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Edward Introduces PressurCombo®
Solution for High Pressure Drain Services

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ABSTRACT

Edward Univalve forged steel globe valves were introduced over 50 years ago, primarily for difficult power plant water and steam applications where competitive valves were not satisfactory. Design improvements and upgrades have been introduced periodically to maintain leadership as newer power plant designs produced new challenges for valves. Current Univalves in nuclear power plants and in supercritical fossil fueled plants face challenges that original designers could not have imagined.

While high differential pressure drain and vent applications in fossil fuel plants are not new, lifetime limitations in such valves have become an increasing concern because of the ways that many plants are now operated. These valves are typically operated only during startup and shutdown, but many power plants are now used for "peaking" to satisfy variable load demands. Some new combined cycle plants undergo daily shutdown/startup cycles at times. With more frequent plant cycling, life expectancy improvements are desirable.

Edward has introduced two new Univalve design options that can be implemented individually or in combinations to enhance service life of valves in high differential drain service. All basic Univalve features are retained, so they provide good traditional globe valve shutoff features (no sliding of seating surfaces and good sealing at both low and high differentials). The new options are designed to minimize erosive wear of seating surfaces and to maintain "live loading" of seats to overcome possible effects of stem relaxation or inadequate seating force.

Introduction

Figure 1 illustrates the most recent version of the standard Edward Univalve globe stop valve. Some Univalves are made as piston lift check valves and others are offered as stop-check valves. Some Univalves are also furnished with motor actuators, but the standard "handwheel" valve shown in *Figure 1* is the most common and best illustrates the basic features.

Design change during the over fifty year Univalve history has been "evolutionary" to employ new technology and to meet changing user needs. Internal changes in the 1960s introduced body guided disks to avoid high torque, requirements and damage in high differential pressure drain service. A 1980 Edward publication[1] described significant changes in some features, but there was no identified need to change the basic seating arrangements or flow passage designs. Evolution continued with 1992 improvements including:

- Stub Acme bonnet threads like those in stainless steel valves now employed in carbon steel and low alloy steel valves for improved in-line maintainability.
- Improved bonnet locking device for unwelded valves.
- Positive engagement feature to insure foolproof alignment of gland bolts with glands.

In addition to the design improvements, new maintenance tool kits have been made available to facilitate disassembly of Univalves and seat repair. Thus, the current Univalves are significantly improved as compared to the earliest designs.

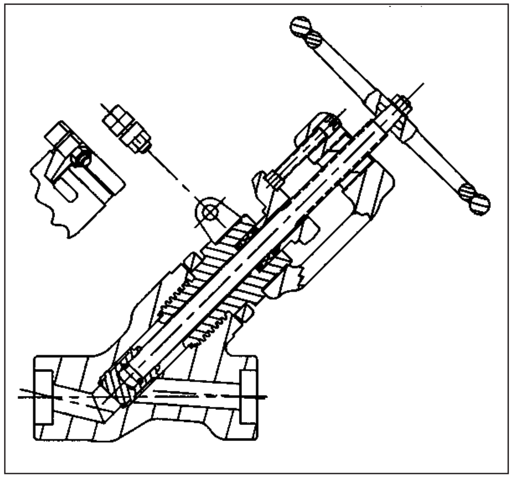

Figure 1: Standard Edward Univalve

Univalves in Drain Service

User satisfaction with Univalve performance has been generally very high, even in the difficult power plant services for which Univalves were introduced. Functional problems in high pressure vent and drain applications were solved by the body guided disk feature thirty years ago, but improvement in valve service life was considered desirable. A study was undertaken to identify enhancements that would improve on a well-proven product line.

Drain valve problem studies were first undertaken as part of the standard Edward system to evaluate customer feedback. An evaluation of standard Univalves in drain applications revealed that there were no "immediate breakdowns" like the jamming experienced before body guided disks were introduced. Most problems were due to moderate or severe seat leakage after a service time period that was considered short by the customer. Service times before valve removal from service ranged from about 6 months to 2 years. A number of removed valves were inspected in our plant.

