure Number \_\_\_\_\_

- 1. Equipment Identification No.  
("Valve No." in APPENDIX A) \_\_\_\_\_
- 2. Model No. \_\_\_\_\_
- 3. Port Size, Inch \_\_\_\_\_
- 4. Rating, ANSI # \_\_\_\_\_
- 5. End Connections \_\_\_\_\_
- 6. No. of Ports \_\_\_\_\_
- 7. Other (describe) \_\_\_\_\_
- 8. Valve Characteristic Curve, Dwg. No. \_\_\_\_\_



TABLE VI (continued)

B. Air Operators (continued)

- 3. Model Number \_\_\_\_\_
- 4. Power Supply: (as applicable) \_\_\_\_\_
  - a) Air Pressure, psig \_\_\_\_\_
  - b) Electrical Data, Volts/Phase/Hz       /      /       \_\_\_\_\_
- 5. Control Signals, psig/ma       /       \_\_\_\_\_
- 6. Piston Ring or Diaphragm Material \_\_\_\_\_  
Useful Life under Radiation Zone as specified \_\_\_\_\_
- 7. Diaphragm Area, sq. in. \_\_\_\_\_
- 8. Weight of Operator, Lbs. \_\_\_\_\_

C. Electric Motor Operator

- I Valve Operator Type \_\_\_\_\_
- II Motor Manufacturer \_\_\_\_\_
- III Motor Type or Class Description \_\_\_\_\_
- IV Actuator Torque Minimum \_\_\_\_\_
- V Motor Rating Data \_\_\_\_\_
  - 1. Horsepower, hp \_\_\_\_\_
  - 2. Speed, rpm \_\_\_\_\_
  - 3. Service factor \_\_\_\_\_

TABLE VI (continued)

C. Electric Motor Operator (continued)

V Motor Rating Data (continued)

- 4. Voltage, Phase, Frequency \_\_\_\_\_
- 5. Full Load Current, Amps \_\_\_\_\_
- 6. Locked Rotor Current, Amps \_\_\_\_\_
- 7. Type of Enclosure \_\_\_\_\_
- 8. Insulation Class \_\_\_\_\_
- 9. Safe Stall Time (Sec) \_\_\_\_\_
- 10. Duty Cycle (Continuous, 30 min,  
15 min. etc.) \_\_\_\_\_
- 11. Space Heater (Volts/Watts) \_\_\_\_\_
- 12. Allowable No. of Starts per Hour \_\_\_\_\_

VI Limit Switch Contact Rating:

- |               | AC    | DC    |
|---------------|-------|-------|
| 1. Continuous | _____ | _____ |
| 2. Make       | _____ | _____ |
| 3. Break      | _____ | _____ |

VII Weight of Operator

- 1. Shipping, lbs. \_\_\_\_\_
- 2. Net, lbs. \_\_\_\_\_
- 3. Support Requirements, if any \_\_\_\_\_

TABLE VI (continued)

D. Air Set

- 1. Manufacturer \_\_\_\_\_
- 2. Type \_\_\_\_\_
- 3. Model Number \_\_\_\_\_

E. Limit Switches

- 1. Manufacturer \_\_\_\_\_
- 2. Type \_\_\_\_\_
- 3. Model Number \_\_\_\_\_
- 4. Contact Type \_\_\_\_\_
- 5. Contact Rating \_\_\_\_\_

F. Solenoid Operated Air Pilot Valves

- 1. Manufacturer \_\_\_\_\_
- 2. Model Number \_\_\_\_\_
- 3. Type \_\_\_\_\_
- 4. Electrical Rating \_\_\_\_\_
- 5. Minimum Pickup Voltage, Volts \_\_\_\_\_
- 6. Minimum Dropout Voltage, Volts \_\_\_\_\_

G. Handwheels

- 1. Manufacturer \_\_\_\_\_
- 2. Type or Material \_\_\_\_\_

---

TABLE VI (continued)

G. Handwheels (continued)

- 3. Model Number \_\_\_\_\_
- 4. Handwheel Diameter, Inch. \_\_\_\_\_
- 5. Maximum tangential force required on the handwheel rim to manually operate the valve during the most severe valve operation, lbs. \_\_\_\_\_

H. General

- 1. Weight of Complete Valve assembly including valve, operator and accessories, lbs. \_\_\_\_\_
- 2. Sound Pressure Levels, dbA \_\_\_\_\_

APPENDIX A

VALVE LIST



CLINCH RIVER BREEDER REACTOR PLANT PROJECT  
 SPECIFICATION VALVE 'ST  
 BY TYPE, SIZE, PRES RATNG, MAT, END C , BYPASS, MODE OF OPER

SPECIFICATION NO: 3066-10-102A  
 APPENDIX A

VALVE NUMBER	B	R M			B M			MAX		D S O R C S S		VL	VL	V F		S		A T													
	D VALVE Y SIZE	A T T L	E P J C O V	S W	P G S U	C S G N P R E S	D S G N T E M P	O P E R P R E S	O P E P T E M P	D I F F P R E S	S E W G I	A L T N O	T A N G	P O F	P O N O	A L C U	V L V C L S	P I P S C H	S L	S P E C I A L R E Q R M N T S	C S T Y	B L D									
75CFV----347	0	01.00	E	SS	SW	N	M	600	110	410	AME	0410	D	3	3	0	M	C	N	NO	FA	N	X	51	40S	0			N	N	TGE
75CFV----352	0	01.00	E	SS	SW	N	M	690	110	410	AME	0410	D	3	3	0	M	C	N	NC	FA	N	X	51	40S	0			N	N	TGE
75CFV----368	0	01.00	E	SS	SW	N	M	600	110	410	AMB	0410	D	3	3	0	M	C	N	NO	FA	N	Y	51	40S	0			N	N	TGE
75CFV----373	0	01.00	E	SS	SW	N	M	600	110	410	AMB	0410	D	3	3	0	M	C	N	NC	FA	N	Y	51	40S	0			N	N	TGE

