CONNECTION BULLETIN

Vogt Valves

Post Weld Heat Treatment of
Socket Weld Valves

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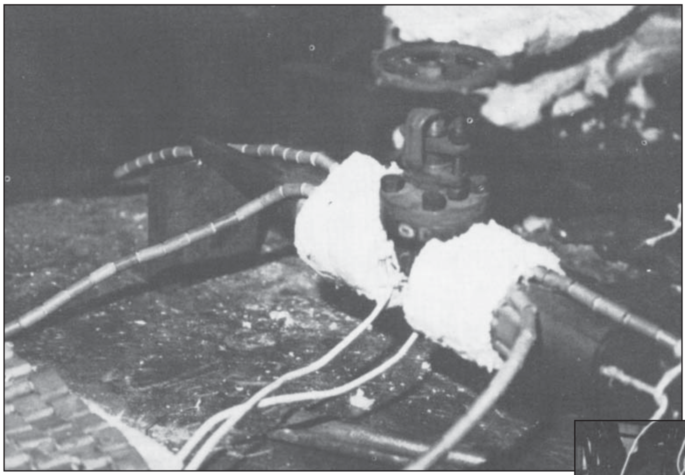
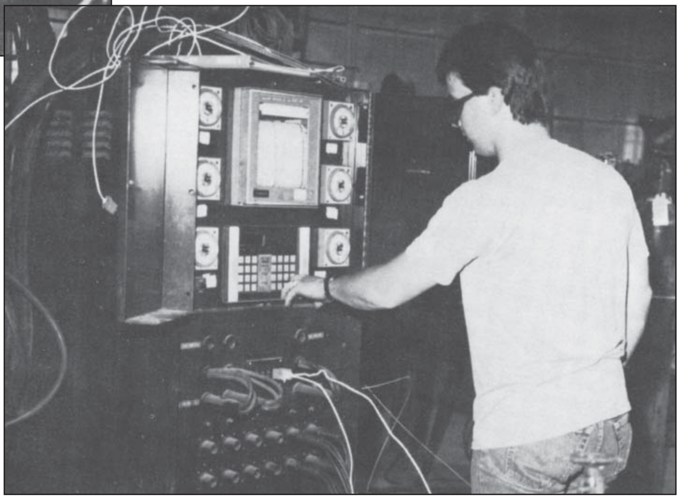




Experience In Motion

Post Weld Heat Treatment of Socket Weld Valves

Introduction

Some manufacturing and user construction codes require that welds connecting valves to pipe runs in process systems be post weld heat treated. Flowserve Vogt Valves is occasionally asked for recommendations and comments on post weld heat treating of valves. This report contains our current recommendations. While no single paper can cover all the problems faced by the post weld heat treater in the field, this short report describes Vogt experimental heat treating that will help in the difficult tasks of localized field post weld heat treating. A basic description of valve and valve trim components and how they react to elevated temperatures is included.

Background

Technical articles on post weld heat treatment at the grass roots level are few. This article is a basic document on post weld heat treatment of valves. No new or radical metallurgical phenomena or hypotheses here—just some critical temperatures, preheat temperatures, and the results of work done by Vogt to provide tips on equipment and setup to make post weld heat treatment of socket weld valves easier. Planning for post weld heat treatment with respect to equipment, temperature control and thermocouple placement is critical and must be emphasized. The report gives rules of thumb on the effect of post weld heat treatment on some of the common body, bonnet and trim materials used in many valves with emphasis on materials used in Vogt valves.

Post Weld Heat Treatment of Socket Weld Valves

Many piping and construction codes require that valves welded into pipe line runs have the welds and heat-affected zones heat treated after welding. Properly done, post weld heat treatment reduces residual welding stresses and softens hard metallurgical microconstituents that form in both weld metal and base metal heat-affected zones.

Post weld heat treatment is, depending on the alloy, involve temperatures generally not lower than 1100°F and not normally above 1350°F. Most post weld heat treating is done below the lower critical AC_1 temperature of both base and weld metal. The critical temperatures for plain carbon steel and for the alloy steels commonly used in valve construction—F11, F22 and F5—are shown in Table 1. While hardenability of these alloys is relatively high, their low carbon levels in concert with proper preheating for welding preclude development of extremely high as-welded hardnesses. F11, F22 and F5 within the ASTM A182 chemistry ranges respond well to stress relieving temperatures: 1150°F, 1250°F and 1325°F, respectively.

