Edward Valves

Edward Valves

Development of the Rockwell Edward Equiwedge Gate Valve

V-Rep 75-5

Development of the Rockwell Edward Equiwedge Gate Valve

by
Roger D. Norden
Product Engineering Manager, Globe, Gate and Check Valve Products, Measurement & Flow Control Division, Rockwell International
First Published 1975

INTRODUCTION

Many types of valves have been invented by man to control the flow of fluids. Of those which have survived the test of time, each has at least several features which are unique or important. One offers tight shut-off, another low cost, others effective control of the fluid flow, still others, perhaps combinations of these, and on and on. To date, however, no valve inventor has discovered the ideal valve which combines all these features into one package and experience teaches us that it is unlikely anyone will.

Thus, valve designers have created the globe, plug, ball, gate and numerous other valve types, all of which are in extensive use throughout the world's vast and complex industrial processes. The gate valve is among the most common because it offers several advantages of function and cost effectiveness over other types. What follows is a discussion of the Rockwell Edward Equiwedge Gate Valve development program. The Equiwedge Cast Steel Gate Valve has been tailored especially for the high pressure, high temperature water and steam services common to many electric utility, industrial and petrochemical applications. It offers all the advantages inherent in the wedge gate concept plus several novel design features, two of which are the subjects of patent applications. Further, certain disadvantages common to gate valves have been minimized in the Equiwedge Gate Valve design.

Why A Gate Valve?

Probably the single most important characteristic of a gate valve is the efficiency with which fluid flows through the valve. All valves must control fluid flow, meaning they must stop, regulate or allow fluid to pass through. For the majority of industrial and utility services, the conservation of fluid energy as it moves through piping and valving is critical to efficient operation of the system. Because the gate valve provides a straight-through, unobstructed flow passage, it is a very efficient fluid control device.

As a result, the seat port or minimum opening through the valve will be smaller than for some other valve types having equivalent flow capacity, such as butterfly or globe. Since the seat port size has a major effect on valve cost, the gate valve has an important advantage in reducing valving capital expenses.

Gate valves also require only relatively moderate force to open or close and thereby require less manual operating effort or smaller power operators. The closure element is positioned perpendicular to the fluid flow regardless of flow direction. The force the stem must deliver to the closure element is essentially $F_S = m W$, where W is the pressure load on the gate and m is the coefficient of friction of the gate against the body seat. This compares to globes where $F_S = W$, so that the gate is only m (commonly 0.3) times the globe.

In addition, gates can be designed for high temperature and high pressure services through the use of proper materials and hardfacings on seats and sliding components. Gates also are bidirectional and

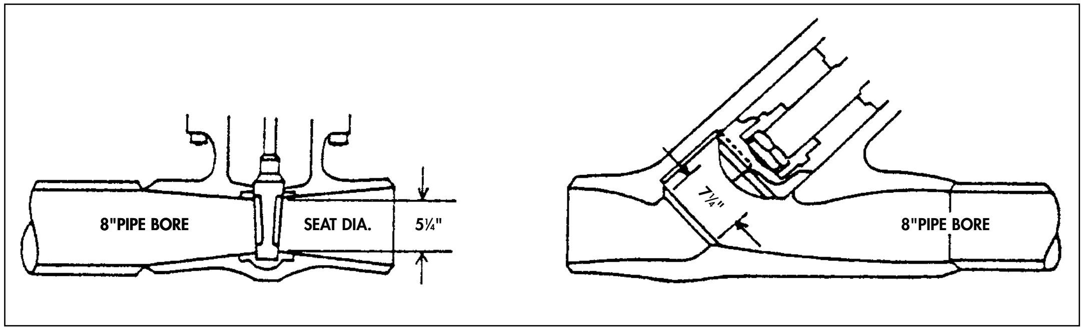

Figure 1: Comparative Seat Port Sizes for Venturi Gate & Y-Type Globe Valve, both sized for Dp=5 psi handling 2 x 10^6 lbs/hr water at 3000 psi and 400°F.

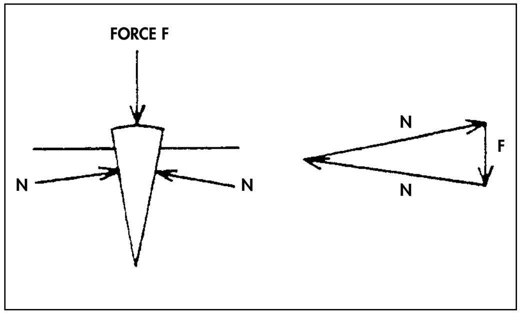

Figure 2: Stem force F is multiplied by the wedge, represented by the normal force N (neglecting friction).

normally have similar flow characteristics in both directions.

Because of greater closure element travel. however, gate valves require a longer time to open or close especially compared to plug and ball valves, they are more subject to wear due to their slicing components. tend to seal less perfectly than a properly designed globe or plug valve, cannot combine stop and check functions, cannot replace an elbow in a piping system and are generally greatest in overall height requiring more installation space.