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CLINCH RIVER BREEDER REACTOR PLANT PROJECT  
 SPECIFICATION VALVE LIST  
 BY TYPE, SIZE, PRES RATING, MAT, END N, BYPASS, MODE OF OPER

SPECIFICATION NO: 3066-10-102A  
 APPENDIX A

VALVE NUMBER	B D Y	VALVE SIZE	R A T	M I L	B END CON	M P S	M D D	DSGN PFES	DSGN TEMP	OPER PRES	OPEN TEMP	PAX DIFF PRES	D S E G I	S E W I N	O R A L D	R C H N G	S S T A L T A N G F	VL NO	VL FA	V F C U	S L	SPECIAL REQRHNTS	A T C S T Y P E						
75HWV---040	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---043	0	01.00	G	CS	SW	N	M	350	150	70	AHB	0070	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---050	0	01.00	G	CS	SW	N	M	350	150	70	AMB	0070	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---055	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---061A	0	01.00	G	CS	SW	N	M	350	212	160	200	0350	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---061B	0	01.00	G	CS	SW	N	M	350	212	160	200	0350	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---075	0	01.00	G	CS	SW	N	M	350	320	265	180	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---077	0	01.00	G	CS	SW	N	M	350	320	265	180	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---079	0	01.00	G	CS	SW	N	M	350	320	265	200	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---090	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---100A	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---100B	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---100C	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---100D	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---100E	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---100F	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---100G	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---100H	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---103A	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---103B	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---103C	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---103D	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV---103E	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE

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CLINCH RIVER BREEDER REACTOR PLANT PROJECT  
 SPECIFICATION VALV 1ST  
 BY TYPE, SIZE, PRES RATNG, MAT, END L., BYPASS, MODE OF OPER

SPECIFICATION NO: 3066-10-1024  
 APPENDIX A

VALVE NUMBER	R D Y	M VALVE SIZE	R M		R M		D SGN PRES	D SGN TEMP	O PER PRES	O PER TEMP	M A X. D I F F P R E S	D S E L E C T E D I N G	R E S T R I C T E D I N G	C O N D I T I O N S	S S V L V P I P S	V L V P I P S	V L V P I P S	V L V P I P S	S P E C I A L R E Q U I R E M E N T S	A T T R I B U T E S	T Y P E O F B L O C K								
			A T T R I B U T E S	E N D P O I N T																									
75HWV----103F	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV----103G	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV----103H	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV----116A	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV----116B	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV----116C	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV----116D	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV----116E	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV----116F	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV----119A	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV----119B	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV----119C	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV----119D	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV----119E	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV----119F	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	TGE
75HWV----371	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	SGE
75HWV----378	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	SGE
75HWV----379	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	SGE
75HWV----395	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	SGE
75HWV----402	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	SGE
75HWV----403	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	SGE
75HWV----474	0	01.00	G	CS	SW	N	M	350	320	265	300	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	RWE
75HWV----473	0	01.00	G	CS	SW	N	M	350	320	265	250	0125	D	3	3	0	M	C	N	NO	FA	N	J	48	40	0	N	N	RWE

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COMPILATION OF ITEMS OR  
REQUIREMENTS COMMONLY INCLUDED  
IN PROCUREMENT SPECIFICATIONS  
WHICH ARE RECOMMENDED FOR DELETION

EXHIBIT 7

- o All valves shall meet the requirements of ANSI B31.1 and ANSI B16.34. Weld end preparations shall be in accordance with paragraphs 3.5.1.11 and 3.5.1.12.
- o Valves shall not be fabricated prior to Purchaser's approval of the submitted drawings and data.
- o All documents submitted shall be identified with the appropriate Purchaser's Equipment Identification Numbers.
- o Austenitic stainless steel materials shall be in the solution heat treated condition and shall not be exposed to sensitizing temperatures after the final solution heat treatment, except for welding.
- o Nickel alloys shall be in the stabilized annealed condition.
- o Body and bonnet material as specified in TABLE IV shall be subject to the additional nondestructive test requirements listed below:

ASTM A 351 - Supplemental Requirement S-6, Liquid Penetrant Examination. Acceptance criteria shall be in accordance with ANSI B31.1, Paragraph 136.4.4B.

ASTM A 182 - Supplemental Requirement S-5, Liquid Penetrant Examination. Acceptance criteria for the above materials shall be in accordance with ANSI B31.1, Paragraph 136.4.4B.

ASTM A 105 - Supplemental Requirement S-5, Magnetic Particle Examination. Acceptance criteria for the above material shall be in accordance with ANSI B31.1 Paragraph 136.4.3.

ASTM A 216 - Supplemental Requirement S-4, Magnetic Particle Inspection. Acceptance criteria for the above material shall be in accordance with MSS SP 53.

- o Protective Coating Material Requirements. Coating materials shall conform to the following requirements:

Coating System A (for use when service temperatures do not exceed 200°F). Primer and topcoat for valve external ferrous surfaces and for appurtenances such as handwheels, operators, etc. shall be an epoxy polyamide type system. Contractor shall use one of the systems listed below or Purchaser approved equal. The finish color shall be Federal Standard 595a, No. 15180, blue.