Most valves inspected after removal from service had extensive foreign material (e.g. magnetite deposits) in the flow passages. None of the valves inspected had been subjected to seat Maintenance. In two cases, seat tightness was restored in our plant within a few minutes of service with standard seat repair tools. Thus, the study showed that the service life of standard valves could be improved by use of the repair tools that are now available.

In addition to valves examined in our plant, some were inspected by Edward personnel in customer facilities. Several turbine drain valves from a power plant in Australia revealed a pattern that was considered very useful in defining one type of problem:

- Valve body seats showed large areas of very minor "frosted" erosion in the 4 o'clock to 8 o'clock position as viewed through the valve inlet. See *Figure 2*.
  - – Since the valves were normally fully open during power plant startup, passing wet and possibly dirty steam, it appeared that the "frosting" was the result of erosion in the main high-velocity flow path while the valves were fully open.
  - – Edward engineers concluded that this minor erosion could have caused some seat leakage after valve closure, but it did not appear that it should have caused leakage so severe that the valves would have required replacement.
- Within the frosted erosion bands (above), localized areas in the seats showed minor but significant localized "steam cutting" – the type of erosion that can cause severe leakage if not repaired on a timely basis.
- The damaged valves suggested strongly that the ultimate leakage problems were the result of a 2-stage process:
  1. Minor seat erosion in high velocity regions due to wet and dirty steam flow during startup periods.
  2. Minor leakage developed after valves were closed after startup as a result of the minor erosion (above), and leakage increased progressively due to long-term superheated steam cutting during normal power operation.

In an attempt to develop better grass-roots information about power plant drain valve applications, a selective Market Survey was conducted in 1992. A list of technical questions about vent and drain valve operating procedures was developed by Edward Engineering for discussion with customers. Area Sales Managers then reviewed these questions with selected power plant Operations and Maintenance personnel who had extensive experience with drain valves. While the number of people interviewed was not large, the survey covered a broad geographic area and different types of power plants.

Results of the market survey interviews provided a good basis for improvement opportunities for Univalves in difficult drain services. Among the responses were:

1. In plants of all types, drain valves must handle choked flow of water (sometimes cavitating), and both wet and steam during startup. There is often dirt and pipe scale in these lines, because there is no flow during normal operating periods between shutdowns.

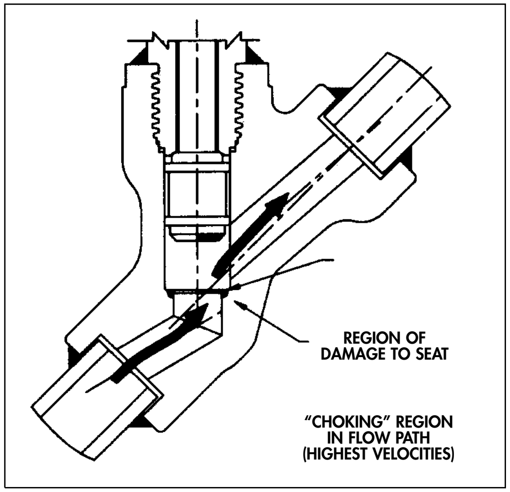

Figure 2: Seat Damage in Turbine Drain Valve

2. Duration of drain blows is quite variable. Four to eight hour blows were mentioned by several interviewees, but some are shorter (as little as 30 to 45 seconds) and some are much longer.
3. Frequency of operation is highly variable.

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- Large base load stations undergo shutdown/startup cycles only at, major outages, which may be only annual or 2 to 3 per year at the most. However, these may involve very long drain valve blows if startups are "aborted" due to other problems.
- Peaking stations undergo cycles as, frequently as daily. Some of these are older units that operate only when peak power is needed. Others are small, modem units specifically designed for peaking service. Some COGEN stations report weekend shutdowns.

