# Solutions for Application Obsolescence in **Nuclear Power Plants**

*Since the mid 1860's through the end of the 19th century, names very familiar to the valve industry, such as Lunkenheimer, Grinnell, Powell, Jenkins and Crane have been granted patents for the globe valve. The earliest of which is attributed to Frederick Lunkenheimer on March 7, 1865. Since then its inherent design has gone generally unchanged. Enhancement through the years in materials and hardfacing along with designs such as Y-pattern to reduce turbulence and increase flow have allowed to globe valve to find its way into isolation applications. Designed for throttling, globe valves are largely used in vent drain and isolation applications in power generation.*

*By Bill Henwood – ValvTechnologies*

This is especially true in the nuclear industry. Widely accepted because the Generation I plants were built with them. It is one of most misapplied valve technologies in operating nuclear plants. Its time has come and gone, but old habits are hard to break.

The nuclear industry thrives on obsolescence. Everything about it is basically obsolete, from the technology of the domestic operating fleet to the aging workforce, where according to the Nuclear Energy Institute (NEI) the average age is beyond 50 years old and close to 40% is eligible for retirement in the next few years. It is no wonder that the ability to adapt to new technologies due to regulatory constraints and the cost associated with change hinders the utilities ability to implement upgrades that would safely and economically increase plant efficiencies and operations.

In most cases where valves are concerned, the cost of the engineering design package far exceeds the cost of the equipment being upgraded, including installation. Even where the plant can justify the associated cost, the regulatory issues imposed due to the operating license is but another barrier toward plant improvement. Despite their ubiquitous presence in nuclear plants, the globe valve designs of three inch NPS and smaller, defined as high energy or severe service used in the aforementioned applications are obsolete.

The Generation I nuclear plants were essentially a design/build on the fly. In the heyday of the first wave of construction, valve manufacturers were scrambling to provide what was needed as the specifications changed and engineers played catch up. Conversely the Generation III and III+ plants currently under construction worldwide and in Georgia and South Carolina are built to design. Meaning all components are preselected and many of the systems are constructed as modules and assembled at the construction sites.

It is important to reiterate that the operating domestic fleet is Generation I design from the 1960's. The industry deserves plenty of credit for operating safe and reliable base load power while overcoming the daily struggles of obsolescence. The Nuclear Utility Obsolescence Group (NUOG) is an industry users group devoted to dealing with the day-to-day obsolescence problems of operating nuclear plants, all within the regulatory restrictions imposed. NUOG's mission is to share information and solutions to the daily issues surrounding the safe, successful and profitable operation a nuclear power plant.

The use of quarter turn severe service metal seated ball valves (MSBV), largely perfected in the mid 1980's is a new technology to the mature nuclear industry. Because of the costs associated with upgrades and improvements previously described, there is an inert reluctance to change. The path of least resistance is generally taken unless the threshold of pain is so great that the particular the responsible System Engineer says enough. He or she then implements a plan that includes a cost benefit analysis, including O&M costs; proof of improved safety of personnel, piping and equipment along with efficiency upgrades and a rapid return on investment, are but some of the elements presented to the Plant Health Committee. No easy task.

## Globe Valves vs. Metal Seated Ball Valves

Globe valves are linear operated valves and are commonly found in every conceivable high energy vent, drain and isolation application in a power plant nuclear or fossil fueled. The most common sizes and pressure classes utilized in nuclear plant applications can range from .375 inch through three inch with pressure classes ASME 600# though 2500#. Materials are typically A105, F22 and 316SS. There are two valve types are "Tee" *(Figure 1)* and Y-pattern *(Figure 2)*.

Globe valves are normally supplied in compliance with FCI-70-2 Class IV or V leakage standard. It is important to realize that these leakage standards allow for leakage during the cold hydrostatic testing during manufacture. Once installed in high energy applications it is not unusual to notice leakage at a very early stage of startup.