<u>Primer</u>	<u>Topcoat</u>	<u>System Manufacturer</u>
Carboline 193 3.0 - 4.0 mils DFT	Carboline 191 HB 4.0 - 6.0 mils DFT	Carboline Co. St. Louis, Missouri
Amercoat 90 4.0 - 6.0 mils DFT	Amercoat 90 4.0 - 6.0 mils DFT	Ameron Brea, California
13-R-56 Val-Chem Zinc Chromate Epoxy 2.0 - 4.0 mils DFT	89 Series Val-Chem Hi-Build Epoxy 5.0 - 7.0 mils DFT	Mobil Chemical Edison, New Jersey
66-1211 Epoxoline 3.0 - 5.0 mils DFT	66 Color Hi-Build Epoxoline 4.0 - 6.0 mils DFT	Tnemec Co., Inc. North Kansas City, Missouri

Coating System B (for use where service temperatures exceed 200°F). Coating shall be solvent base ethyl silicate inorganic zinc having a minimum of 80% zinc by weight in the applied dry films base. Contractor shall use one of the coatings listed below or Purchaser approved equal. The finish color shall be Federal Standard 595a, No. 15180, blue.

<u>Coating</u>	<u>Touch-Up</u>	<u>Manufacturer</u>
Carbo Zinc 11 2.0 - 4.0 mils DFT	Carbo Zinc 11-50% thinned	Carboline Co. St. Louis, Mo.
Dimetcote #6 2.0 - 4.0 mils DFT	Dimetcote #6 or Amercoat #160	Ameron Brea, Calif.
13-F-12 Mobil zinc 2.0 - 4.0 mils DFT	13-F-4 Mobil zinc 4	Mobile Chemical Edison, N.J.
Tneme-Zinc 90 - 92 E 2.0 - 3.5 mils DFT	Tneme - Zinc 90-93	Tnemec Co., Inc. No. Kansas City, Mo.

Weld Preparation Coatings. Corrosion inhibiting coating specified in paragraph 3.9.3.1 shall be Deoxaluminite, manufactured by Special Chemicals Corp., Ossining, New York or Purchaser approved equal.

Rust Preventive Coatings. Rust preventive coatings specified in paragraph 3.9.3.2 shall conform to SSPC PS 8.01, Type B or C Compound, or Purchaser approved equal. Coatings shall be non-water sol-uble, and shall be capable of being removed by a non-halogenated solvent.

Typical products are as follows:

<u>Coating</u>	<u>Manufacturer</u>
ASTROL, RP EXTRA	Imperial Oil & Grease Co. Los Angeles, Calif.
Rustproof Compound L	Texaco New York, N.Y.

- o Stem packing for all valves shall be "Graphoil" or "Graphlok" unless otherwise specified in TABLE IV.
- o All welding shall be in accordance with paragraph 3.6 of this specification.
- o All field weld end preparation drawings shall be submitted to Purchaser in accordance with TABLE I.
- o Electric motor operators shall be Philadelphia Gear "Limitorque", Rotork, or Purchaser approved equal.
- o Contractor shall be responsible for the proper selection of motor characteristics and mountings to meet the requirements of the driven valve.
- o All electric motors shall be in accordance with paragraph \_\_\_\_\_ of this specification.
- o The operator reduction gearing shall operate submerged in a lubricant or packed in a life-time lubricant. Shafts shall be mounted in ball or roller bearings. The entire transmission, including couplings, shall be capable of withstanding the maximum torque output of the motor including the requirements of paragraph \_\_\_\_\_ without damage.
- o The mount shall be designed to withstand the maximum torque output of the motor without damage.
- o The position indicator may be of the standard dial type mounted at the valve.
- o Limit switches shall facilitate both control and indication.

- o Limit switch enclosures shall provide a minimum of 150 cubic inches of free space for stripping incoming control cables and preparation of connections to switches.
- o Contractor shall be responsible for the proper selection of motor characteristics and mountings to meet the requirements of the driven equipment and application.
- o Motors shall be in totally enclosed non-ventilated or NEMA ICS 6 Type 6 housings. Housings not in compliance with NEMA Type 6 shall be provided with a breather or vent type drain plug.
- o Motors shall be capable of withstanding all thermal and mechanical stresses.
- o Bearing lubricant shall be suitable for the service and environmental conditions specified herein.
- o Rotors for all valve motors shall be dynamically balanced.
- o Operator reduction gearing units shall consist of a worm gear and worm in a totally enclosed grease-packed and sealed gear case which will not require further lubrication over the life of the valves.
- o Limit switches shall be installed in a manner that will not interfere with the normal operation of the valve. The mounting of the limit switches on the valve shall be of sufficient rigidity to preclude misalignment and false indication of position when the conduit is connected to the switch enclosure.
- o Actuator sizing shall take into account dynamic unbalanced forces, particularly for flow tending to close valves.

- o Contractor shall indicate for each actuator type the maximum stroking speed for opening and closing at the standard indicated air supply pressure, as well as the total stroking time. Closing shall be defined as the elapsed time from initiation of control signal for closing to tight shut off.
- o Solenoid valves shall have brass bodies with stainless steel discs and resilient seats suitable for operating with the selected control pressure.
- o Solenoid operated air pilot valves shall be ASCO Series 8300 or Purchaser approved equal. Solenoid coils shall be of the high temperature industrial type.
- o Instrument valves, where required, shall be 200 lb. globe type, Crane 88, or Purchaser approved equal.
- o Points in the wiring of the equipment requiring connection with wiring external to the unit, shall be brought to terminal blocks mounted within NEMA ICS 6 Type 4 boxes.
- o Terminal blocks shall be General Electric CR151B20 or Purchaser approved equal. Terminal blocks shall be in accordance with NEMA ICS 4 and shall be of materials which will neither support combustion nor propagate fire.
- o Welding Processes. Limitations regarding the welding methods used in the fabrication are as follows:

Low hydrogen electrodes must be used for shielded metal arc welding.

Alloy-fortified flux may not be used for submerged arc welding.

All gas tungsten arc process welding must be made with filler metal addition.

Gas shielded-arc welding by short-circuiting transfer may be used only to deposit the root pass and additional weld passes in the root region of butt joints; however, any deposited weld metal thickness produced by the multiple pass technique shall not be more than 1/4 inch.

