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Robert C. Howard

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INSTALLATION OF VALVTECHNOLOGIES BALL VALVES IN SEVERE SERVICE APPLICATIONS WITHIN THE ADVANCED TEST REACTOR

Robert C. Howard
Idaho National Laboratory
P.O. Box 1625
Idaho Falls, Idaho 83415
Phone: 208-533-4365
Robert.howard@inl.gov

ABSTRACT

The Advanced Test Reactor (ATR) located at the Department of Energy's Idaho National Laboratory, is the most powerful test reactor operating in the United States rated at a design power of 250 MW(t). Operating cycles are nominally seven per year with outages that last 7 to 14 days, allowing time for routine plant maintenance and experiment insertions and manipulations. While the ATR pressurized water loops can operate at the same temperature and pressure requirements of a pressurized water reactor, the loops also have the ability to operate at higher conditions. Hence, it is critical to ensure that when component replacements are called for, they can meet or exceed design requirements of a typical power reactor, while continuing to satisfy the design requirements of the ATR experiment loops.

INTRODUCTION

The ATR located at the Idaho National Laboratory has operated for over 30 years. Not unlike the current fleet of commercial reactors, the ATR is facing life extension issues and component replacements due to age and operation. One such example was a series of valves that had been in use for 15 years and were selected for replacement with no clear options as to a viable alternative.

In 1998, the ATR Experiments organization was faced with the decision to replace a series of globe valves that routinely leaked, required constant maintenance, continually delayed start up of the reactor, caused unplanned shut downs, and were prohibitively expensive to maintain. Several options were considered prior to finalizing the best path forward for replacing the valves. These options included the following: 1) replacing the valves with a brand of valve that was currently in use at the plant, 2) replacing the valves with an identical model of valve currently in use at the plant, 3) modifying a valve we had experience with but was not readily available, or 4) selecting a new valve that looked promising, but had never been used at the plant. Regardless of whatever valve was selected, it would have to meet specific design requirements for the plant, as well as ASME code requirements imposed by the plant piping specification and system design description. This paper documents the defining of requirements, selection process, installation, and performance of this specific modification.

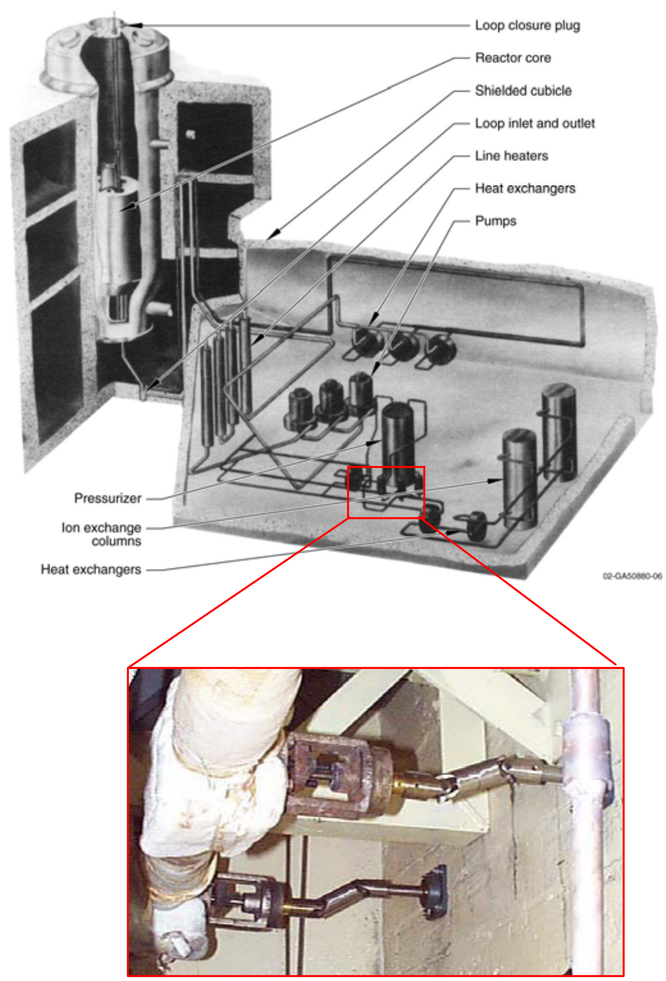
VALVE REQUIREMENTS

The ATR has five pressurized water loops. Four standard loops and one high temperature loop. The valve replacement was required in the high temperature loop (Figure 1), which has a design temperature of 710° F (377°C) and design pressure of 3800 psi (26.2 MPa). These conditions alone defined a severe service application. In addition to temperature and pressure requirements dictated by the loop piping specification, all piping and components were to be fabricated from 347 stainless steel. Since the modification encompassed replacing the valves on the loop drain lines, pressurizer degassing line, and pressurizer surge line, different requirements applied depending on location of installation. The drain valves would need to be ASME Section III, class 3, while the surge and degas lines would need to be class 2. To further complicate the definition of requirements, the piping specification contradicted the system design description by adding the requirement that the valves be "N" stamped. It was eventually determined that the valves to be replaced were "N" stamped and the requirement for "N" stamping written into the piping specification at a time when "N" stamping capabilities by vendors was easily obtained, but was not required for this application.