In these conditions Class V valves will rapidly deteriorate to Class IV then III and so on. There are other contributing factors toward leakage typical of globe valves in isolation applications. Globe valves are susceptible to damaged due to vibration, steam damage from wire drawing, flashing, cavitation and internal erosion Other factors contribute in part due to the functionality

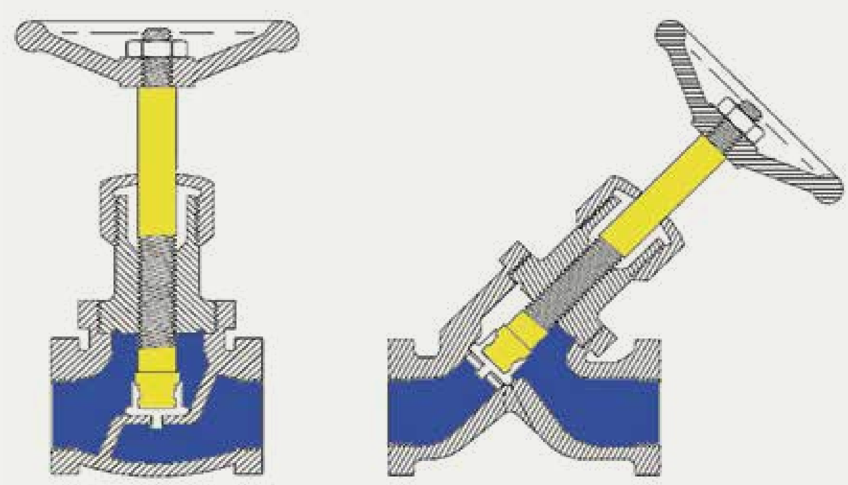

*Figure 1* *Figure 2*

of globe valves. The rising stem and torque seating feature of the design can cause damage to both the stem as it passes through the deep stuffing box and seat damage caused when the valve is closed on particulate in the system. Packing and gasket leakage is such a problem in the nuclear industry that another user group, the Fluid Leak Management Users Group (FLMUG) was formed to address external or visible leakage due to the packing and gasket issues so prevalent in the industry it is a "Top 10" problem in operating nuclear plants.

Stem thread and bearing hysteresis combined with extremely high unseating forces inherent in the operation of globe valves can cause additional degradation of the yoke nut, and stem threads. Those high axial seating forces along with high velocity at the seats assist in the acceleration of seat leakage.

In short the combination of a tortuous flow path, high turbulence and the susceptibility of impingement as the media passes through the seat during an opening all contribute to the rapid deterioration of globe valves in vent, drain and isolations services.

Typical seating surfaces in high energy isolation globe and gate valves are hardfaced with Alloy 6. Alloy 6 has excellent wear and corrosion resistance, but it is very prone to cracking with rapid temperature swings. It also is susceptible to scratching and galling at elevated temperatures as it softens with temperature which is noticeable at 500°F. The cobalt content is also a deterrent to use, but the industry has yet to identify a satisfactory weld overlay substitute for Alloy.

## Metal Seated Ball Valves

Conversely metal seated ball valves are a quarter turn operation. They are a posi-