4. Responses to questions on need for "throttling" (extensive operation in partial open positions) with vent and drain valves did not show any consistent pattern. Responses indicated recognition that this can be very damaging to valves that are not "control valves," but all responses showed that some valves are throttled (whether authorized or not).
5. Many superheater and turbine drain applications use a tandem assembly of two valves in series – an inboard "root valve" and an outboard "guard valve." Recommended procedures are to open the root valve first and to close it last, so that it operates only under no-flow conditions; the guard valve takes the "punishment" of opening and closing under choked flow conditions. In theory, this procedure prolongs the seat tightness of the tandem assembly by delaying damage to root valve seats.

It was reported that root valves in tandem drains are often not closed as recommended. A factor is the time required to close a second manual valve. In some cases, actuators have been provided on guard valves to speed up startup cycles, but this has not been done with root valves because of economic limitations. In peaking stations involving frequent startups, this could be a significant limitation.

Other Valve Types in Drain Valve Applications

For many years, this market was principally shared among Edward Univalves and a number of other competitive inclined-stem forged steel globe valves that had adopted Univalve features. More recently, other valve designs have been advocated for this service.

The new entries in the power plant drain valve marketplace are floating ball valves and parallel-slide gate valves. A number of manufacturers of these valve types claim "advantages" based on the sliding contact between the moving valve closure member and the fixed seat(s). Manufacturers claim that these designs protect the seats from erosion damage and provide a "wiping" action to clean the seats. Also, since these valves are "position-seated", it is claimed that they do not require high "seating torques" like globe valves to effect a seal.

While some merits, were recognized for ball and gate valves by Edward engineers, it was concluded that three major disadvantages made these design approaches undesirable for power plant drain and vent valves:

1. The seat sliding action that provides the "wiping advantage" also assures that the seating surfaces must slide under very high contact stresses when a valve is opened or closed under very high differential pressures. Even without considering dirt and scale, this sliding may cause scratching or galling that will later erode into serious leakage paths.
2. Position-seated floating balls or parallel slide gates depend upon differential pressure loading to provide effective seat sealing. Serious leakage may develop under low differential conditions that are sometimes encountered in power plant service.
3. Compact floating ball valves and parallel slide gate valves typically do not offer practical in-line repairability for the cases where inevitable maintenance is required. Many lower pressure ball valves are flanged into the line and can be removed for maintenance, but this is not practical for many higher pressure valves.

Based on careful evaluations of competitive product types, including testing in Edward facilities, it was concluded that the best approach to drain valve improvements was to offer special enhanced features for the Univalves already widely used in this service.

Univalve Enhancements for Drain Services

The results of the evaluations described above were reviewed carefully and compared with data in Edward archives. Development test data and field experience with Univalves in most "normal" applications in both fossil fuel and nuclear power plants did not reveal any widespread or general problems with the current design (*Figure 1*). No general redesign was considered necessary, but special feature options were judged to be desirable for at least some of the valves used in fossil fuel plant drain and vent services.

After considerable engineering study and prototype testing, it was concluded that a combination of optional features should be offered instead of a single "improved drain valve." This decision came about because the evaluations showed a variety of problems – not necessarily the need for a radical combination of special features in all drain valves. Desirable features (not necessarily required in all valves) that were identified in the study are:

- Reduce velocity in body seating regions during choked flow in full-open drain operation to minimize erosion of critical seating areas. This should eliminate the problems observed in turbine drain valves and discussed above.
- Improve resilience in "seat loading system" to assure maintenance of adequate seating loads during and after thermal transients (e.g. following "cooldown" of a valve closed at maximum temperature).
- "Pressure-energized" seating forces to supplement the resilience noted above and to assure tightness if pressure increases after closure or if stem loading should be reduced due to stress relaxation.
- Essentially, it is desired to simulate the pressure-energized seating forces of a ball or gate valve while retaining the globe valve advantages for sealing at low pressure differentials.
- Seating materials with improved erosion resistance to promote better valve life in drain valves that require occasional or moderately frequent throttling.

The relatively widespread use of tandem assemblies of root and guard valves suggested that there would be merit in offering two different valve options to enhance performance in applications that are, or can be conveniently provided with double valves.