Flux-cored wire designed for operation without the use of externally supplied shielding gas is not allowed.

o Filler Metal.

Carbon Steels (P-1) and Low Alloy Steel (P-3 , P-4, and P-5). Covered electrodes for manual shielded metal arc welding shall conform to AWS A5.1 or A5.5, low-hydrogen type. The use of E70XX-A1 electrodes is required for materials whose carbon is specified as greater than 0.30 percent, and where the minimum tensile strength is specified as 70,000 psi. The use of E80XX-B2 electrodes is required for P-4 materials. The use of E90XX-B3 electrodes is required for P-5 materials with chromium content not exceeding 3%.

- a. Inert gas welding shall employ filler metal or consumable inserts that will deposit weld metal similar to the base material and shall be defined in Contractor's welding procedure specification and qualification test records.
- b. Submerged arc welding shall employ filler wire and flux that will deposit metal similar to the base material and shall be defined in

Contractor's welding procedure specification qualification test records.

- o Austenitic Stainless Steels (P-8). Covered electrodes and bare filler metals for austenitic stainless steel welding shall conform to AWS A5.4 or AWS A5.9 and shall comply with the following: shielded metal arc (coated electrodes) filler metals shall be purchased to an analysis which will yield 5 to 15 percent delta ferrite in an as-welded all-weld-metal undiluted sample. Bare filler metals, i.e., consumable inserts, spooled wire or normally fed wire shall be purchased to an analysis which, when fused as an all-weld-metal undiluted sampler, will contain weld metal ferrite in the range of 5 to 15 percent. The bare filler wire chemistry can be used for the ferrite determinant when an inert gas is used for shielding the welding arc. The above analyses are to be applied to the Schaeffler diagram for ferrite determination. Nitrogen is assumed to 0.06 percent for this determination.

NOTE: Stainless steel materials operating above 700°F shall require special filler metal consideration and acceptance for use by Purchaser.

- o Nickel-Chromium-Iron Alloys (P-43). Covered electrodes for manual shielded metal arc welding shall conform to AWS A5.11, Classification E Ni Cr Fe-3, Consumable Inserts, and shall have filler wire for use with inert gas metal arc (consumable or nonconsumable). Submerged-arc welding processes shall conform to AWS A5.14, Classification ER Ni Cr-3.
- o Tungsten Electrodes. Gas tungsten arc welding electrodes shall be thoriated tungsten conforming to AWS A5.12, Classification EWTH-2.
- o Storage and Handling of Welding Materials. Low hydrogen electrodes shall be stored in ovens at 250°F to 300°F for approximately 8 hours

immediately prior to use. Electrodes removed from storage ovens shall not be exposed to ambient temperature for more than 4 hours. Electrodes removed from ovens and not used within the 4-hour period are to be returned to the ovens for an 8-hour redrying period at 250°F to 300°F temperature. Electrodes with chipped or cracked coating shall not be used. Bare filler metals shall be stored in dry, clean areas and shall never be used in an oxidized or dirty condition. Electrode control shall be described in written procedures submitted to Purchaser in accordance with TABLE I.

o Circumferential Joints.

All root pass or passes shall be deposited in machined open root joints from one side by the gas tungsten arc process with filler metal addition or with consumable insert in the root of the weld joint. Welding may be manual or automatic.

Where used, backing rings shall be in accordance with ANSI B31.1, Paragraph 127.2.2. When backing rings are left in place, they shall be flat machined or machined and tapered. All backing rings shall fit closely to the underside of the weld preparation (maximum permissible offset between inside diameters of adjoining pipe to be 1/32 inch).

o Preheating Before Thermal Cutting. Thermal cutting shall be performed under the same conditions of preheat and post weld heat treatment as required for welding each class of materials. However, post weld heat treatment is not required when:

The heat affected zone produced by thermal cutting is completely removed by mechanical means immediately after the cutting operation.

Thermal cutting is a part of a fabrication or manufacturing sequence leading to a weld end preparation.

Thermal cutting or gouging of P-6 and P-8 (Martensitic and Austenitic Stainless Steels) groups materials is not permitted.

o Cleaning of Surfaces to be Welded.

Carbon Steel and Ferritic Materials. The edges or surfaces of the parts to be joined by welding shall be machined or thermal cut as shown on Contractor's qualified welding procedure and shall be cleaned of all oil, grease, scale and rust. Where thermal cutting is used, all loose scale must be removed. Remaining kerf material (that fused during the cutting process) and cut surface cavities must be removed by grinding or chipping.

Austenitic Materials. The edges or surfaces of the parts to be joined by welding shall have the abutting edges prepared by machining, grinding, chipping, or filing. Prior to welding, the abutting edges and immediate weld area of the sections to be joined shall be cleaned of all oil, grease, scale and foreign materials. All degreasing shall be done by swabbing the weld area with acetone or other halide free solvent approved by Purchaser. Any grease which may encounter the weld seam shall be completely removed. No residual cleaning compound shall be left on surfaces prior to welding.

No grinding shall be done with wheels previously contaminated by grinding materials other than stainless steels. Brushing shall be done with a stainless steel wire brush not previously used on other materials.

o Welding Procedure and Welder Qualification.

Welding procedure qualifications and welder performance qualifications shall be in accordance with the ASME B&PV Code, Section IX and addenda, in effect at the time of qualification and the applicable requirements of ANSI B31.1.

A written Welding Procedure Specification (WPS), containing information detailed in Form QW-482 of ASME B&PV Code, Section IX, and the qualification test data containing the information detailed in Form QW-483 of ASME B&PV Code, Section IX shall be submitted to Purchaser in accordance with TABLE I.

All major base metal repairs performed by welding shall be made in accordance with a qualified written welding procedure submitted to Purchaser in accordance with TABLE I.

