Trim Materials

Valtek uses 316 stainless steel as standard plug and seat ring material except in the case of special alloy bodies where trims are usually furnished in the same material as the body. It is difficult to assign specific limitations to the use of stainless steel because of the insufficient information about the actual condition of the flowing stream. However, Valtek applies one general rule: Hardened trim is considered for all choked flow conditions or for temperatures above 600 degrees Fahrenheit.

Hardened Trim Selection

Hardened trim is used in control valves to protect the trim against erosion and/or corrosion. As shown in Figure 10-1, hardened surfaces may include the seat surface of the plug and seat ring, the full seat ring bore, the full contour of the plug or the lower guide area of the plug stem.

Valtek stocks No. 6 Stellite for many valve trim parts which require hardened trim. Stellite offers a good combination of relative hardness and corrosion resistance. For corrosion resistance, special alloys—such as Alloy 20, Hastelloy C and Monel—are also available.

A major problem with material selection is deciding when to apply a hard face to protect the control valve trim. Scientific studies have not adequately predicted when hard facing should be used. Therefore, opinions and conclusions based on experience must be used to set practical guidelines.

Aside from corrosion, the main factors that cause wear in valve trim are the conditions of the process fluid:

- Gas versus liquid
- Velocity and pressure differential
- Temperature
- Flashing
- Presence of abrasive solids.

All these factors must be examined when considering hardened trim.

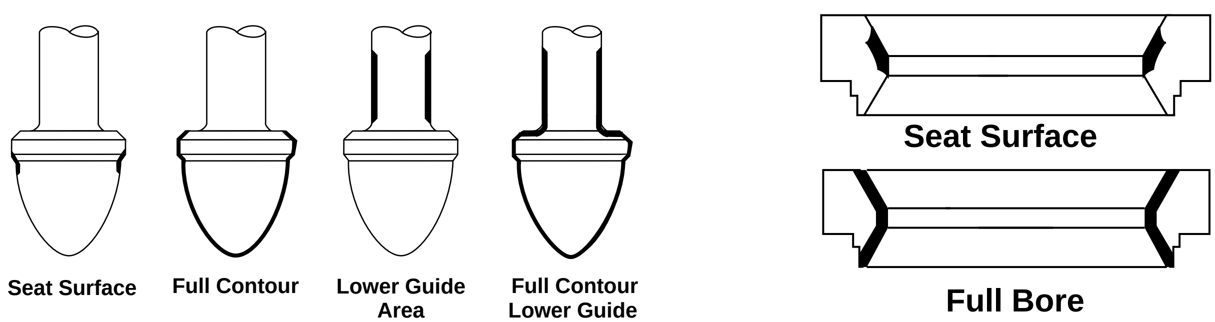

Figure 10-1: Hard Facing Variations With Seat and Plug

Gases Versus Liquids

Clean gases are not usually a source of trim erosion, even at high velocities. However, entrained solids or liquid droplets in high velocity gas can wear the trim rapidly.

Depending on the fluid's composition, liquids at high velocity can produce accelerated erosion. For example, at high velocities water causes more damage than lubricating oil.

With liquids, another harmful effect is cavitation which can erode most trim material, even hardened trim. Liquid application valves require the use of hardened trim more often than gas application valves.

Table 10-I: Pressure Differential (psi) Requiring Hardened Trim

Inner-valve Size	Gases (Clean)		Steam (Super-heated)		Steam (Saturated)		Water		Process Fluids (General)	
	Throttling	On/Off	Throttling	On/Off	Throttling	On/Off	Throttling	On/Off	Throttling	On/Off
$^1/_2$ - $1^1/_2$	600	900	300	600	100	200	175	250	175	250
2 - 3	350	600	200	300	25	50	150	200	150	200
4 - 6	200	300	100	150	All Apps.	25	100	125	75	125
8 - 12	125	175	50	100	All Applications		50	100	50	100

Velocity and Pressure Differential

Erosion caused by flowing fluid is a function of the velocity of the fluid. Velocity is dependent on flow rate and area. In order to have a large flow rate through a relatively small area, large differential pressures are required. Therefore, hardened trim selection becomes a function of differential pressure. Pressure differential values which are anticipated to require the use of hardened trim are shown above.