SELECTION PROCESS

The selection process took over six months and involved extensively researching the following options: 1) replacing the valves with a brand of valve that was currently in use at the plant, 2) replacing the valves with an identical model of valve currently in use at the plant, 3) proposing a design change and modifying a valve we had experience with but was not readily available from a vendor, or 4) selecting a new valve that looked promising, but had never been used at the plant. Options 1-3 were determined to not be feasible due to the high cost of modification and the fact that current valves were not trustworthy. Option 4 was eventually selected after several key factors; a valve manufacture that could meet the requirements was identified, meetings were conducted with manufactures to further explore the capabilities of the product; and extensive research was performed with existing customers concerning operating performance of the valves. At the completion of the down select process, the Valvtechnologies Severe Service ball valve was selected. After selection, the valves had to undergo rigorous quality assurance testing before being acceptable for use. ATR Quality Assurance, in agreement with ATR Engineering, procured the valves as "commercial grade" complying with ASME/ANSI B16.34, "Special Class" requirements. The use of B16.34 "Special Class" is specifically referenced as an acceptable design alternative in the current revision of ASME Section III, Subsection NC, Article 3513 (Alternative Design Rules). To further satisfy the selection , the following dedication process were performed in house: 1) Certificate of Conformance were reviewed for all materials used in fabrication, 2) Certified Material Test Reports were reviewed for all pressure boundary materials, 3) Radiography of the valve body, bonnet, and cover per ASME NC 2500 was performed by the vendor and inspected in-house, 4) all exterior and accessible interior surfaces were given a liquid penetrant examination per ASME NC 2500, hydrostatic pressure testing was performed per ASME B16.34, and a stress analysis was performed per NC 3513 and NC 3521 as seen in Figure 2.

Figure 1: ATR Schematic Showing Location of High Temperature Loop Valve Installation



INSTALLATION

All valves selected for replacement were of a double block configuration. A spool piece was assembled with two valves per spool piece and welded for each replacement location. The spool pieces were then hydrostatically checked at 110% of design pressure before installation. Due to the lack of operating experience of the valves selected, one spool piece was installed with Grayloc end connections to allow for quick change-out to the original valves should the new selection fail. After four operating cycles totaling approximately 200 effective full power days with no problems, the decision was made to install the remainder of the spool pieces permanently.

PERFORMANCE

Installation of all the spool pieces was completed in 1998. Each valve is cycled approximately 25 times per year with no failures or preventative maintenance required to date.

PRODUCT DISCLAIMER

References herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government, any agency thereof, or any company affiliated with the Idaho National Laboratory.

Figure 2: 1/2" Ball Vale Class II Analysis

Author: R. G. Rahl
filename: ballvalv.mcd

1/2" Ball Valve Class II Analysis
Checked by: M.E. Nitzel

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Use NC-3640 minimum thickness formula to check minimum thickness of the valve body.

NC-3640 t_{min} calculation $d := 1.295 \cdot in$ Max valve body ID

$P := 3800 \cdot psi$ $S := 14700 \cdot psi$ $y := 0.4$ $A := .0003 \cdot in$

$t_{minactual} := 1.23 \cdot in - \frac{d}{2}$ $t_{minactual} = 0.583 \cdot in$ actual minimum thickness of valve body

effectively, $D_o := \frac{d}{2} + t_{minactual}$ $D_o = 1.23 \cdot in$

$t_m := \frac{P \cdot d + 2 \cdot S \cdot A + 2 \cdot y \cdot P \cdot A}{2 \cdot (S + P \cdot y - P)}$ $t_m = 0.198 \cdot in$ $\frac{D_o}{t_m} = 6.196$ **>6 OK**

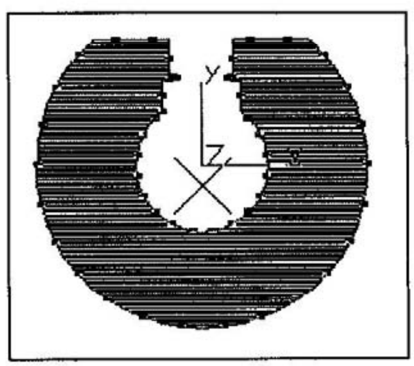
t_m < $t_{minactual} = 0.583 \cdot in$ **OK**

Use NC-3332 to check reinforcement for valve stem penetration.

The opening has a maximum diameter of 0.76 inches. Since this is less than 2 in. nominal pipe size, NC-3332.1 is satisfied and reinforcement is not required.

Calculate area and section modulus of minimum valve body section.

Moment of Inertia (XY Plane Projection):
Area = 5.8794 Xcg = 6.3995e-009 Ycg = -0.19531
Ixx = 3.5158 Iyy = 5.0212



1/2" schedule 80 pipe properties

$D_o := .84 \cdot in$ $t := .147 \cdot in$ $D_i := D_o - 2 \cdot t$

$A_p := \frac{\pi}{4} \cdot \left(D_o^2 - D_i^2\right)$ $I_p := \frac{\pi}{64} \cdot \left(D_o^4 - D_i^4\right)$

$A_p = 0.32 \cdot in^2$ $I_p = 0.02 \cdot in^4$

$A_v := 5.88 \cdot in^2$ > $1.10 \cdot A_p = 0.352 \cdot in^2$ **OK**

$I_{vmin} := 3.5158$ > $1.10 \cdot I_p = 0.022 \cdot in^4$ **OK**