Wedge vs Parallel Slide

There are two basic types of gate valves in common use today for high pressure-temperature water and steam service—the wedge and parallel slide. The wedge gate concept has been selected by Rockwell for its Equiwedge Gate Valve because of several functions advantages. The wedge, of course, is one of the earliest of machines and the first prehistoric man to apply the wedge as a chisel or a means of splitting logs was indeed someone to respect. Undoubtedly he did not understand the mechanics but nevertheless applied the idea.

In wedge gate valves, both the idea and an understanding of the mechanics have been applied effectively. History records that an Englishman, James Nasmyth, invented the wedge gate sluice valve in 1839. In his valve as well as today's, the closure of the gate interrupts the flow and at the same time effects a seal at the gate-body interface via the high wedging forces generated between the seats. Herein lies the major difference with the parallel slide, that is, the presence of the wedging force.

It should be understood that this wedging force is added to the primary fluid pressure force acting on the gate. Extensive laboratory tests at Rockwell have demonstrated the advantage of this extra loading in achieving superior seat tightness. Test valves sealing marginally with fluid pressure loading always showed improvement and often attained drop tightness with the extra stem loading.

If the design cannot accommodate the wedging, however, it can become a disadvantage. Extremely high forces generated by the wedge must be accompanied by a rigid body which will sustain these forces without harmful stresses. Also, inadequate wedge flexibility can cause sticking, particularly when thermal effects or external pipeloads are present. The Equiwedge two-piece wedge has a high degree of flexibility to accommodate such conditions within safe operating limits.

Another advantage of the wedge gate valve as compared to the parallel slide is minimized seat rubbing and scuffing during opening and closing. While closing a wedge gate, any pressure load on the gate is carried by the gate guide system until the final increment of seating travel. This is only some 5% of the total gate travel.

By comparison, the seats of most parallel slide valves carry the gate load through essentially all of the travel. Should high differential pressure be present, very high stresses develop especially on the body seats, accelerating wear and possibly causing galling damage to the seal surfaces. For this reason, parallel slide valves commonly require bypass valves to equalize the pressure across the gate before opening.

Equiwedge Product Line Description

The Equiwedge Gate Valve is being designed and manufactured at this time in four ANSI pressure classes, Class 600, 900, 1500 and 2500. They range from nominal port size 16 to size 28. It is expected that in the future sizes will cover 2Y2 thru 36 or larger, as market needs dictate. An ANSI Class 4500 series is also contemplated. Valves are available in both Regular and Venturi ported designs (See *Figure 3*).

The Regular ported series is designed with seats approximately 90% of the ANSI B16.5 "Inside Diameter of Fitting" dimension which yields an 80% area port. The flow resistance of this series expressed as an "equivalent length in pipe diameters (L.D.) is approximately 10 (when installed in piping with a valve port to pipe L.D. ratio = 0.8).

This compares with an L.D. of about 13 for typical wedge gate valves and the 25% lower flow resistance is a result of the two piece wedge. Details of this design are described later but the key factor is a wedge thickness of some 30% less than that for typical gates. Due to its more compact design, the Equiwedge gate cavity produces less flow path interruption and discontinuity, thereby reducing fluid turbulence. To demonstrate this improved flow efficiency, the valve flow shape was reproduced in a 4″ wooden model and compared to the reference design in air flow tests at the Rockwell Valve Engineering and Research Laboratory in Pittsburgh, PA.

The Venturi line is made by casting enlarged ends on the body center section. one or two sizes larger as indicated in the chart. The venturi seat ports are approximately 80% of ANSI B16.5 "Inside Diameter of Fitting" dimensions and about 60% in area. For the Venturi line, the L.D. = 17 and this too compares favorably with typical venturi gate valves since the same narrow two-piece wedge design is utilized.

In addition to butt welding ends, the Equiwedge is available with ANSI flanges. End-to-end and face-to-face dimensions comply with ANSI B16.101973. Valve sizes not listed in ANSI B16.10 have end-to-end lengths extrapolated consistent with this Standard.

The quality level of the product line is "premium" throughout and extensive use has been made of hardfacings on critical seal and wear surfaces. All wedge and body seats as well as the bonnet backseat are inlayed with cobalt base hardfacing. The body pressure seal area is inlayed with Type 18-8 stainless steel to assure material soundness and provide a corrosion resistant zone for effective sealing and ease of field bonnet disassembly.

Another premium feature is the additional hardfacing of the rails for the wedge guide system. Both the body and wedge guides are precision machined, the wedge rails hardfaced and then finished to assure smooth guiding throughout the life of the valve. Standard valve materials such as carbon steel grade WCB and low alloy WC6 and WC9 are available for high temperature service to 1100F.

Code Compliance

The Equiwedge Gate Valve has been designed for complete compliance with the latest valve standards, ANSI B16.5-1973, "Steel Pipe Flanges, Flanged Valves & Fittings" and B16.34-1973. "Steel Butt-Welding End Valves." Body minimum wall thicknesses are in accordance with Table 24 of B16.34 which specifies the wall thickness, t_m, for the valve inside diameter, d.

Both the Regular and Venturi series are designed for the Standard Class Ratings in B16.34. In addition, the optional Special Class Ratings are applicable to the butt-welding end valves. Since the Venturi series has enlarged ends and the same central body section is used for both series, the inside diameter dimension, d, for the enlarged ends of the venturi determines the minimum body wall thickness.