A certification of the welder or the welding operator performance qualification test shall contain the information as detailed in Form QW-484 of ASME B&PV Code, Section IX, and shall be kept on file by Contractor for Purchaser's inspection on request.

o Preheating.

The parts to be welded shall be evenly heated to the preheat temperature, preferably by resistance or induction coil heating. Propane, natural gas or burner rings may also be employed. The metal temperatures shall be determined by contact pyrometer, temperature sensitive crayons or other suitable methods. Preheating shall be in accordance with the requirements of ANSI B31.1, Paragraph 131.

Welded joints in austenitic stainless steel material need not be preheated except where the ambient temperature is below 32°F. In this case, the joint shall be heated to 100°F before any welding is per-

formed. The preheating shall be by neutral flame (torch or burner) or electric resistance. Use of oxyacetylene flame is prohibited.

The interpass temperature for austenitic stainless steel shall not exceed 350°F.

o Miscellaneous Welding Requirements.

The number of weld beads, electrode size, mean voltages and current shall be as shown on Contractor's welding procedure.

The width of weld passes deposited with shielded metal arc electrodes shall be limited to a maximum of 4 times the core wire diameter. The thickness of any deposited weld layer shall be 1/4 inch maximum.

Arc strikes shall be removed by grinding. The ground out arc strike area shall be blended uniformly into the surrounding surface and liquid penetrant inspected; any crack or linear indication shall be a cause for rejection. The grinding shall not result in a reduction in thickness below the minimum required by the applicable material specification. A reduction in thickness beyond the minimum required caused by grinding shall be treated as a defect. In case of repair, the ground out area shall have the groove faces angled or flared to 15 degrees and the bottom of the groove shall have a minimum of a 1/8-inch radius to provide welding accessibility and to prevent a stress riser.

When post welding heat treatment is required, Contractor's post welding heat treatment procedure shall be submitted to Purchaser for information.

- o Cleanliness of the equipment furnished shall be in accordance with Manufacturer's Standard supplemented by the following: the cleanliness

of the equipment furnished shall be such that it is smooth and free of all foreign matter such as scale, sand blisters, weld spatter, metal chips and shavings, oil, grease, organic matter, and rust. Contractor shall submit detailed cleaning procedures to Purchaser in accordance with TABLE I. Cleaning procedures shall assure that cleaning materials do not adversely affect the surface or base material of the equipment.

- o All external surfaces shall be free of contaminants such as deposits of mill or heat treating scale, oil, thick oxide films, slag, flux, weld spatter, dirt, metal chips and abrasive particles.
- o All carbon and alloy steel finished surfaces, including edges prepared for field welding for a distance 1-1/2 inches from the welding edges, shall be cleaned and protected against corrosion during shipment and storage without the application of paint. The surfaces shall be protected by coating with Deoxaluminite (Special Chemicals Corp.) or Purchaser approved equal.
- o Corrosion inhibitors shall not be allowed to come into contact with materials intended for coolant surfaces; however, inhibitors may be employed for minimizing corrosion of metal and parts intended for non-critical applications during fabrication, shipment, storage, and installation.
- o Cleaning agents and demineralized rinse water in contact with austenitic stainless steel shall contain less than 1 ppm of chlorides. No residual halogen-bearing or sulfur materials shall be used in cleaning austenitic stainless steel parts.
- o All external steel surfaces shall be primed and topcoated in accordance with paragraphs \_\_\_\_\_ and \_\_\_\_\_ unless otherwise specified. Contractor shall submit a surface preparation and coating procedure

including identification of coating system to be used to Purchaser in accordance with TABLE I.

o Priming of Surfaces.

Surface Preparation. All deposits of oil and grease shall be removed with solvents from all surfaces to be primed in accordance with SSPC SP 1 prior to blast cleaning. Removal of light deposits of oil and grease by blasting without prior solvent cleaning is not permitted. Steel surfaces to be primed shall be near white blast cleaned in accordance with SSPC SP 10. Only clean, dry abrasives shall be used. The height of anchor profile shall be 1-2 mils as measured in accordance with the requirements of paragraph

Mixing and Thinning. Materials shall not be adulterated by Contractor in any way. Materials shall be activated, thinned and mixed in strict adherence to Manufacturer's instructions. All materials shall be thoroughly mixed before use ensuring the breakup of any lumps, the complete dispersion of settled pigments and a uniform composition with no streaks of color. Uniform conditions shall be maintained during application by constant agitation. Coating materials which have exceeded the pot life or which have been subject to adverse conditions which would affect the film characteristics shall be discarded. The freezing or chilling of coatings to retard curing or prolong workability will not be permitted. Mixed coating materials shall not be retained for future use. Mixing equipment shall meet the coating manufacturer's recommendations.

Application of Primer. Within eight (8) hours of blast cleaning or before rusting occurs, one (1) coat of primer, as specified in paragraph \_\_\_\_\_ or \_\_\_\_\_ shall be applied in the shop to the specified ferrous surfaces to obtain the required dry film thickness

(DFT) as measured in accordance with the requirements of paragraph 4.5.2. Application of the coatings shall be in accordance with Manufacturer's instructions and with SSPC PA 1.

- o Shop Conditions. Provisions shall be made in the shop area, enclosed or open, for conditions which are conducive to keeping the prepared surface free of moisture, frost and dust and maintaining the steel coatings at Manufacturer's recommended application temperature during application and drying.
  