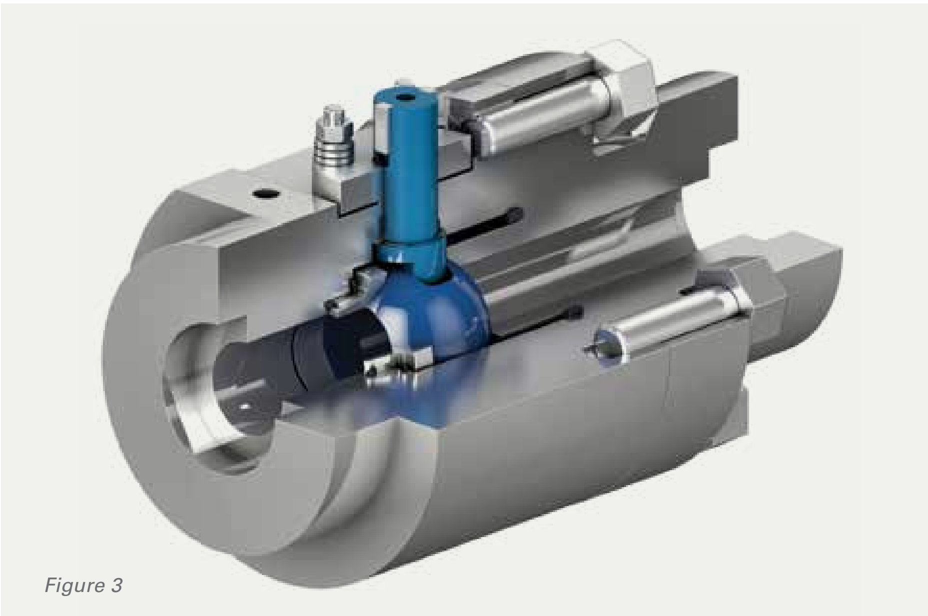

Figure 3

tion seated, or sometimes called a floating ball design *(Figure 3)*. They match all sizes and pressure classes in the nuclear industry and are flexible enough to be considered for gate valve replacement in a bi-directional configuration as well. They are typically lever or handwheel operated, are extremely quick opening manually and are easily actuated when required. These valves are the best available isolation technology.

Due to their design and the requirement to mate-lap the ball and seat(s), creating a matched trim set, these valves are expected to have seat leakage performance that exceeds FCI 70-2 Class VI. Class VI is typically expected in soft seated ball valves. It is also known as bubble tight. Again, even a Class VI leakage standard still allows for some leakage during manufacture. For intent and purpose metal seat ball valves can have their own classification of seat tightness one could call Class VII which is zero visible leakage, hydro for a period of three minutes and Class VIII which is zero visible leakage for a period of three minutes on high pressure gas. This is a reality in 21st century valve technology and design.

Because metal seated ball valves essentially have pressure assisted seating, there are no axial unseating forces as with globe style valves. The seats are also entirely protected in the fully open position eliminating the impingement expected causing damage in globe and gate valves. Additionally metal seated ball valves are typically free from any elastomer seals and are therefore inherently environmentally qualified for harsh nuclear service.

Metal seated ball valves of a position seated or floating design depend on a load applied from a combination Belleville spring with an upstream seat guide. Once the valve endcap is torqued to a specified value the ball defaults to an axial and radial alignment which is fixed. The load is applied to the ball and downstream seat. This load provides a wiping action through the stroke of the valve and therefore system particulate such as pipe scale and magnetite cannot dislodge the seating surface contact.

Other features inherent with ball valve designs are the quarter turn operation which minimizes packing wear and tear for extended packing life. The straight-through flow path eliminates turbulence and high velocity seat erosion. The sealing surfaces are fully protected in both the open and closed position and the Cv's are much higher than globe valves and can match or exceed those of gate valves.

Finally, absolute zero leakage can be achieved when properly engineered and manufactured internally and externally. This is especially important to the safety conscience nuclear industry.

The hardcoating used is the heart and sole of the product once properly designed and applied. The manufacture of high energy MSBV applications in the nuclear industry incorporates a chrome carbide or tungsten carbide combinations.

The process is known as High Velocity Oxygen Fuel (HVOF) *(Figures 4 and 5)*. This is not a hardfacing process; rather it is a relatively low temperature application. The substrate rarely exceeds 300°F (149°C), thus stress reliving in not needed. The mechanical bond strength can be greater than 25,000 psi and it withstands thermal cycling without cracking. The friction coefficient is low .2 – .28, which is appealing to the nuclear industry.

The most impressive aspect of the hardcoating is its hardness which in the case of nuclear power applications with rare exception will never dip below 68-70 Rc. At this value the carbide particles are harder than most, if not all particles in a pipeline including ferrites and magnetite. It resists any wear, scratching, galling and corrosion. This is illustrated in the comparison with Alloy 6 *(Figure 6)*.

## Comparison

When placing a globe valve side by side against a metal seated ball valve the benefits are eye-opening:

1. Globe valves are exposed to high pipeline unseating forces versus a metal seated ball valve where pipeline pressure equates to higher seating forces.

