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Guidelines for procurement of cast stainless steels for large pumps and valves for the pulp and paper industry

1. Scope

This TIP is intended to assist mill engineers in procurement of high quality cast stainless steel pumps and valves, especially those of large size intended for critical services, where failure would pose unacceptable safety or production problems. The information is also useful in reviews and procurement of pumps and valves for less critical applications.

2. Background information

Castings for pumps and valves are procured by the pump or valve manufacturer from either their own, or from independent, foundries, hence mill engineers must deal with indirect procurement through an intermediate. The current American Society for Testing Materials (ASTM), the Manufacturers Standard Practices (MSS), the Swedish SS and the German DIN are the specifications most frequently used. Mill engineers need to have a general knowledge of these specifications, especially their limitations, and the supplementary requirements needed to insure the quality expected and required. Explanatory information is included in sections of the text as appropriate. While this TIP can provide useful information on procurement, there is so substitute for procuring from known suppliers of quality castings with a good, well established track record.

3. Materials and alloy selection

3.1 The cast alloy designation, the wrought equivalent and typical compositions of the cast stainless steels normally used for pumps and valves are shown in Table 1. The preferred ASTM specification and the mechanical properties in Table 2; and a comparison of Swedish and ASTM specifications, compositions and mechanical properties in Table 3. Common usages in pulp and paper are given in Table 4. Applicable specifications are listed in Section 6.0 Referenced documents.

3.2 Alloy Selection

3.2.1 The principal factor mill engineers can influence is alloy selection. Table 4 shown common applications for the cast alloys in the pulp and paper industry, but is intended only as a general guide. A number of alloys will perform well in many of the applications listed, not just the alloy listed. Some general guidelines for the alloy selection follow.

3.2.2 Select the alloy based on prior experience in the intended service or on materials specialist's input.

3.2.3 Select the duplex grades over the common austenitic grades where abrasive wear is a consideration. Generally, the duplex grades can also be used as alternatives to the austentic grades with no reduction in corrosion resistance, even when wear is not a consideration.

3.2.4 Always select and specify low carbon grades of the common grades, CF-3, CF-3M, and CG-3M, in preference to the higher carbon grades also offered in some ASTM specifications. The low carbon grades are not

5.5.1 *Visual Examination*

5.5.1.1 Manufacturers Standardization Society, (MSS) Standard Practice SP-55 provides photographic acceptable/not acceptable criteria for 12 common surface defects. Table A1 in MSS SP-55 correlates MSS SP-55 criteria with those of ASTM A802 "Standard Practice for Steel Castings" visual standards and Steel Castings Research and Trade Association, (SCRATA) graded reference plastic comparators. It is desirable to include inspection to MSS SP-55 visual standard criteria in all procurement of pumps and valves, not just those for critical services.

5.5.1.2 LP, UT and Radiographic Examination MSS SP-93 Liquid Penetrant (LP), SP-94 Ultrasonic (UT), SP-54 Radiographic examination provide useful acceptance criteria for each NDT method. LP will disclose hair line cracks and other surface defects, but not sub-surface defects that may be uncovered during machining or later in service. Ultrasonic examination of castings will detect subsurface defects on machined flat surfaces, and with less accuracy, on curved and smooth as cast surfaces.

5.5.1.3 Radiographic examination is a powerful tool in insuring quality castings. Radiographic examination adds substantially to the cost of the casting. Critical sections, such as foot support-to-case, and flange-to-body transitions, of pressure containing components are the type of locations where radiography should be considered. Only critical sections should be radiographed. It is costly and not normally economical to simply call for "100% radiography". Criteria for acceptance for different wall thicknesses are given in SP-54.

5.6 *Hydrostatic Testing*

5.6.1 Hydrostatic testing is required only under ASTM A703. It should be mandatory for all pressure containing castings and a record of the hydrostatic test should be requested and kept on file.

5.7 Weld Repair

5.7.1 *Major/Minor defects*

5.7.2 Foundries routinely weld repair casting defects especially on large castings as generally permitted by ASTM specifications without prior notification. The ASTM specifications define major repairs as "those that either result in: 1) leakage on hydrostatic test; or 2) are > 20% of wall thickness; or 3) are >1" (25mm) in depth; or 4) exceed 10 sq in (65 sq cm)". All other defects are considered minor.