The following should be considered when using the differentials from Table 10-I:

1. When operating differentials are 50 percent more than the values in Table 10-I (factor above figures by 1.5), the use of full bore and full contour hardened trim is recommended.
2. The factory should be consulted on any choked liquid application where the differential pressure exceeds 500 psi.
3. Use hardened full bore, full contour and lower guide area whenever the temperature exceeds 600 degrees Fahrenheit.
4. Liquid applications with high pressure drops should also consider the valve Sigma. (Refer to Section 14 for a discussion about Sigma values.)

Temperature

As temperatures increase, many trim materials become susceptible to erosion because of the general deterioration of their mechanical properties. Therefore, the selection of the hardened trim must be compatible with high temperature conditions. For example, hardened 440C would not be recommended for service above 800 degrees Fahrenheit, whereas Stellite can be used up to 1500 degrees Fahrenheit. At the other end of the temperature scale–such as cryogenic service–most available hardened materials become excessively brittle and 316 stainless steel becomes relatively hard. Whenever the temperature exceeds 550 degrees Fahrenheit, seating surfaces should be hardened. The plug stem and bushings should be hardened above 600 degrees Fahrenheit regardless of the pressure differential.

Corrosion

The erosion and abrasion of valve and trim is aggravated by the corrosive effect of the process fluid. In some cases, this may be the deciding factor in selection of the hardened trim. In other cases, it may dictate the use of a trim which is resistant to corrosion by the fluid, but which cannot be hardened.

Types of Hardened Trim

The term “hardened trim” may cover such materials as: 1) stainless steel hard-faced with Stellite; 2) flame-sprayed with tungsten carbide or aluminum oxides; 3) hard materials such as wrought Stellite 6B or the various sintered metal carbides and oxides; and 4) materials which are hardened by heat treatment, such as 416, 17-4 PH, 440C, or 329 stainless steels, or K Monel K-500.

Hard-Facing

The most common material used by Valtek for hard-facing is Stellite No. 6, a product of Haynes Stellite Co. It is a cobalt-based alloy.

Stellite No. 6 is the most common of all hard-facing materials used in the control valve industry. It has one of the best combinations of corrosion, abrasion and impact resistance. In addition, it has a low coefficient of friction with itself and an even lower one with Stellite No. 12.

Heat Treatable Materials

Type 17-4 PH (product of Armco Steel) combines high hardness with good corrosion resistance.

17-4 PH is a precipitation hardened stainless steel. Its corrosion resistance is comparable to that of 304 stainless steel. Maximum tensile strength, hardness and corrosion resistance are obtained by the hardened condition H900. In this condition, the upper operating temperature limit for steel is 800 degrees Fahrenheit and the lower limit is -10 degrees Fahrenheit. A minimum temperature of -320 degrees Fahrenheit can be expected if the heat treatment is changed to condition H1150M; this condition is also the most ductile at any temperature.

Table 10-II: Trim Material Characteristics

Trim Material	Hardness Rockwell C	Impact Strength	Corrosion Resistance	Recommended Max. Temp.	Erosion Resistance	Abrasion Resistance	Availability
316 Stainless Steel	8	Excellent	Excellent	600° F	Fair	Fair	In stock
Stellite No. 6	44	Excellent	Excellent	1500° F	Good	Good	In stock
416 Stainless Steel	40	Good	Fair	800° F	Good	Good	Good
17-4 PH H900	44	Good	Good to Excellent	800° F	Good	Good	Fair
440C Stainless Steel	55-60	Fair	Fair	800° F	Excellent	Excellent	Fair
K Monel	32	Good	Good to Excellent	600° F	Fair to Good	Good	Fair
Tungsten	72	Fair	Good on Bases Poor on Acids	1200° F	Excellent	Excellent	Poor
Colmonoy No.5	45-50	Good	Fair	1200° F	Good	Good	In stock

Type 440C stainless steel is a high carbon, 17 percent chromium steel and is available (for trim sizes 3.50 and smaller) in bar and cast form. It can be hardened to Rockwell C56 to 60. It has fair corrosion resistance which deteriorates rapidly above 800 degrees Fahrenheit. However, it is dimensionally unstable during heat treatment and is susceptible to cracking after heat treating. For these reasons, caution must be taken when using 440C for seat rings. However, 300 series stainless with Stellite seat surfaces is an alternative.