The two different fundamental optional features for Univalves were developed and subjected to extensive testing in Edward steam testing facilities shown in *Figure 3*. These facilities permitted testing on superheated steam at 2300 psi (159 bar) and 1050°F (566°C). While some Univalve drain valves in supercritical plants operate at higher pressures, few operate at higher temperatures. Essentially, the facilities

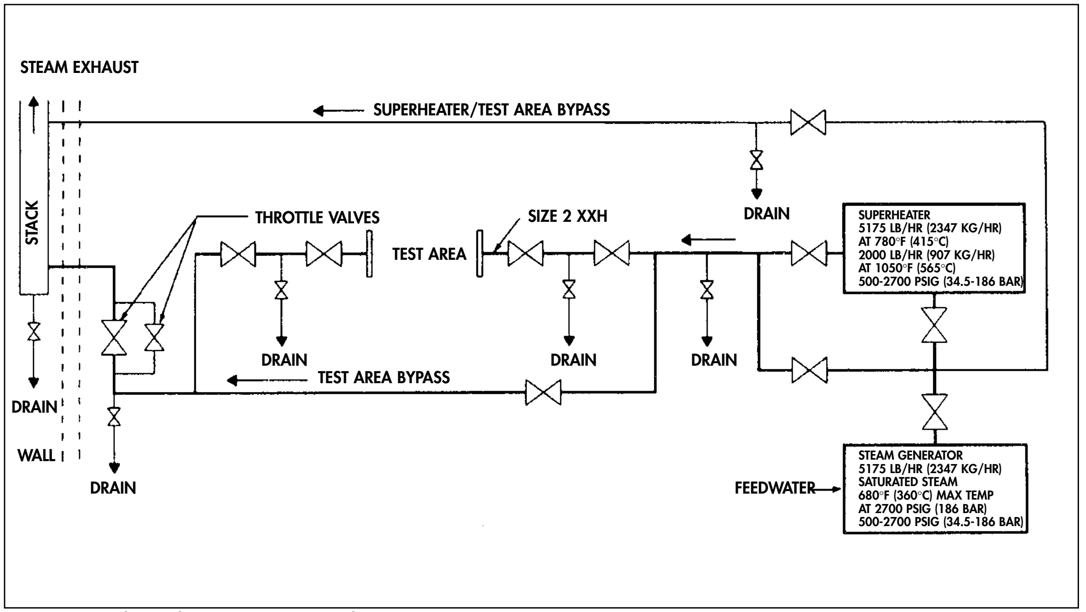

Figure 3: Edward Steam Test Facility

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allowed simulation of the final operating conditions (after startup) of many superheated and turbine drain valves in operating fossil fuel plants. Further, by using the steam generator without the superheater, it was possible to simulate many of the saturated steam conditions that exist during startup.

The new Univalve special feature options and some combinations are described below:

1. The *PressurSeat*[2] option shown in *Figure 4-A* (U.S. Patent claims approved) is proposed for use primarily as an upstream root valve in tandem drain assemblies.
   - In lieu of the integral stellite 21 seat used in standard Univalves, the PressurSeat option utilizes a separate "seat insert" that is sealed into the body with a flexible graphite seal.

     Flexible graphite seal tightness has been demonstrated by long experience with unwelded bonnet seals that were introduced in Univalves in 1980.

     The flexible graphite installed below the seat insert also provides resilience in the seating system, which is desirable to guard against load loss from stem contraction. The relationship of the flexible graphite seal and seat diameters insures that the seat is pressure-energized into the disk after an initial preload is overcome by stem thrust during closure.
   - The PressurSeat option retains the cone-in-cone seating that has been successful in Univalves for many years, so good globe valve seating features at low pressures are maintained.
   - The non-integral seat insert in the PressurSeat option allows use of materials that cannot be welded practically, so very hard (HRC 51-54) stellite 3 disks and seats are used for enhanced erosion resistance. In addition to offering improved seat life in full-open drain valve applications, the stellite 3 seating material offers improved life in applications where throttling is necessary.

     In testing on Edward steam testing facilities, no visible erosion damage has been detected on stellite 3 seating assemblies.
   - A handwheel is used in lieu of the "impactor" handwheels or handles used on larger standard Univalves.

