



*Flowserve - Edward Valves
Quick Closing Isolation Valves
-The Equiwedge Alternative*

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Problem

Fast isolation of a large bore main steam or feedwater line during a pipe rupture that seals flow in both directions.

Solution

The Flowserve-Edward Equiwedge gate valve with the gas-hydraulic Type A actuator.

Nuclear power plants have become important contributors to the power requirements of the United States and other countries worldwide. These plants have an excellent record from the standpoint of safety. Nevertheless, there has been increasing concern for safety in the event of unlikely, but credible, accidents. One such potential accident—the rupture of a main steam or feedwater line—has led to demand for large, quick closing isolation valves. As a result of continuous development related to these difficult applications, the Flowserve Edward Equiwedge gate valves are available. Figure 1 illustrates a typical valve of this type with its stored energy actuator.

Uni-directional Valves

Initial quick-closing valves for main steam line isolation were required to close with flow in only one direction (from the reactor toward the turbine). Initial designs relied on simple balanced globe valves using “air-spring” actuators.

Gate Valve Advantages

The foremost advantage of the gate valve over the globe valve is that the gate valve offers less pressure drop at normal flow conditions. While Flowserve research on globe valve flow passage designs led to flow optimization in balanced globe valves, similar flow research led to even better flow characteristics in Equiwedge valves. The low pressure drop feature of the gate valve may be exploited by users to reduce pumping power and increase cycle efficiency or, if desired, it may be applied to reduce capital investment by using a smaller nominal valve size (a venturi valve). A second advantage to the user following the later approach is that reduced valve size and weight simplify piping arrangement and support problems.

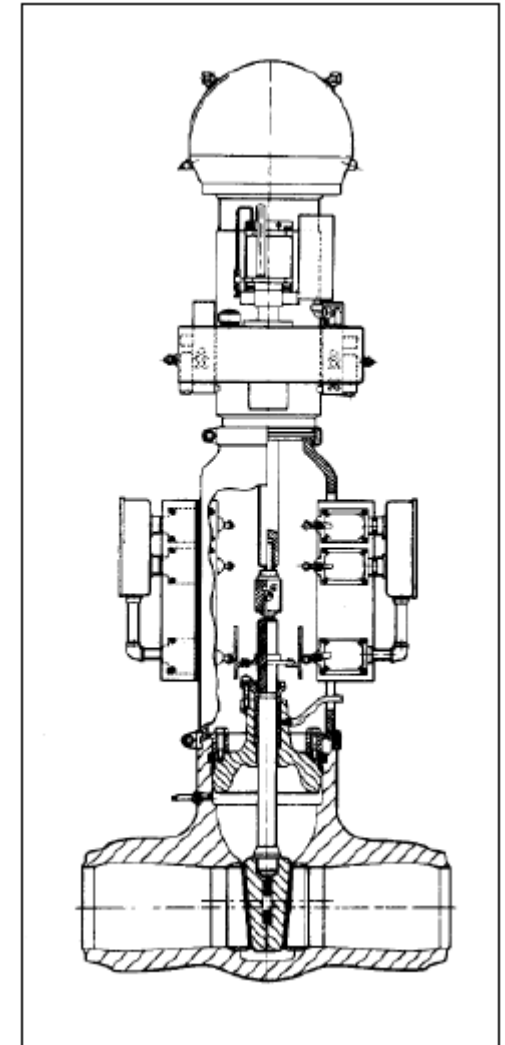


Figure 1: Cross sectional drawing of the Flowserve-Edward Equiwedge gate valve with the Type A Actuator

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A gate valve offers the same performance and seat tightness with flow and differential pressure in either direction. While bi-directional globe valves can close with either direction of flow such valves have different tightness depending on the direction of differential pressure after closure.

Gate Valve Challenges

Two historical complaints against gate valves were foremost in the planning of the design and prototype testing program: first, the valve should not stick in the closed position; and second, the seats should not be damaged by excessive sliding under high differential pressure loading.

Parallel slide gate valves offer freedom from sticking at the expense of substantial exposure of seating surfaces to damage from sliding under high loading. At the other extreme, solid wedge valves minimize sliding of seating surfaces at the risk of wedge-action sticking. The Equiwedge employs a highly flexible dual-wedge gate construction to obtain the best features of both valve types.

Flowserve Equiwedge Gate Valve

Prototype tests were conducted to confirm resistance against wedge sticking during thermal transient tests from as high as 1000°F (540°C). Valve performance was satisfactory throughout thermal shock tests which exposed valve seats to a 550°F (290°C) temperature differential in 25 seconds. In these tests, valve opening force never exceeded the design value and it averaged considerably less. These additional tests add to the confidence that the Equiwedge is resistant to wedge sticking under conditions equal to, or worse than, the most severe conditions expected in service.

Throughout these tests, the valve operated freely with no evidence of binding. Operating torque was consistently within the design range, and there was no significant degradation of seat sealing.

Subsequently, the valve and an associated piping system were connected to a test boiler (Figure 2) and subjected to steam testing at temperatures over 600°F (315°C). The valve was cycled over 130 times using steam, and hot leakage tests were conducted at 50 and 100 cycles. As in the room-temperature tests, operating torque and seat tightness were satisfactory.