Monel K-500 is a copper-nickel alloy, with a chemical composition that differs from Monel 400 by the presence of 3 percent aluminum. Whenever the specifications call for Monel trim, the bushings will normally be supplied in Monel K-500. This ensures a differential hardness between the plug stem and the guide bushings.

The corrosion resistance of Monel K-500 and Monel 400 are comparable. The major limitation of Monel K-500 as a bushing or plug stem is its availability only in bar or wrought form. Monel K-500 is hardened by a single thermal treatment consisting of aging at the required temperature followed by controlled cooling.

Additional Information

Table 10-II provides general guidelines concerning Valtek's trim materials. Table 10-III shows the wear and galling resistance of various material combinations. And, Table 10-IV indicates the temperature limits of various trim materials.

Table 10-III: Wear & Galling Resistance of Material Combinations

	304 SS	316 SS	Bronze	Inconel 600	Monel 400	Hastelloy B	Hastelloy C	Titanium 75A	Nickel	Alloy 20	Type 416 Hard	Type 440 Hard	17-4 PH	Alloy 6 (co-cr) Stellite	ENC*	Cr Plate	Al Bronze
304 SS	P	P	F	P	P	P	F	P	P	P	F	F	F	F	F	F	F
316 SS	P	P	F	P	P	P	F	P	P	P	F	F	F	F	F	F	F
Bronze	F	F	S	S	S	S	S	S	S	S	F	F	F	F	F	F	F
Inconel 600	P	P	S	P	P	P	F	P	F	F	F	F	F	F	F	F	S
Monel 400	P	P	S	P	P	P	F	F	F	F	F	F	F	S	F	F	S
Hastelloy B	P	P	S	P	P	P	F	F	S	F	F	F	F	S	F	S	S
Hastelloy C	F	F	S	F	F	F	F	F	F	F	F	F	F	S	F	S	S
Titanium 75A	P	P	S	P	F	F	F	P	F	F	F	F	F	S	F	F	S
Nickel	P	P	S	F	F	S	F	F	P	P	F	F	F	S	F	F	S
Alloy 20	P	P	S	F	F	F	F	F	P	P	F	F	F	S	F	F	S
Type 416 Hard	F	F	F	F	F	F	F	F	F	F	F	F	F	S	S	S	S
Type 440 Hard	F	F	F	F	F	F	F	F	F	F	S	F	S	S	S	S	S
17-4 PH	F	F	F	F	F	F	F	F	F	F	F	S	P	S	S	S	S
Alloy 6 (co-cr) Stellite	F	F	F	F	S	S	S	S	S	S	S	S	S	S	S	S	S
ENC*	F	F	F	F	F	F	F	F	F	F	S	S	S	S	P	S	S
Cr Plate	F	F	F	F	F	S	S	F	F	F	S	S	S	S	S	P	S
Al Bronze	F	F	F	S	S	S	S	S	S	S	S	S	S	S	S	S	P

* Electronic Nickel Coating

S - Satisfactory
F - Fair
P - Poor

Table 10-IV: Valve Trim Material, Temperature Limits (Degrees Fahrenheit)

Material	Lower	Upper
Type 304 Stainless Steel	-423	600
Type 316 Stainless Steel	-423	600
316 Stainless Steel/Stellite	-120	1500
Bronze	-423	450
Inconel	-400	1200
Monel K-500	-400	900
Monel 400	-400	900
Hastelloy B	-325	700
Hastelloy C	-325	1000
Titanium	-300	600
Nickel	-325	600
Alloy 20	-50	600
Type 416 Stainless Steel 40RC	-20	800
Type 440 Stainless Steel 60RC	-20	800
17-4 PH	-40	800
Alloy 6 (co-cr)	-425	1500
Electroless Nickel Plating	-425	800
Chrome Plating	-425	1100
Aluminum Bronze	-460	600
Nitrile (Buna N)	-40	200
Fluoroelastomer (Viton and Fluorel)	-10	400
TFE	-425	450
Nylon	-100	200
Polyethylene	-100	200
Neoprene	-40	180