Size	16		18		20		22		24		26		28		30		32	
ANSI Class	R	V	R	V	R	V	R	V	R	V	R	V	R	V	R	V	R	V
600	16	*	18	16	20	18	22	20	24	20	26	22	28	24	*	26	*	28
900	16	*	18	16	20	18	22	20	24	20	26	22	28	24	*	26	*	28
1500	16	*	18	16	20	18	22	20	24	20	*	22	*	24				
2500	16	*	18	16	20	18	22	20	24	20	*	22	*	24				

Figure 3: Equiwedge Size-Pressure Classes. Numbers indicate nominal port sizes for Regular & Venturi Series.

*Available at a later date

This increases slightly the body weight of the Regular series but results in a significant savings in casting pattern expenses.

The Special Class rated valves are dimensionally the same as the Standard Class but are manufactured in conformity with the nondestructive examination requirements of ANSI B16.34 for Special Class Valves. This includes radiographic and magnetic particle examinations of body and bonnet castings to specified acceptance criteria. Special Class valves are satisfactory for increased ratings of up to 30%, at certain temperatures in the four ANSI Pressure Classes.

Although the Equiwedge Gate Valve is being introduced first to non-nuclear services, it is designed to meet the requirements of Section III of the ASME Boiler and Pressure Vessel Code as well as ASME Code Case 1621-1 for Internal & External Valve Items.

The Wedge

The seal element is the heart of any stop valve. For this reason a large part of the development effort has been directed toward the wedge. It was recognized that wedge flexibility—that is, a high deflection index—was essential for good sealability and freedom from wedge sticking, a problem all too common to wedge gates.

Why is flexibility important? All valves in high pressure-temperature service, whether gate or any other type, are subjected to forces caused by external loads imposed by the connecting piping and thermal effects caused by temperature changes. A rigid body shape will minimize the seat deformation produced by these forces but the cost effectiveness of material added to increase rigidity is not attractive. Therefore, flexibility must be designed into the wedge to accommodate these distortions in the body seat area. It should be noted that distortion in this context becomes harmful only when the performance of the valve is affected, for example, the valve leaks or cannot be opened.

Cause and Effect

Having discussed the problem in general, let's look at it in more detail. The causes of body seat distortion are largely from piping induced loadings and thermal changes in the valve body, either non-uniform or uniform. Piping induced loadings can be of the bending, compressive, tensile or torsional type, or the most probable, a combination of several of these. They are the result of expansion or contraction of the piping system during heat up or cool down as well as the weight of the piping and attached components.

Temperature-induced forces are sometimes the result of non-uniform or localized temperature changes in the valve body. These are caused by varying wall thicknesses, localized heating such as welding the valve in the line, thermal shock, the way insulation is applied and other similar factors, most of which are uncontrollable.

Operational procedures can produce thermal and pressure differentials which also cause dimensional changes in the body seat region. When a valve is closed hot and allowed to cool, components contract at varying rates and amounts. The absence or presence of the line pressure when the valve is closed adds another load source.

Regardless of the cause, the effects of these forces on the body seat geometry can be several. The seat angle can increase or decrease or the plane of either body seat can rotate about one or more of its axes. The gate opening—that is, the distance between the seats—can expand or contract. The other major effect is that of the body seats losing their flatness in one or several localized areas across the seat faces. This is especially troublesome because it's the most difficult to handle. The most likely seat distortion is a combination of several of these effects.

The order of magnitude of these distortions determines the degree of seat leakage or wedge lock up, but in the ideal wedge, flexibility is adequate to accommodate the worst case within satisfactory working

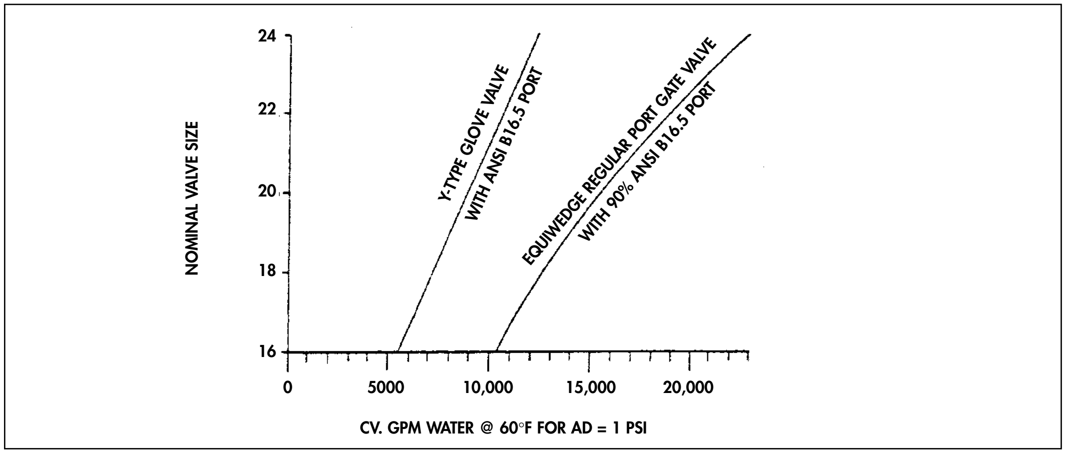

Figure 4: Cv Comparison-Class 1500 Y-Type Globe vs Equiwedge Regular Port Gate.