Post weld heat treatment criticality increases as the carbon level increases and as the valve and pipe wall thickness and diameter increase. The welding process involving both preheat and post weld heat treatment is most successful when there is no interruption between preheat and post weld heat treatments. To assure that all hard microconstituents have formed, the weld should be allowed to cool to the recommended minimum preheat temperature, shown in Table 1 before starting the post weld heat treatment.

Figure 1 – Tempering Characteristics of 410 SS

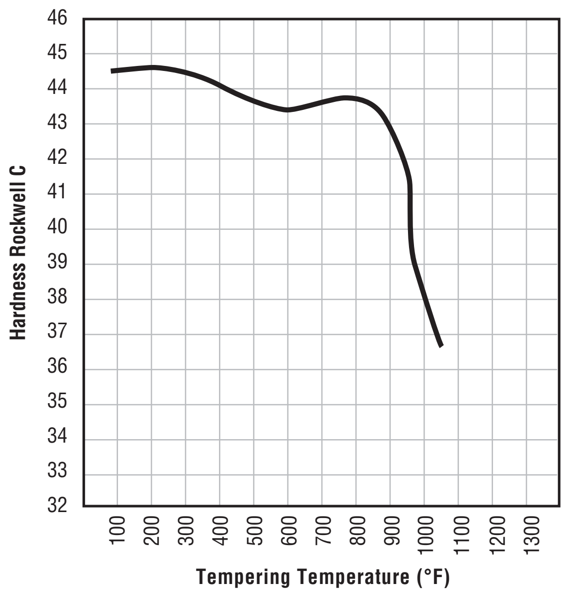
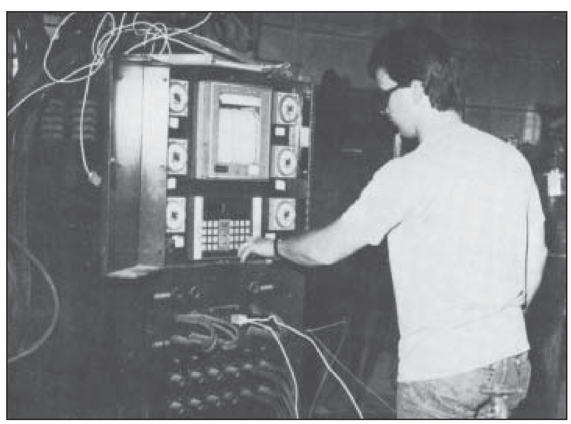


Figure 2



Technician programming a controller to post weld heat treat a small valve in the Flowserve Vogt Metallurgy and Welding Department Laboratory.

Post Weld Heat Treating and Valve Trim

Post weld heat treatment of valves is technically difficult because, unlike pipe to pipe or pipe to fitting welds, valves contain internal parts whose properties are alterable in post weld treatment. The most standard valve trim is 13% chromium (410 and 416) martensitic stainless steel. Gate valve trim parts include a gate, seat rings, and the 416 or 410 stem. The 13% chromium steels are most corrosion resistant in the fully hardened condition. Tempering reduces corrosion resistance. The lower the tempering temperature, the greater the corrosion resistance and the higher the hardness and strength. Conversely, the higher the tempering temperature, the lower the corrosion resistance, hardness and strength.

When gate valve seat rings are hardsurfaced with either cobalt or nickel-based hardsurfacing material, the hard-surface deposits retain their wear- and corrosion-resistant qualities even after exposure to high stress relieving temperatures. Seat ring distortion has not been a problem.

Globe valves with 13% chromium trim are subject to the same thermal influence as in gate valves with respect to discs and stems. Globe valve seats are generally integrally hardsurfaced and are, as in the case of the gate valve seat ring, virtually unaffected by post weld heat treatment. When the valve trim is unstabilized 300 series stainless steel, some sensitization of the parts may be encountered during post weld heat treatment. Depending upon application of the system, this may or may not be troublesome.