- o Shop Coating. The shop coating shall consist of a prime coat and a final finish coat. No portion of the coating films shall be less than the specified thicknesses. In the event the specified thickness is not achieved, then additional coats shall be applied until the required thickness is obtained. In the event the thickness achieved exceeds the recommended maximum or the coating runs or sags, the area shall be brushed out immediately to the required thickness. If this is not possible the coating in the affected area shall be removed, the surface again prepared and then recoated with the same type of coating and number of coats originally specified. Each coat shall be in a proper state of dryness before application of the succeeding coat. If freshly applied coating is damaged by exposure to below freezing temperatures, excess humidity or dust, it shall be allowed to dry. The damaged coating shall then be removed, the surface prepared again and the area recoated. If the coating is damaged in fabrication, it shall be repaired before leaving the shop.
  
- o Drying of Coated Steel. No coat shall be applied until the preceding coat has dried. The recommended minimum time shall be allowed for coatings to dry before recoating or exposure. No coating shall be force dried under conditions which will cause checking, blistering and formation of pores. Coatings shall be protected from rain, condensation, contamination, snow, and freezing until dry.

o Special Applications of Coated Surfaces.

Field Weld Preparation. Surfaces within two inches of any machined weld edge shall be coated with 2-4 mils of corrosion inhibiting material specified in paragraph 3.4.8.3. The application shall be per Manufacturer's recommendations.

Machined Surfaces. All external machined surfaces other than machined weld preparations specified in paragraph 3.9.3.1 shall be coated with rust preventive coating specified in paragraph 3.4.8.4. The application shall comply with the requirement of SSPC PS 8.01, except that film thickness shall be in accordance with Manufacturer's recommendations. The type of coating chosen shall be submitted to Purchaser in accordance with TABLE I.

Masking of Surfaces to be Primed. Contractor shall mask or otherwise protect those surfaces not to be coated or which receive a corrosion or rust preventive treatment, as specified in paragraph 3.9.3.1 or 3.9.3.2, prior to and during the coating operation.

Handling of Coated Steel. Coated steel shall not be handled until the coating has dried, except for necessary handling in turning for coating or stacking for drying. Coating which is damaged in handling shall be scraped off and touched up with the same number of coats and types of coatings as were previously applied to the steel. Coated steel shall not be loaded for shipment or shipped until it is dry. Coated members shall be handled, stacked and transported in a manner not to damage coating films.

- o These operations shall be identified on a Manufacturing Sequence/Schedule prepared and submitted in accordance with Contract administrative instructions and TABLE I. This document may be combined with other schedules required in this specification.

- o The following list of operations is considered the minimum required Witness points:

Later - after receipt of Manufacturing Sequence/ Schedule.

- o Design Verification. Formal approved documentation shall be prepared by Contractor verifying that the product configuration selected conforms to all the quantitative requirements of this specification. When the documentation includes calculations, these calculations shall be independently checked by a person with competence equivalent to that of the originator. Documents shall be reviewed and approved by Contractor prior to submittal of drawings which use the information. The documents shall identify the revision number, purpose, applicable references, assumptions and conclusions, and shall include pagination. These documents shall be available for review by Purchaser.
- o Hydrostatic test and leakage test procedures shall be submitted to Purchaser in accordance with TABLE I.
- o Whenever radiography is used, Contractor shall utilize double film technique (two separate films in the same cassette) radiographic procedures with the film properly exposed and developed for single film viewing. For irregular surfaces and thickness transition areas, the double film radiographic technique using films of different speeds may be used.
- o All nondestructive examination (NDE) procedures and acceptance criteria shall be submitted to Purchaser in accordance with TABLE I.
- o Coating Operations Inspection.

Surface Preparation. Surface preparation shall be visually inspected prior to application of prime coat. Visual acceptance criteria shall

be in accordance with SSPC Vis 1 for specified surface preparation. The height of anchor profile shall be measured with a visual profile comparator such as a Keane-Tator surface profilometer, a corrected depth gauge or a magnetic gauge with a calibration factor. Any deficiencies in surface preparation noted shall be corrected by Contractor before surface may be prime coated.

Coating Application. Wet film thickness measurements shall be used during application for providing immediate indications of thickness so that inadequacies can be corrected. Measurements for determining acceptance of thickness shall be DFT as measured with a magnetic dry film thickness gauge such as Nordson Model DFG 101 or Elcometer dry film thickness gauge, in accordance with the requirements of SSPC PA 2. DFT shall be within the range specified in paragraph 3.4.8.1. No DFT lower than or in excess of the specified values will be accepted.

- o Cleanliness Requirements. The valve and accessories shall be inspected for cleanliness immediately before packing according to the cleaning requirements specified in paragraph 3.8.
- o All valves furnished under this technical specification shall be packaged in a dust and moisture-impervious shrouding, and shall be adequately crated to ensure protection from transit damage, exposure to the weather and during storage.
- o Threaded, machined and sliding surfaces shall be thoroughly lubricated prior to packaging.
- o After completion of cleaning and drying, all valve ends shall be closed with suitable nonmetallic covers and sealed tightly with Manufacturer's standard pressure-sensitive tape. Nonmetallic protecting caps shall meet the following requirements:

The nonmetallic caps shall be brightly colored.

Simplicity of installation, inspection and removal without damage to the ends, shall be considered.

All caps shall be clean and free of visible contamination prior to placing on the ends.

- o Valves and accessories shall be protected with an overwrap and packed securely in weatherproof crates. Crates shall be clearly labeled as to their contents. Packages shall be blocked, crated, strapped or otherwise held in position during shipment to prevent separation of parts or damage.
- o Overwrap materials shall be moisture/vapor proof, heat sealable and strong enough to resist tearing, shredding or piercing. Overwrap material used for stainless steel parts shall not contain halides.
- o Contractor shall submit a sealing, packing and packaging procedure to Purchaser in accordance with TABLE I.
- o Shipping and Handling of Coated Equipment.

Coated equipment shall be handled at all times with equipment such as stout belt slings and padded skids designed to prevent damage to the coating. Bare cables, chains or hooks, shall not be permitted to come in contact with the coating.