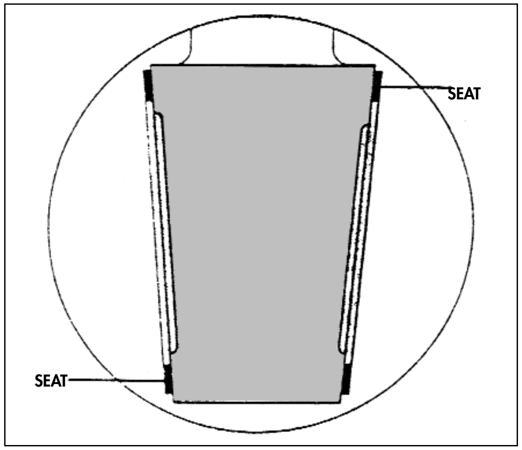

Figure 5: Solid Wedge Design.

stresses. This is a tall order and numerous attempts have been made by valve designers to accomplish this.

Gate Designs

The simplest wedge gate is the solid wedge shown in *Figure 5*. It is used in some designs of high pressure-temperature steel gate valves, but its useful flexibility is very limited. For this reason, an "H" design is more common.

The "H" shape is achieved generally by casting a groove around the outside periphery and leaving a connecting hub in the center. This provides for relative bending between the wedge halves, which is needed to adjust for body seat angle changes. The degree of bending varies significantly with individual designs. In all cases, however, the center hub acts as a connecting link between the wedge "halves" and severely limits the freedom of the wedge to make the necessary adjustment. If the hub is made small enough to permit adjustments of any magnitude, stresses in the hub can exceed the yield strength of the material. A large hub on the other hand diminishes the desired flexibility of the wedge "halves" (See *Figure 6*).

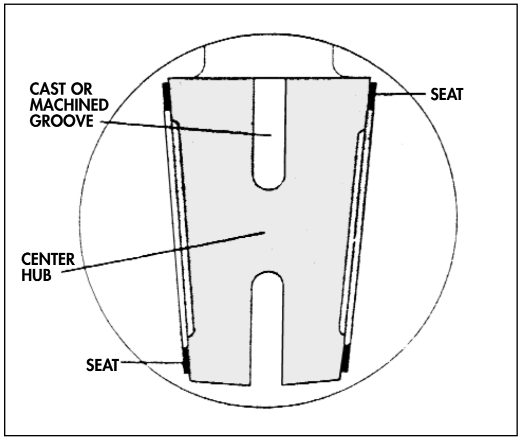

Figure 6: "H" Shape Wedge Design.

The wedge, being a circular plate supported by the body seat on one side and loaded by the fluid pressure and stem on the other (i.e., the hub side), must also be designed for deflection at the outer edge. An analysis of commercial wedge gate valves indicates that adequate attention has not always been paid to optimizing deflection within satisfactory factory working stresses. However, adequate flexibility at the plate edge, i.e. the seat joint, is critical to effective sealing against a body seat which has been distorted at any location across its face.

Figure 7: Cutaway of Equiwedge Gate Valve.

It is because of these serious deficiencies that Rockwell looked for a "better way". The result is the Equiwedge two-piece wedge shown in *Figure 8*. The important features of this design are:

- Independent wedge halves for maximum freedom of the wedge to adjust for angular distortions in the body seats.
- An optimized "tapered plate" design with a high degree of flexibility at the edge. or seat joint, to accommodate distortions in the body seat faces (out of flatness), within code allowable working stresses.

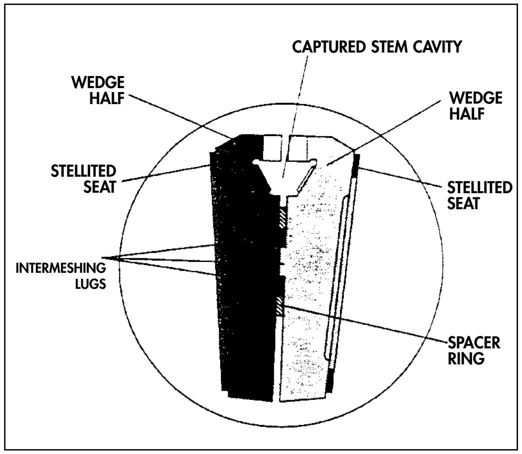

Figure 8: Cutaway of Equiwedge Two-Piece Wedge.

Development of the Rockwell Edward Equiwedge Gate Valve

- Adaptability to a captured stem design resulting in a more compact stem-wedge connection and reducing the overall valve height several inches.
- Minimum wedge thickness for a reduced gate cavity width and improved flow characteristics.
- Superior wedge casting quality due to the absence of a center hub.
- Better quality control during manufacture because of the accessibility of all wedge surfaces to visual and NDT inspection.
- Adaptability to a center spacer ring, facilitating wedge fitting and permitting certain field repairs without wedge replacement.