The higher the alloy content in the valve body, the higher the post weld heat treating temperature. The higher the temperature, the greater the influence on the hardness, strength and corrosion resistance of the stainless trim parts. Standards recommend carbon steel post weld heat treatment temperatures of 1100°F minimum, 1150°F minimum for F11, 1250°F minimum for F22 and for F5. Heat treatments above 1000°F can result in softening 410 stems, gates and discs. See Figure 1. Therefore, preparation for post weld heat treatment should be well planned and implemented to specific procedures.

Bolted bonnet valves and seal weld bonnet valves are best handled differently in post weld heat treatment. Bolted bonnet valves can be disassembled prior to heat treatment; seal weld bonnet valves cannot. To eliminate thermal change in the 13% chromium steel trim components (other than seat rings) for bolted bonnet valves, the bonnet subassembly can be removed from the valve body prior to post weld heat treating. If done in this manner, this special note of caution for gate valves: *Gates are seated in during factory assembly to create a match between gate and seat rings. It is important that the pair and orientation be reestablished during reassembly on completion of post weld heat treatment.* Orientation is not a factor in globe valves, but it is recommended that body and subassemblies be reunited after heat treatment. When heat treating socket weld ends of seal weld valves or assembled bonnet valves, we suggest that the gate or disc be in the retracted position so that there is as much distance as possible between the gate or disc and the weld joint during heat treatment. This will minimize the temperature reached by the stem and gate or disc. When the valve packing is subjected to temperatures above 850°F, it should be replaced.

Our experiments indicate in carbon steel valves, that this temperature is not reached during 1150°F stress relieving. In alloy valves the packing may reach these temperatures, and therefore the temperature of the packing chamber should be monitored during post weld heat treatment. When heat treating alloy steel valves at temperatures above 1250°F, anticipate some lowering in hardness in gates and discs, and replace the packing as necessary.

Post Weld Heat Treating Equipment

By far the most frequently used method for heating in post weld heat treatment is electric resistance heating elements. These elements come in various shapes, sizes and construction. Those made with solid wire tend to be rigid and generally more adapted to post weld heat treatment of larger items, such as pressure vessel shells, and large pipe joints. Those of stranded wire construction, being flexible, lend themselves to post weld heat treating of small items such as valves. The pads can be designed for specific sizes and shapes, and can be made or purchased in any configuration. Vogt has made several sizes for special applications. Care must be exercised in powering the pad, as the resistance of a reduced-size pad will be significantly reduced and the pad current dramatically increased.

It is convenient to connect the various element combinations to a multioutlet power transformer such as shown in Figure 2. The on-and-off action is controlled by a programmable logic controller. The alternative is attachment to constant current welding machines controlled by a tong ammeter. Care in both setups must be taken to prevent overheating and burnout of the elements. It is important that the power recommendations of the heating element manufacturer be followed.

Table 1 – Critical Heat Treating and Welding Temperatures

Grade	Critical Temperatures (°F)*				Martensite** (°F)		Preheat and Interpass Temperatures (°F)
	Heating		Cooling				
	AC_1	AC_3	AR_3	AR_1	Start	Finish	
Carbon Steel (.21%C)	1360	1530	1440	1300	800	——	———
1¼ Cr – ½ Mo (F11)	1430	1635	1550	1340	660	——	300 to 600
2¼ Cr – 1 Mo (F22)	1480	1600	1510	1330	740	——	300 to 600
5 Cr – ½ Mo (F5)	1505	1620	1445	1325	865	——	400 to 700

Heating rate 250°F/hr; Cooling rate 50°F/hr

Critical temperatures: On heating are:
AC_1 — Lower critical start of transformation
AC_3 — Upper critical end of transformation

Critical temperatures: On cooling are:
AR_3 — Upper critical start of transformation
AR_1 — Lower critical end of transformation

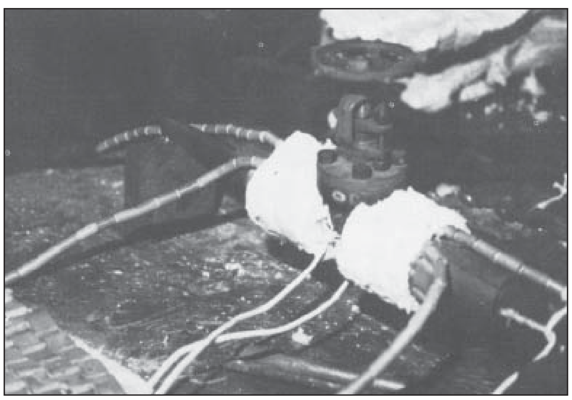
*** Martensite start temperature on cooling from temperatures above the AC_1 temperature.*