     For typical power plant pressures at which drain valves are used, the standard handwheel permits adequate torque to activate the self-energized PressurSeat.
2. The *PressurEater*[2] option shown in *Figure 4-B* is proposed primarily for use as a downstream guard valve in tandem drain assemblies, although it may also be a cost-effective improvement for single-valve drains that are not throttled excessively in service.
   - This option is a standard Univalve as in *Figure 1*, except that an integral "choke nozzle" is provided in the outlet (overseat) port to restrict the choked flow through the valve under high differential pressure "blowdown" conditions. With this feature velocities are reduced in the valve seat port regions during full-open drain operation.

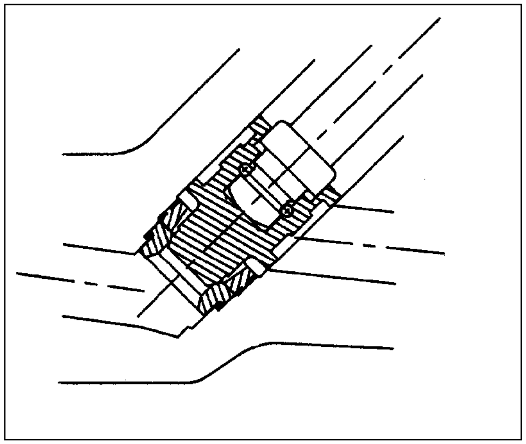

Figure 4 A: PressurSeat Features

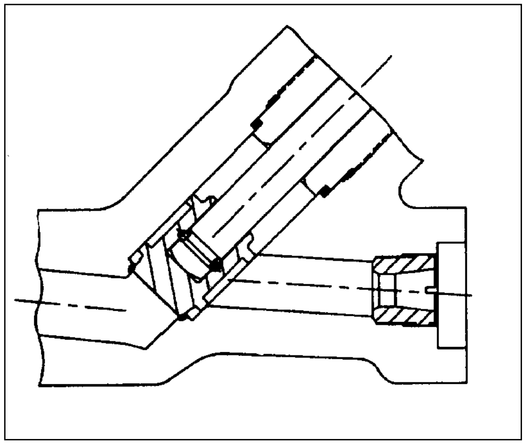

Figure 4 B: PressurEater Features

- The diameter of the choke nozzle reduces choked flow of the valve by about 50%, and reduces the seat area velocities even more because of its downstream location. An integral high-recovery truncated diffuser minimizes pressure drop under low differential flow conditions.
- 13% chromium stainless steel nozzle material minimizes erosion damage, but note that nozzle erosion will not affect valve tightness. The main function of the nozzle is to minimize damage to seating materials.

3. For many and perhaps most tandem drain valve assemblies, the standard PressurCombo (*Figure 4-C*) will provide a cost effective combination of options if operated as recommended for most standard root/guard valve assemblies. With a Univalve with the PressurSeat option upstream, opened first and closed last, the user should benefit from excellent long-term tightness of the assembly.