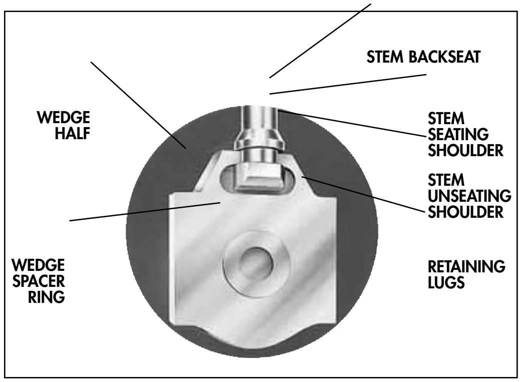

Figure 9: One Equiwedge wedge half showing spacer ring.

Wedge Spacer Ring

Matching a one piece wedge to the body seats with the proper wear allowance requires a precision fitting operation during manufacture. Further, should damage to the seats in the field—caused by, say, foreign matter—necessitate seat refinishing, the wedge thickness must necessarily be reduced. This destroys the factory fit if the defect is so deep that excessive seat facing must be removed. Since one thousandth of an inch removed from each seat of a 10° wedge causes a movement of eleven thousandths into the gate cavity, a 0.060 defect in one wedge seat drops the wedge more than three-tenths of an inch.

The spacer ring shown in *Figure 9* provides a novel and inexpensive means of varying the wedge thickness either during manufacture or for field repair. A spacer ring of appropriate thickness can be installed for optimum wedge fitting, within the limits of the clearance in the wedge guiding system

Figure 10: Equiwedge "Captured Stem" head is entrapped between the two wedge halves.

The ring is Type 410 stainless steel to control corrosion. It is securely held between the wedge halves by interlocking lugs protecting from each half. The ring O. D. is sized for maximum wedge deflection when stem loaded.

Captured Stem

The stem head is entrapped between the wedge halves in a cavity normal to the flow centerline and located between the seats. A stem shoulder loads the top of the wedge during closing. Upon opening, the stem head lifts against the underside of the wedge stem cavity. Clearances are liberal around the stem head so that no stem guiding is imparted to the wedge. Because gate valves employ non-revolving stems accurately machined pads on each wedge half are used to take the torsional reaction. They eliminate any bending load on the stem as well.

Locating the stem head in the cavity between the seat lowers it several inches compared to conventional tee-connections. Since the space saving is in the heavy body wall region, there is a considerable weight savings also.

Guiding Systems

The Equiwedge two-piece wedge is fully guided throughout its stroke by a body groove guide system. In the fully open position, therefore, the wedges are both trapped and guided because the body guide groove extends high into the body neck region. By using this construction, rather than a convention wedge groove-body tongue, the stem wedge assembly is held securely together without the need for pins, fasteners, disk clips, etc. This simplifies the design and eliminates completely the chance of assembly components failing and causing leaks, or becoming entrained in the flow stream.

Other Design Features

The welded in seat rings have cobalt base hardfaced seats for long life. This hardfacing has excellent high temperature hardness, corrosion-erosion resistance and eliminates galling and rapid wear of the seats. Seat ring material chemistry is equivalent to the body to eliminate dissimilar growth/contraction rates which might cause seat ring distortion.

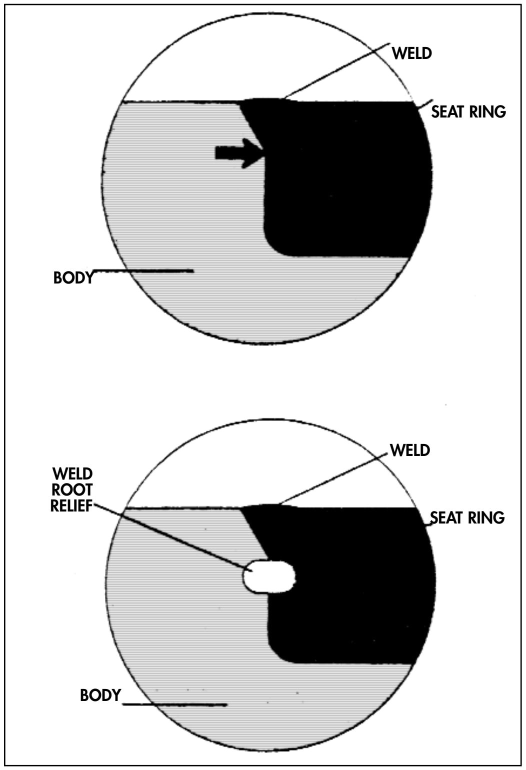

Figure 11: Conventional weld joint has a potential crack propagation point (shown by arrow). Equiwedge body seat ring weld joint is relieved at the root.

The geometry of the body to sea ring weld is unique to gate valves. Relief is provided at the bottom or root of the weld to minimize the stress concentration and eliminate potential crack propagation from this point.

An integral, hardfaced backseat is standard on all Equiwedge Gate Valve A conical design is used, created by a 60° shoulder (included angle) on the stem mating with a 57° hardfaced bonnet backseat.