Insulation

Throughout our experimentation, ceramic fiber blanket insulation material was confined to the weld joint being heat treated. At no time were efforts made to totally insulate the valve body and superstructure. To minimize mechanical changes in the heat-sensitive trim material, this insulating procedure is suggested (Figure 3).

⚠ **CAUTION:** Do not encapsulate heating elements with insulation, as element overheating and burnout may result. Always provide a surface to which the element can dissipate heat.

Figure 3 – Insulating a ½" Valve for Post Weld Heat Treating



Temperature Control during Post Weld Heat Treatment of Socket Weld Valves

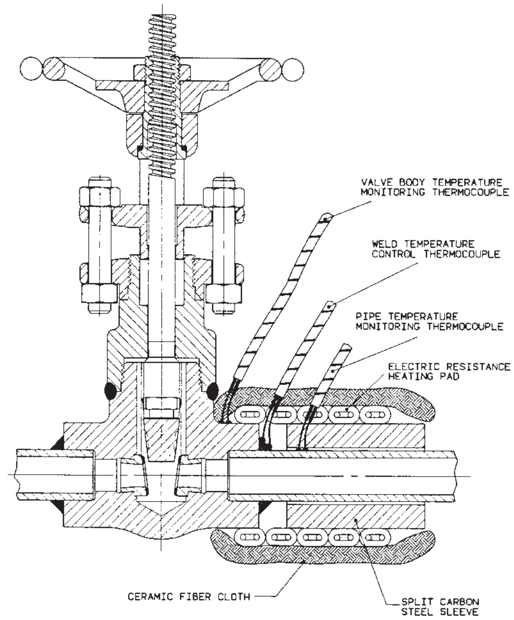
The mass of the valve body and the weld joint normally exceeds that of the pipe welded into the body. This can be a problem because improper placement of the heating elements results in overheating of the lighter wall pipe, while the more massive valve body has not reached stress relieving temperature. Each localized post weld heat treatment requires careful positioning of electric heat treating pads or elements, control thermocouples and monitoring thermocouples. In most of our experimental work, the heat zone was controlled, and the pipe and body adjacent to the weld were monitored.

To avoid pipe overheating, split carbon steel sleeves were attached to the line piping and butted up to the valve (Figure 4). This assembly simplified attachment of the heating pads and insulation, and also lowered the temperature of the pipe section to acceptable stress relieving temperatures. This technique works well on both large and small valves. In laboratory experiments the temperature difference between pipe and weld joints in the body was held to 40°F. With this technique we were able, in larger valves, to confine the heat to the weld joint and heat zones. In post weld heat treating to 1150°F, neither the gate nor the stem in the 2 inch valves exceeded 800°F. These temperatures would neither soften 13% chromium stainless steel nor sensitize 300 series steel. When post weld heat treating a ½ inch gate valve (Figure 3), the gate invariably reached temperatures of 1000°F. Such temperatures result in significant tempering of the gate.

When heat treating the larger 2 inch valves, heat treating one end at a time minimizes gate and stem temperature. In the ½ inch valve there was no advantage to heating one end at a time. The gate, even when fully retracted from the gate-seat ring slot, reached temperatures in excess of 1000°F.

Temperature is normally monitored with 22 gage chrome-alumel thermocouples attached to the valve, weld and pipe by the capacitor discharge technique. With this technique the hot junction is not the joint between chromel and alumel but between chromel-iron and iron-alumel, as shown in Figure 4. This combination of two thermocouples in series can, when the wires are reasonably close together, read as one chromel-alumel thermocouple. When temperature is monitored in this way, the problem of intimate contact with the surface to be heat treated is avoided, as in the uncertain influence of intense heat from incandescent heating elements on a thermocouple joint mechanically attached to the part being heat treated.

Figure 4 – Typical Post Weld Heat Treat Configuration



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