When shipped by rail, all equipment shall be carefully loaded on properly padded saddles or bolsters. All bearing surfaces and loading stakes shall be properly padded. Equipment sections shall be separated so that they do not bear against each other, and the whole load shall

be securely fastened together to prevent movement in transit. The equipment shall be loaded and tied into a unit load in strict accordance with the current loading plan of the Association of American Railroads, whenever applicable.

In truck shipments, the equipment shall be supported in wide cradles of suitably padded timbers hollowed out on the supporting surface to fit the curvature of equipment, and all chains, cables, or other equipment used for fastening the load shall be carefully padded. For smaller size equipment, sand or sawdust-filled bags must be used instead of hollowed-out timbers.

- o This storage level will be indoors (i.e., inside of a pre-engineered metal building, air structure or storage trailer). This structure will be provided with heat and ventilation to maintain the temperature between 40°F and 140°F, but no humidity control. This storage area will be designed and placed in an area where flooding will not occur after five (5) inches of rain in a 24 hour period. The floor will be paved or similarly finished.
- o This storage level will be indoors (i.e., inside of a pre-engineered metal building, air structure or storage trailer). This structure will not be provided with temperature or humidity control. This storage area will be designed and placed in an area where flooding will not occur after five (5) inches of rain in a 24 hour period. The floor will be paved or similarly finished.
- o The Contract Document Index required by the Contract administrative instructions shall be an expansion of TABLE I, of this specification. The index shall be specific giving title, identification number, and applicable issue identification of each document to be supplied. If the submitted document is a report, the index shall identify

Purchaser's Equipment Identification Number and subassembly (if applicable) to which the report applies. This index shall be current, keyed to and compatible with the Overall Work and Document Submittal Schedules.

TABLE I  
DOCUMENT SUBMITTAL TABLE

Item No.	Spec. Para. No.	Name, No. & Para. of Code or Std. being invoked	Document Description	Approval Level* (Data Type)	Required Submittal Date	Submitted for: Approval/Info.
-	6.1.6	Contract administrative instructions	Contract Document Index	4	60 Days After Contract Award and Updates as required	X
-	-	Contract administrative instructions	Overall Work Schedule	4	60 Days After Contract Award	X
-	-	Contract administrative instructions	Preliminary Spare Parts List, Preliminary Maintenance and Instruction Manuals	4	60 Days After Contract Award	X
-	4.4.1	APPENDIX C	Schedule of Seismic Test Dates	4	60 Days After Contract Award	X
-	4.1.1	Contract administrative instructions	Manufacturing Sequence/Schedule (including Hold Points)	4	15 Working Days After Release for Fabrication	X
-	3.6.3.5 3.6.7.2 3.6.7.3	ASME BPVC Sect. IX	Welding Procedure Specification and Qualifications, Weld Repair and Electrode Control Procedures	4	90 Days Prior to Use	X
-	4.3.3.4	MSS SP 61	Hydrostatic Test and Leakage Test Procedures	4	90 Days Prior to Use	X

-	4.3.5	ANSI B31.1, Sect. 136	NDE Procedures and Acceptance Criteria	4	90 Days Prior to Use		X
-	4.4.1	APPENDIX C	Seismic Test Plan and Procedure	3	90 Days Prior	X	
-	4.4.1	APPENDIX C	Seismic Test Results	3	10 Days After Test	X	
-	4.4.1	APPENDIX C	Seismic Test Report	3	30 Days After Test	X	
-	3.9	-	Surface Preparation and Protective Coating Procedures	4	90 Days Prior to Use		X
-	3.9.3.3	-	Recommended Coatings for Appurtenances	3	90 Days Prior to Use	X	
-	3.8	-	Cleaning and Protection Procedures	4	90 Days Prior to Use		X
-	3.5.1.12	-	Field Weld End Preparation Drawings	4	90 Days Prior to Use		X
-	5.2.5	-	Sealing, Packing and Packaging Proce- dures	4	150 Days Prior to Use		X

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Applicable Piping Classifications: 150-1, 300-1

Constructions:

All - Top entry, or swing out, bolted bonnet cover joint, short pattern (long pattern for butt weld end valves)

1" to 2" - Socket weld or flanged ends

2-1/2" to 8" - Butt weld or flanged ends

Stem Seals\*\* - "Graphlok" or "Graphoil", reinforced poly-tetrafluoroethylene (PTFE)

Springs - Inconel

Bolts - Alloy steel, ASTM A 193 Grade B7

Nuts - Carbon steel, ASTM A 194 Grade 2H

Thrust Bearings - Polyphenylene Sulfide (e.g. Ryton)

\*Balls may be made from wrought plate stock ASTM A 240, Type 316 provided the rough machine ball is heat treated at a minimum temperature of 1900°F, held for a sufficient time to heat the material to temperature, followed by a water quench or other rapid cooling method.

\*\* Maximum fluid temperature for UHMW Polyethylene is 180°F; Polyurethane, 175°F; EPDR, 300°F; Polysulfone, 320°F; Polyethersulfone, 350°F; Polyphenylene Sulfide, 375°F; PTFE, 400°F; and Polyimide, 500°F.

\*\*\* EPDR shall not be used for fluid Class E.

\*\*\*\* PTFE may be used only for Radiation Zones 0, 1 and 2.

\*\*\*\*\*ASTM A479 Gr. 316 is an acceptable ball material provided that the ball axis is perpendicular to the direction of rolling.