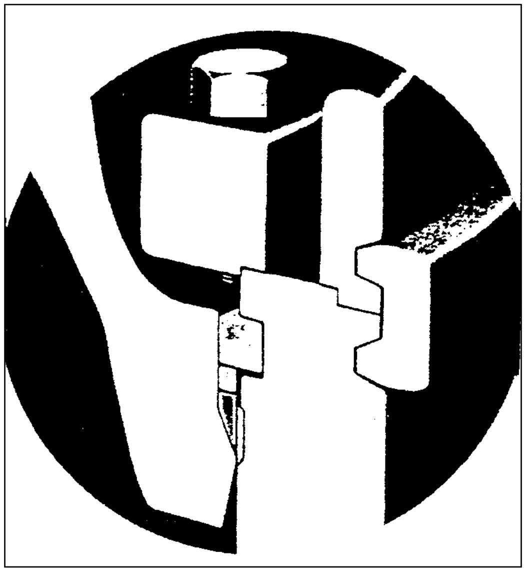

Figure 12: Pressure-Seal Design for Class 900-2500 Valves.

This cone-on-cone design will withstand considerable over-torquing, a problem common to backseating operating procedures.

The Equiwedge Gate Valve features the Rockwell Edward Pressure Seal Design, proven successful in hundreds of thousands of service hours.

The segmental retaining ring design is used for the higher pressure ANSI Class 900 thru 2500 series. In the Class 600 series, where the pressure loading is more suitable to nominal sized bolting. Studs are substituted for the segmental retaining ring.

The Rockwell Edward Pressure Seal provides an effective bonnet closure for high pressure-temperature applications where pressure and thermal cycling can cause relaxation and leakage in conventional bolted-gasket designs. The absence of threads of any kind within the valve assures freedom from corrosion and ease of disassembly.

The valve bonnet, being a pressure vessel, has been optimized in terms of wall thickness and weight by employing a hemispherical type geometry between the pressure seal region and stuffing box. A special finite element computer program is used to verify the design to code allowable material stresses. The bonnet shape has the additional advantage of accommodating the upper half of the wedge. This also significantly shortens the height of the valve body, producing a considerable weight savings.

The extended bonnet region between the hardfaced backseat and the packing is a cooling chamber. When the stem is lifted to the open position the hotter portion rises into the cooling chamber rather than the packing. Since temperature is a major factor causing packing compression set and accelerated wear, the life of the packing is thus extended.

The yoke is designed for adequate stiffness to support the heaviest motor operator in the "stem horizontal" position. Four "windows" promote good air circulation to aid in cooling the packing, permit easy entry to the stuffing box and gland, and provide ready access to the Pressure-seal bonnet pull-up bolting.

An all too common valve problem is stem damage caused by packing gland cocking during gland bolt adjustment. This in fact occurred during the prototype test program (which is reviewed later in this paper). A soft bronze bushing in the gland bore, as shown in *Figure 13*, protects the stem from damage should the gland bolts be tightened nonuniformly and the gland cocked.

The yoke bushing/bearing assembly is similar to that used successfully on the Rockwell Edward large high pressure globe valves. Tapered roller bearings provide low turning friction, carry the stem thrust and provide additional radial support for side loads from the handwheel or motor operator. The handwheel is keyed directly to the revolving bronze yoke bushing. Standard handwheel diameters are 36″, 48″, 60″ and 72″.

Development Program

The development program for the Equiwedge Gate Valve has been a major undertaking by two engineering groups, the Valve Engineering & Research (VER) Department in Pittsburgh and the Raleigh Product Engineering Group from the Rockwell manufacturing facility in Raleigh, North Carolina. It was recognized that very close communications and coordination of the program were necessary to assure success and optimization of engineering program costs. For this reason, the Raleigh Plant has participated in many of the development phases.

The program began with the joint preparation of a Product Specification Objective (PSO) by engineering, marketing and manufacturing. The PSO sets forth such basics as the desired design features, product size range & pressure classes, the intended markets, selling prices and other factors considered necessary for a successful product. Management's approval of the PSO is a basic requirement. This document, although approved for engineering's use is necessarily preliminary and receives periodic updates as the product development progresses. The value of this document is the carefully considered inputs of all responsible groups in the very early stages of the development program.

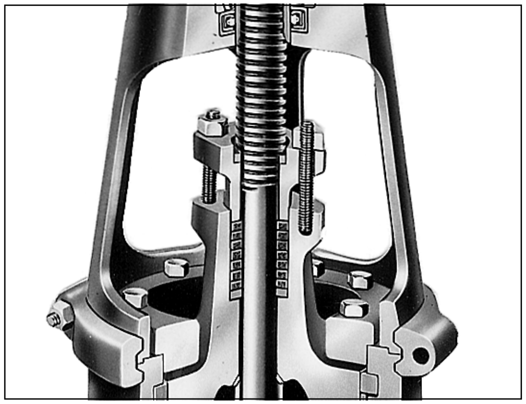

Figure 13: A bronze bushing protects against stem damage due to gland cocking.

Prototype Design & Manufacture

The first engineering effort was the design of a prototype test valve along with the development of basic design parameters. The need for a new wedge concept was recognized early and "idea records" were prepared of various wedge designs. In fact, an early one-piece wedge was abandoned for the Equiwedge two-piece design during manufacture of the first prototype.