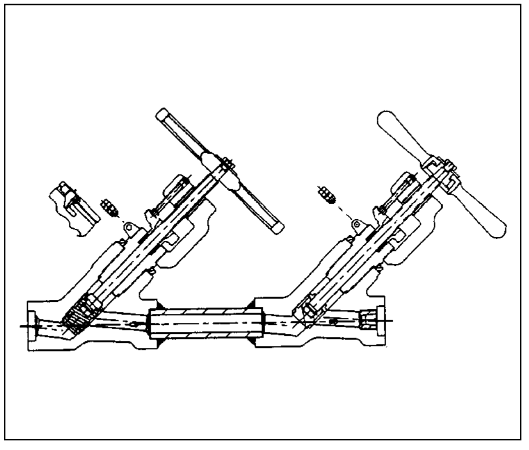

Figure 4 C: PressurCombo Tandem Assembly

- The Univalve with the PressurEater option downstream enhances the combination, because the choke nozzle limits velocities in the seating regions of both the root valve and the guard valve during startup flow conditions. If throttling is required, the user must choose which valve is to be used to throttle.
- If throttling is done with the downstream PressurEater valve, its standard integral seat may suffer damage, because the choke nozzle does not protect the seats completely when the disk is throttled. Still, with the upstream PressurSeat valve protected, the combination should provide excellent tightness. Of course, the tightness of the downstream valve can be restored with standard Univalve seat repair tools if necessary.
- If throttling is done with the upstream PressurSeat valve, its harder stellite 3 seat and disk will provide inherently better resistance to damage. Some users may consider throttling with a root valve unadvisable to be sure this valve remains tight, but this may be satisfactory in some applications. Again, the seat insert may be repaired with standard Univalve seat repair tools if necessary.

4. Grouping of the enhanced Univalve features as options permits individual valves to be furnished with both the PressurSeat and PressurEater features. While perhaps not necessary or cost-effective for all drain valve applications, a valve with both the hard, live-loaded PressurSeat insert and the downstream PressurEater choke nozzle may provide valuable life enhancement in some applications, specifically:

- Single-valve drain applications involving significant throttling – When an existing system does not have both a root valve and a guard valve, a Univalve with both the PressurSeat and PressurEater options may be cost effective on the basis of overall life enhancement for valves used frequently.
- For use as guard valves in tandem assemblies that require extensive throttling – The compromises described above may be avoided by using the PressurSeat feature in both the upstream Root Valve and the downstream Guard Valve. By using the guard valve for all throttling, the root valve seating surfaces receive maximum protection from erosive action.

A series of size 2 prototype Univalves with the PressurSeat and PressurEater design features was built and tested on the Edward saturated and superheated steam test facilities (*Figure 3*). A standard size 2 Figure 66224 (F22) Univalve was also included in the test program for comparison.

One of the first tests involved closing both the standard valve and a PressurEater prototype with. the valves fully hot, with 2300 psi (159 bar), 1025°F (552°C) steam at the upstream (underseat) ports. A torque wrench was used to seat the valves, using torques recommended for standard Univalves. Taps from the downstream side of both valves were connected to condensers for leakage measurement, and leakage of both valves was negligible. The steam generator and superheater were then shut down.

To check for possible effects of stem contraction, a pump was connected to maintain pressure at the valve inlet during cooldown. The following day, with all metal parts at ambient temperature, there was no measurable leakage. A check of stem torques showed that there was sufficient resilience in the stems and yokes of the valves to overcome effects of stem contraction and maintain sealing load. While even the standard valve performed well in this test, even better results were achieved later in tests of prototypes with the PressurSeat option.

The tests on our steam testing facilities were designed to try to "compress time" by conducting extensive cycling to simulate long-term service even in peaking plants. Long periods of operation with valves "cracked open" with high differential pressure simulated throttling conditions. Still, it was recognized that we could not duplicate all real world service conditions, so field trials were also arranged for a group of early-generation PressurEater valves. The field tests all indicate significant improvement as compared to standard valve performance.

The special feature options described above and illustrated in *Figure 4* are now offered for enhancement in power plant drain applications that have displayed marginal life with standard Univalves or competitive products. It will be noted that many of the standard Univalve design features shown in *Figure 1* are retained.

Conclusions

The PressurSeat and PressurEater options now offered for Edward Univalves are enhancements intended for the most severe service conditions. These optional features are the latest of a series of improvements offered since the Univalve product line was first introduced.

A market study and engineering evaluation provided important information on root causes of problems that sometimes occur in power plant drain and vent applications, and the new options provide features that minimize erosion damage and assure long-term seat scaling forces. Univalves with the new features have performed very well in tests on Edward steam testing facilities and in field trials. These options may be used individually or combined to extend service life in severe duty applications while retaining the traditional globe valve advantages that have been demonstrated by Univalves for over 50 years.

References

1. E.A. Bake & R.L. Schweitzer, *"Univalve Evolution Another Advance."* Edward Technical Article V-Rep 80-1, 1980

2. Registration Pending

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