Figure 2: A size 16 (400mm) class 1500 Flowserve-Edward Equiwedge gate valve with a Flowserve-Limitorque actuator undergoes hot-functional testing.

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Friction Coefficients

When a gate valve closes under high differential pressure, friction between the gate and its guide surfaces, or its seats, is the dominant resistant force. Consequently, it is necessary to know, with good statistical confidence, the range of friction coefficient in a gate valve. The maximum likely friction coefficients must be determined for actuator sizing and for conservative calculation of some stresses. The minimum likely coefficient is also necessary for conservative evaluation of other stresses, such as those involved with gate wedging forces. A comprehensive friction test research program was necessary to establish design data and to determine the best material combinations for water and steam service at temperatures approaching 600°F (315°C).

Cobalt Alloy No. 21 was chosen to be deposited on the gate guide rails, the valve body guide grooves, and all seating surfaces of quick-closing Equiwedge gate valves. This alloy gives the best combination of low friction coefficient and good wear characteristics. High-confidence friction coefficient design values, which are different for feedwater and steam, were established by the test program for use in stress analyses and actuator sizing.

Gas-Hydraulic Actuator Features

Gas-hydraulic actuators use a stored volume of high pressure gas to duplicate the stored energy function of springs. The gas pressure acting on top of a piston provides the valve closing force. Hydraulic fluid acting underneath the same piston is used to recompress the gas and to provide force to open the valve. Regulated release of the hydraulic fluid provides essential closing speed control. A basic representation of the gas-hydraulic actuator concept is shown in Figure 3.

All gas-hydraulic actuators supplied by Flowserve include two separate manifold control assemblies, each capable of closing a Main Steam or Feedwater Isolation valve within five seconds. One manifold contains both hydraulic “dump” and pumping circuits while the other manifold contains a redundant hydraulic dump circuit. Each dump circuit contains three basic components:

- A dump valve which, when opened, allows a fast closure of the main isolation valve. The dump valve can be triggered open by either receipt or loss of an electrical signal (depending upon the user’s requirements).
- A pressure-compensated flow control valve assures consistent closure times regardless of loading conditions.
- An “exercise” valve which enables testing of the dump valve, actuator and main valve without fast closure of the main valve.

Proof Testing

The prototype Type A actuator was adapted to the size 16 (400 mm) production valve, and the assembly was installed in the air blowdown system at Flowserve’s test station. The valve and actuator assembly is shown in Figure 4. Tests were conducted with the valve initially open, or partially open, and connected to a 300 ft³ (8.5 M³) air storage system pressurized at 1500 psig (103 bar). A downstream Flowserve Hypresphere ball valve is equipped with a quick-opening (<0.5 sec) actuator permitting the system to discharge freely through a muffler, simulating a line rupture. An immediate signal to close the test valve permits demonstration of capability to close under line rupture conditions. Using this procedure, the size 16 (400 mm) valve was closed repeatedly within three seconds with terminal differential pressures up to 1200 psig (83 bar). Figure 5 shows the system under free discharge prior to valve closure.

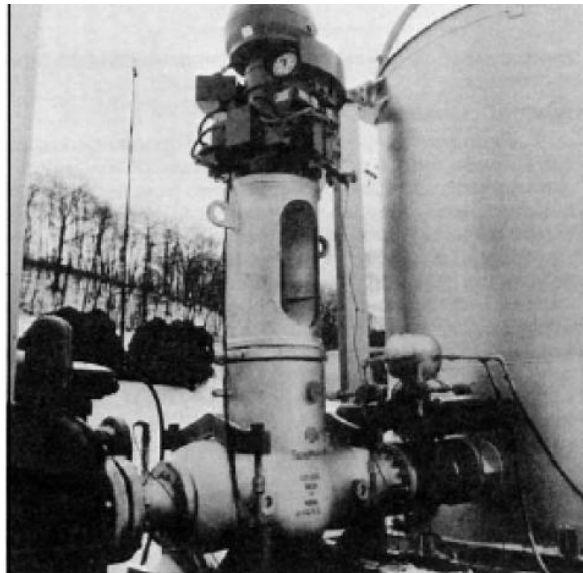
Following the test, the valve was disassembled for inspection prior to resumption of production valve proof tests. Due to the severity of these high differential closure tests, the need for seat refinishing was expected; however, inspection revealed no unusual wear or damage. Consequently, the valve was simply reassembled and the production valve proof tests were resumed. Seat leakage tests after the flow interruption tests revealed no significant deterioration.

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Summary

The Flowserve Equiwedge gate valve and the Type A actuator development programs have provided a substantial data log supporting performance integrity under conditions expected in power plants. Further, analyses conducted in accordance with ASME Boiler & Pressure Vessel Code, Section III criteria support confidence in the long-term reliability of the valves in nuclear plants. Friction coefficient tests have provided data to size actuators to assure capability of closing Equiwedge valves under the severest line rupture conditions. This valve development effort combines with work done on stored-energy actuators to assure high integrity performance of these valves in quick-closing, safety-related applications.

Figure 4: A size 16 (400 mm) Equiwedge gate valve with a Type A actuator is prepared for a steam blow-down test.



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