2. Globe valves are throttling valves

Figure 4

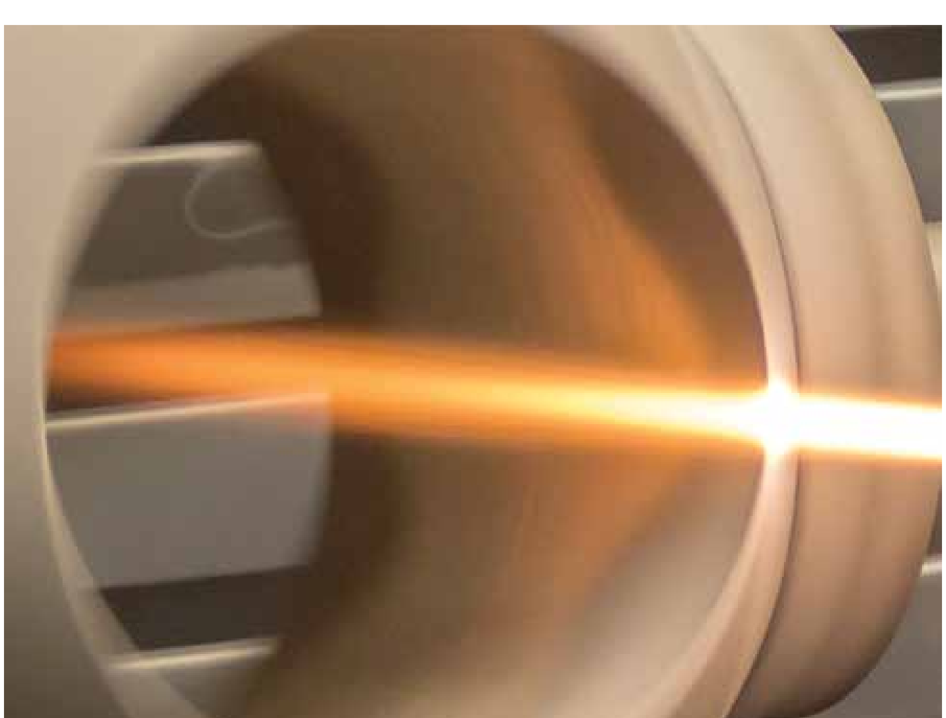

Figure 5

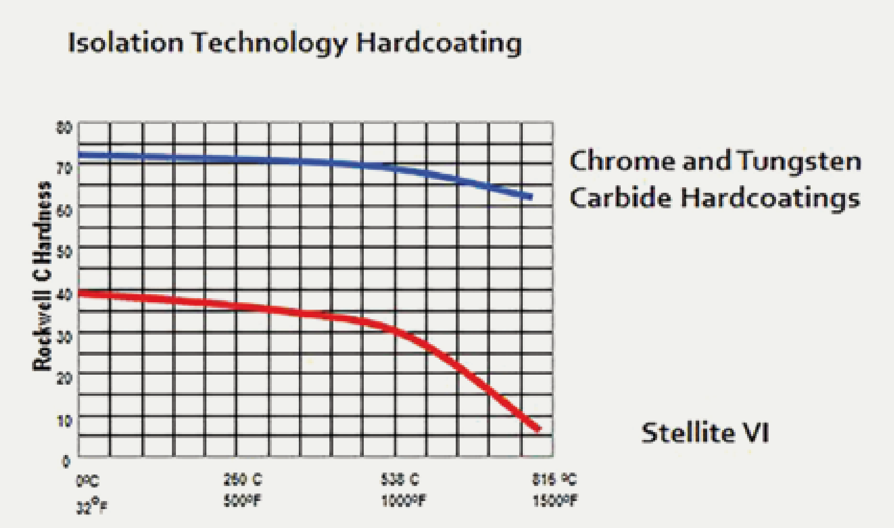


*Figure 6*

used in isolation applications. Ball valves are designed for isolation.

3. Globe valves have exposed seating surfaces when open. Ball valves seating surfaces are always protected.

4. Globe valves have a torturous flow path for increased turbulence and reduced Cv. Ball valves have an undistorted flow path for the highest possible flow capacity.

5. Globe valves are multi-turn linear operated with a deep stuffing box with maximum potential for scoring and leakage. The ball valve is quarter turn with a hardened and polished stem with a minimum four bolt live loaded packing system, standard for drastically reduced packing wear and tear for long term leak free reliability.

6. Additionally, due to the expected/allowable leakage, continuous seat degradation when in operation at pressure and temperature globe valves has a much higher cost of ownership.

## Real Success

The article would not be complete without examples of where upgrading a technology from the incumbent globe and gate style small bore isolation valves to metal seated ball valves.