TABLE IV (continued)

VALVE CLASSIFICATION NO. 49

Stainless Steel Ball Valves (316)

ANSI Pressure-Temperature Rating Class: 150 to 300, Standard  
Type: Ball  
Size Range: 1" to 8"  
Service: Corrosive Liquid and Gas  
Applicable Piping Classifications: 150-4, 300-4, 150-9

Constructions:

All - Top entry, or swing out, bolted bonnet cover joint, short pattern (long pattern for butt weld end valves)

1" to 2" - Socket weld or flanged ends

2-1/2" to 8" - Butt weld or flanged ends

Materials: Body and bonnet cover - Cast stainless steel, ASTM A 351 Grade CF8M (316) or forged stainless steel, ASTM A 182 Type F 316

Ball - Cast stainless steel, ASTM A 351 Grade CF8M (316), ASTM A 182 Type F316, or ASTM A 240 Type 316\*

Stem - Forged stainless steel, ASTM A 182 Grade F316, ASTM A 479 Grade 316 or ASTM A 276 Type 316

Seat Ring and Body Seals\*\* - UHMW Polyethylene, Polyurethane, EPDR (EPDM), Polyimide, Polysulfone (e.g. Udel), Polyethersulfone (e.g. Victrex) or Polyphenylene Sulfide (e.g. Ryton)

Stem Seals - "Graphlok" or "Graphoil"

Springs - Inconel

Bolts - Stainless steel, ASTM A 193 Grade B8

Nuts - Stainless steel, ASTM A 194 Grade 8F

\*Balls may be made from wrought plate stock ASTM A 240, Type 316 provided the rough machine ball is heat treated at a minimum temperature of 1900° F, held for a sufficient time to heat the material to temperature, followed by a water quench or other rapid cooling method.

\*\* Maximum fluid temperature for UHMW Polyethylene is 180°F; Polyurethane, 175°F; EPDR, 300°F; Polysulfone, 320°F; Polyethersulfone, 350°F; Polyphenylene Sulfide, 375°F; and Polyimide, 500°F.

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TABLE IV (continued)

VALVE CLASSIFICATION NO. 50

Alloy Steel Ball Valves (Alloy 20)

ANSI Pressure-Temperature Rating Class: 150 Standard  
Type: Ball  
Size Range: 1" to 2"  
Service: Corrosive liquid and gas  
Applicable Piping Classifications: 150-10

Construction:

All - Top entry, bolted bonnet cover joint, full bore port, short pattern (long pattern for butt weld end valves)

1" to 2" - Socket weld or flanged ends

2-1/2" to 8" - Butt weld or flanged ends

Materials: Body and bonnet cover - Cast nickel alloy steel, ASTM A 351 Grade CN7M, ASTM A 743 Grade CN7M, or ASTM B 473

Ball - Cast nickel alloy steel, ASTM A 351 Grade CN7M, ASTM B 463 (Plate), or ASTM B 473

Stem - Forged nickel alloy steel ASTM B 462 or ASTM B 473

Seat Ring and Body Seals\* - UHMW Polyethylene, Polyurethane, EPDR (EPDM), Polyimide, Polysulfone (e.g. Udel), Polyethersulfone (e.g. Victrex) or Polyphenylene Sulfide (e.g. Ryton)

Stem Seals\* - "Graphlok", Graphoil" or UHMW Polyethylene Springs - Inconel

Bolts - Stainless steel, ASTM A 193 Grade B8

Nuts - Stainless steel, ASTM A 194 Grade 8F

\* Maximum fluid temperature for UHMW Polyethylene is 180°F; Polyurethane, 175°F; EPDR, 300°F; Polysulfone, 320°F; Polyethersulfone, 350°F; Polyphenylene Sulfide, 375°F; and Polyimide, 500°F.

TABLE IV (continued)  
VALVE CLASSIFICATION NO. 51

Stainless Steel Ball Valves (316L)

ANSI Pressure-Temperature Rating Class: 150 to 600, Standard  
Type: Ball  
Size Range: 1/2 to 8"  
Service: Corrosive Liquid and Gas  
Applicable Piping Classifications: 150-8, 300-8

Constructions:

All - Top entry, or swing out, bolted bonnet cover joint, short pattern (long pattern for butt weld end valves)

1" to 2" - Socket weld or flanged ends

2-1/2" to 8" - Butt weld or flanged ends

Materials: Body and bonnet cover - Cast stainless steel, ASTM A 351 Grade CF3M (316L), forged stainless steel, ASTM A 182 Type F316L, ASTM A 479 Gr. 316L, or ASTM A 743 Grade CN7M for ends

Ball - Cast stainless steel, ASTM A 351 Grade CF3M or CF8M, ASTM A 182 Type F316L or F316, ASTM A 240 Type 316L or 316\*, or ASTM A 479 Gr. 316L\*\*\*

Stem - Forged stainless steel, ASTM A 182 Grade F316L, ASTM A 479 Grade 316L, ASTM A 276 Type 316L, or ASTM A 564 Gr. 630

Seat Ring and Body Seals\*\* - UHMW Polyethylene, Polyurethane, EPDR (EPDM), Polyimide, Polysulfone (e.g. Udel), Polyethersulfone (e.g. Victrex) or Polyphenylene Sulfide (e.g. Ryton)

Stem Seals\*\* - "Graphlok", "Graphoil" or UHMW Polyethylene  
Springs - Inconel

Bolts - Stainless steel, ASTM A 193 Grade B8

Nuts - Stainless steel, ASTM A 194 Grade 8F

\*Balls may be made from wrought plate stock ASTM A 240, Type 316L or 316 provided the rough machine ball is heat treated at a minimum temperature of 1900°F, held for a sufficient time to heat the material to temperature, followed by a water quench or other rapid cooling method.

\*\* Maximum fluid temperature for UHMW Polyethylene is 180°F; Polyurethane, 175°F; EPDR, 300°F; Polysulfone, 320°F; Polyethersulfone, 350°F; Polyphenylene Sulfide, 375°F and Polyimide, 500°F.

\*\*\*ASTM A 479 Gr. 316L is an acceptable ball material provided that the ball axis is perpendicular to the direction of rolling.