5.7.3 Supplement S12 to ASTM A703 requires prior approval of major weld repairs. S20 requires documentation of the location of major weld repairs. ASTM A703 S12 and S20 should be included in procurement requirements for critical castings and considered for those in less critical services.

5.8 *Filler metal*

5.8.1 Specifications generally require weld repairs to be made with matching composition filler metal, which is satisfactory for the common grades, but not the higher molybdenum content austenitic or the duplex grades. For the 6% molybdenum containing alloys, CN-3MN and CK-3MCuN, weld repairs should be made with higher Mo content, not matching composition, filler metals, as noted in ASTM A744, but not in A743 or A351. The higher Mo content filler metal compensates for molybdenum segregation in the weld metal without the need for a solution anneal. In the case of the duplex grades a higher nickel content filler metal is required in order to maintain the 50-50 austenite-ferrite structure. Procurement should specify the filler metal to be used for weld repairs of these grades.

5.8.2 Heat treatment after weld repairs. ASTM A744 requires heat treatment after 1) all major repairs, 2) minor weld repairs on wetted surfaces and 3) minor weld repairs which heat a wetted surface to or above 800°F (425°C).

5.8.3 Unless A744 is used for procurement, heat treatment should be required for castings in critical services requiring major weld repairs. Heat treatment after major weld repairs should also become a primary consideration for all castings where major repairs are permitted, in addition to those in less critical services.

5.9 Weld repair of 16Cr 5Ni 1 Mo.

5.9.1 Weld repair of this grade is not covered in the specifications. Producer recommendations should be followed closely.

5.10 Documentation

5.10.1 The following documentation should be requested and obtained for all large castings:

Certified Chemical Composition and Mechanical Properties
Furnace temperatures charts
Hydrotest Certification
Welder and Welding Procedure Qualification Reports

Table 3. Swedish (SS) and U.S. (ASTM) Cast Corrosion-Resistant Alloy Specifications. [a]

		Composition, weight %[b]						Mechanical Properties		
Specification Number	Designation	Cr	Ni	Mo	C max	Mn max	Si max	TS MPa (ksi)	YS MPa (ksi)	El %
ASTM A744	CF-3	17.0-21.0	8.0-12.0		0.03	1.5	1.5	485 (70)	205 (30)	35
SS 14 23 33	SS 23 33-12	17.5-20.5	8.0-11.0		0.06	2.0	1.5	440 (64)	180 (26)	35
ASTM A744	CF-3M	17.0-21.0	9.0-13.0	2.0-3.0	0.03	1.5	1.5	485 (70)	205 (30)	30
SS 14 23 43	SS 23 43-12	17.0-20.0	10.0-13.5	2.5-3.2	0.06	2.0	1.5	440 (64)	200 (29)	35
ASTM A744	CF-8	18.0-21.0	8.0-11.0		0.08	1.5	2.0	485 (70)	205 (30)	35
SS 14 23 33	SS 23 33-12	17.5-20.5	8.0-11.0		0.06	2.0	1.5	440 (64)	180 (26)	35
ASTM A744	CF-8M	18.0-21.0	9.0-12.0	2.0-3.0	0.08	1.5	2.0	485 (70)	205 (30)	30
SS 14 23 43	SS 23 43-12	17.0-20.0	10.0-13.5	2.5-3.2	0.06	2.0	1.5	440 (64)	200 (29)	35
ASTM A744	CG-8M	18.0-21.0	9.0-13.0	3.0-4.0	0.08	1.5	1.5	520 (76)	240 (35)	25
SS 14 23 66	SS 23 66-12	17.5-20.5	13.0-16.5	3.0-4.0	0.06	2.0	1.5	440 (64)	200 (29)	35

[a] Closest alloy types chosen based on chemical composition, heat treatment and mechanical properties.
[b] Incomplete listing of constituent elements (P and S have been omitted from table).