A Utility with a Pressurized Water Reactor (PWR) had a Main Steam System (MSS) with monitored losses from their leaking valves of upwards of 11 -13 MWe. Walk down of the system identified approximately 500 valves of 2.5" and smaller. The condition of the piping system resulting from the poor performing incumbent valves rendered some sections a safety hazard for plant personnel and equipment.

Commencing in 2009 the plant has replaced approximately 50% of the target population of incumbent valves with metal seated ball valves. The applications are "commercial" on the balance of plant (BOP) or secondary side of the plant. It included elements of augmented quality required by the plant. Measured and verifiable results via cycle isolation testing reveal an impressive 6-8 MWe gain since the program began.

This is but one example of a forward thinking System Engineer who took the position of trying to find a solution to his problems. Returning to the original equipment time and time again proved fruitless. He knew there had to be a better answer and he found it with a new technology that was not only cost effective, but improved system output all the while enhancing the overall safety of plant personnel and system integrity.

Another is an example of an installation success where application obsolescence involving globe valves were replaced. This plant was a two unit PWR. Over 200 valves two inch and smaller in steam trap isolation and startup vents and drains were replaced with metal seated ball valves. This installation commenced in 1995. According to the Component Engineer at the time the globe valves ran an annual cost of up to $125,000 in repair and replacement.

Furthermore, due to their degradation over the course of a fuel cycle the plant personnel were unable to perform the required maintenance while the plant was on line for extended periods. To date the valves are in operation for 20 years at a cumulative savings in excess of $2,500,000 dollars.

As with the first example this plant component engineer was forward thinking and well ahead of his time. The technology was less than 10 years old when he made the decision to make the changes. A decision with no regrets.

## Conclusion

One should ask a simple question… Why put a throttle valve in an isolation application? Looking forward, using metal seated ball valves in isolation applications requires a paradigm shift. An understanding of why the use of globe valves in isolation applications is not necessarily the best choice, and because it is the incumbent technology it is not the long term solution for plants expecting to operate 20 years beyond their original license to operate.

Unfortunately, the "Nuclear Renaissance" has hit a few bumps in the road and hadn't panned out as most expected and who believed it was real in the early 2000's. As a manufacturer, huge investment is required to provide the latest technology and product innovation to the nuclear industry.

Programmatic costs are real and unavoidable for those who chose to stay in it rather than bailout once the plant construction in the US all but dried up. The pursuit of application obsolescence is an arduous task; one that requires patience and understanding that the forward thinking engineer everyone seeks is out there and is willing to put forth the effort with management support for the overall good of the safe operation of the plant.

## What to Look for…

There are several features a specifying engineer encountering an application obsolescence issue should look for when sizing and selecting a metal seated ball valve for isolation service in power generation:

1. Body end cap seat should be integral. As with globe valve inbody seat weld inlays Integral seats eliminates a potential for behind seat leakage.

2. The valve stem must be one piece blowout proof, inserted through the body. Stems which are collared and pinned should be considered a weak link and a safety hazard.

3. The stuffing box should be shallow and inserted with flexible graphite packing with proper anti-extruding features and a minimum four bolt live loaded packing system

4. Gland should be 316SS to protect against corrosion.

5. The body seal (gasket) should be Inconel and self-aligning.

6. The ball and seats should be hard coated with tungsten or chrome carbide hard coating with a minimum hardness of 70 – 72 Rc.

7. Shutoff shall be absolute zero leakage, exceeding the requirements of FCI 70-2 Class VI and ASME/ANSI B16.34

8. Every valve is serialized assembled tested and documented with QA signoff.

## ABOUT THE AUTHOR

ValvTechnologies' Nuclear Industry Director Bill Henwood has been an integral part of the ValvTechnologies senior management team since October of 2007 and has over 35 years in the valve industry. Prior to his current position, he spent 11 years in various sales management positions with the Curtiss Wright Flow Control Corporation. Bill is responsible for ValvTechnologies' overall day-to-day nuclear business. His responsibilities also include the implementation of their Nuclear Programs which includes their 10CFR50 Appendix B and the ASME Section III "N" and "NPT" Authorizations.