The Raleigh Plant became active in the program at a very early point by manufacturing the prototypes. Interrupting production and a somewhat longer "delivery" time compared to model shop procurement was considered an acceptable price to pay for the experience factor of the manufacturing plant. It is important to make the point that Rockwell is not new to the gate valve business. Wedge gate valves were manufactured for some 27 years before being discontinued in 1972, largely because patterns and tooling were in need of major replacement or rework to remain usable.

Prototype Testing

With the exception of one test, all prototype testing was performed at the Pittsburgh VER Laboratory. Although product testing is never “completed” as such, the design was qualified following an approximate nine-month test period. The major testing consisted of the following:

1. End weldability
2. Cold functional and sealability
3. Hot performance
4. Wear and life tests at elevated temperatures
5. Thermal effects
6. Bending load evaluations
7. High velocity water flow
8. Manufacturing cost optimizations
9. Pressure drop evaluations on a 4” wood model.

Immediately following receipt of the Prototypes from the Raleigh plant, a dimensional, hydrostatic and seat leakage checks were performed. The first major test was an examination of the effects of *end welding* on the body seats. It was recognized that seat distortion can occur when butt welding end valves are welded into the system and stress relieved. To simulate this, butt weld type flanges, to be used for subsequent tests were welded to each end and stress relieved using standard procedures. The cold seat sealability checks were then rerun and the results showed no adverse effect on seat sealing.

Hot testing was Performed in a high pressure-temperature steam loop. The basic tests consisted of evaluations of the seat and backseat tightness at typical line temperature and pressure conditions. Pressures ranging from a low of 50 to a high of 2250 psig were run and sealability measurements made in three trials, or repeated until three consistent measurements were obtained. Stem load was also varied from 100 ft/lbs to the full stem design torque. From such tests, the effects of pressure loading and pressure-plus-stem loading were evaluated. Results were generally very good and sealability was within MSS-SP-61 limits of 10 cc/hr/inch of seat diameter.

The purpose of the *wear and life tests* was to further verify the design and evaluate the life of the internal components. Gate valves have a relatively large number of sliding and rubbing components so that this test was considered especially important. An electric motor operator was attached to drive the handwheel with the valve pressurized and at temperature. Tests were run with the stem vertical, and repeated with the stem horizontal.

A total of some 1500 test operational cycles were applied to the valve in the initial series, and subsequent tests (some at cold conditions) have accumulated a total of about 3000 cycles. At the conclusion of this test the valve was disassembled for inspection and wear measurements. The body and wedge seats, backseats. wedge guides, stem-wedge connection, bonnet stem guide, gland, packing and stem-yoke bushing threads were carefully inspected for evidence of wear. Parts were found to be in excellent condition with one significant exception. The gland had been tipped slightly out of alignment with the stem by uneven tightening of the gland bolts. This caused the gland bore to contact the stem and the resulting sliding contact damaged the stem and produced subsequent packing wear. As a result of this problem it was decided to provide a bearing bronze gland insert to positively prevent such damage, as previously mentioned and illustrated in *Figure 13*.

The problem of potential wedge lock up due to thermal and pressure effects was a matter of, critical concern in the test program. Four basic *thermal effects* tests were conducted at temperatures through 1000°F and the corresponding ANSI pressure rating, summarized in the table in *Figure 14*. It was most gratifying to find that none of the test combinations caused the opening torque to exceed the closing torque, an appropriate definition of wedge sticking.

To conduct *bend tests,* the prototype was positioned in Rockwell’s 4.25 million lb-inch bending beam with attached pipe of wall thickness adequate for the full valve rating’. Using hydraulic jacks, a uniform bending moment of 750,000 lb-inches was applied through the total valve while pressurized at 50 psig and at full CWP. Seat leakage as well as stem torque measurements were made before, during and after load application. The results were very satisfactory and no harmful permanent body seat distortion was detected. Upon completion of the tests it was found that the valve sealed within specifications with less than half the design stem torque.

The Rockwell 24″ water flow loop at the Kearney, Nebraska plant was used to conduct *high velocity flow tests*. The concern was whether the two piece wedge would vibrate and cause damage or excessive noise. Runs were made at velocities up to 55 ft/sec while the valve was fully open. Then at full pump speed the valve was stroked through the fully opened to closed position. In addition, seven lift positions were selected and the flow rate varied for each from zero to maximum. The wedge was stable at all test conditions and no flow induced vibration of any kind was observed.

Several post-qualification tests were aimed at optimizing the design from a manufacturing cost standpoint. These included welding tests to examine for seat ring welding distortion and the probable extent of post welding seat finishing. An interesting investigation was the effect of seat misalignment on sealability. Seat rings with a 11° included angle were tested with a 10° wedge with no detectable loss of seat sealability Next. these 11° seat rings were rotated within their body counterbores in all possible combinations of CW and CCW directions. and the limits to produce leakage determined. Sealability was found to be within specifications with 1° of seat angle error and — 2° of ring rotation.

The wedge spacer ring went through several design evolutions before it was optimized. The first designs did not have a separate ring but instead a center male-female hub and socket. When it was suggested by a Raleigh manufacturing engineer that wedge design could be improved by using a separate spacer ring, thereby not only facilitating the fitting operation but also producing identical wedge halves, this was tested. The results were clearly positive and the refinement was adopted a standard design feature.

Field seat repair is a question of concern to valve users. Foreign matter can become trapped between the seats and cause damage. A commercial portable seat refinishing machine was acquired and evaluated by refinishing the body seats of one of the prototype valves. The results were very successful and some .020 of hardfacing was removed within 90 minutes, including setup time. Subsequent leakage tests showed that seat flatness was adequate for good sealing.

	Conditions While Seated		Conditions For Opening	
Test	Pressure	Temp	Pressure	Temp
Cool down Type 1	Rated	Hot	Zero	Ambient
Cool down Type 2	Rated		Rated	
Heat up Type 1	CWP	Ambient	Rated	Hot
Heat up Type 2	CWP		Zero	

Figure 14: Thermal Effects Tests.

Product Design Specification

One of the "luxuries" that can be justified in a very large program such a this is the preparation of a detailed and formalized set of design rules. Design work on the twenty-four basic valves would be continuing for approximately eighteen months. Written detailed design rules would therefore be a significant aid in maintaining uniformity of product performance, operating stresses, code compliance, appearance and cost effectiveness. Therefore, a very important activity followed the qualification testing the preparation of—the Product Design Specification.

This document contains design data for all components of each valve in the total product group. The first edition was based on the prototype design rules while factoring in the qualification test results, and then extrapolating these data to the full size range and four ANSI pressure classes. The fourth edition has just been completed reflecting the continuing optimization of this "living" document. It has been and continues to be an invaluable aid to the Raleigh and VER designers preparing layouts and other engineering drawings.

The Raleigh manufacturing and quality assurance people were a vital part of the team effort on this development program. The experience gained from the prototype manufacture provided a base to build upon for the production processes. As discussed earlier, communications among marketing, Raleigh and Pittsburgh engineering groups were given high priority and monthly design reviews were held to accomplish this. Manufacturing, QA and other groups as appropriate were regular participants in these engineering reviews. These meetings were always formalized with written minutes of significant decision and action items.

PERT Team

An ad hoc Program Evaluation Review Technique (PERT) team was formed of members from both Raleigh and Pittsburgh manufacturing, product engineering and marketing. Their mission was to identify all the tasks needed to produce the "first shipment" valves.

The task force met regularly over a several month period until its report and computer PERT/CPM Plan were debugged and readied for use. This program lists all tasks, to whom they are assigned, the earliest and latest start and finish dates as well as the critical path. Regular updates are run so that the program is always current and special efforts can be applied in any "slip" areas on the critical path.

Tooling is in "high gear" at this time in the Raleigh Plant for producing the first Equiwedge gate valve shipments. Orders for machine tools have been placed, patterns are being procured and some components are on order. And, the product engineering groups at Raleigh and Pittsburgh are well into the design layout, casting and detail drawing phases.

Acknowledgements

This has been an interesting and stimulating program not only because of the novelty of the design but in large part due to the dedication, hard work and professional competence of the many people involved. Dozens of individuals—too many to list here—in the marketing, manufacturing, engineering and management groups of Rockwell's Measurement & Flow Control Division have been involved. It is their contribution that has brought the Equiwedge Gate Valve development program to its successful conclusion. I appreciate having been a part of this team and sincerely thank all those who have worked with me.

FLOWSERVE

Flow Control Division

Edward Valves

Flowserve Corporation has established industry leadership in the design and manufacture of its products. When properly selected, this Flowserve product is designed to perform its intended function safely during its useful life. However, the purchaser or user of Flowserve products should be aware that Flowserve products might be used in numerous applications under a wide variety of industrial service conditions. Although Flowserve can (and often does) provide general guidelines, it cannot provide specific data and warnings for all possible applications. The purchaser/user must therefore assume the ultimate responsibility for the proper sizing and selection, installation, operation, and maintenance of Flowserve products. The purchaser/user should read and understand the Installation Operation Maintenance (IOM) instructions included with the product, and train its employees and contractors in the safe use of Flowserve products in connection with the specific application.

While the information and specifications contained in this literature are believed to be accurate, they are supplied for informative purposes only and should not be considered certified or as a guarantee of satisfactory results by reliance thereon. Nothing contained herein is to be construed as a warranty or guarantee, express or implied, regarding any matter with respect to this product. Because Flowserve is continually improving and upgrading its product design, the specifications, dimensions and information contained herein are subject to change without notice. Should any question arise concerning these provisions, the purchaser/user should contact Flowserve Corporation at any one of its world-wide operations or offices.

For more information about Flowserve Corporation, contact www.flowserve.com or call USA 1-800-225-6989.

FLOWSERVE CORPORATION
FLOW CONTROL DIVISION
Edward Valves
1900 South Saunders Street
Raleigh, NC 27603 USA

Toll- Free Telephone Service
(U. S. and Canada)
Day: 1-800-225-6989

After Hours Customer Service
1-800-543-3927

US Sales Offices
Phone: 919-832-0525
Facsimile: 919-831-3369
Facsimile: 919-831-3376

Visit Our Website
www.edwardvalves.com

V-Rep 75-5 3/03 Printed in USA