Chlorimet 2 and 3

DC2 and DC3

Bulletin A/3k

Introduction

Chlorimet 2 and Chlorimet 3 are Flowserve developed Mo-Ni and Cr-Mo-Ni alloys that have been in use since the early 1950s. Although there are many similar and newer alloys available, most notably the Hastelloys®, the Chlorimets, having undergone constant refinement over the years, are equal if not superior to these newer cast versions in most services.

Chlorimet 2

In ASTM A494 for cast nickel base alloys there are two choices of the Mo-Ni alloys: the original Hastelloy B (N-12MV) and Chlorimet 2 alloy (N-7M). (There is no ASTM cast grade for Hastelloy B-2.) The composition and mechanical properties of these two alloys can be seen in Tables I and II. As can be seen in Table I, Chlorimet 2 has lower levels of critical residual elements, such as carbon and iron. Also, Chlorimet 2 does not contain tungsten or vanadium which, along with lower iron and carbon levels, allows for higher contents of nickel and molybdenum to enhance the corrosion resistance of Chlorimet 2 as well as its ductility. This combination of nickel and molybdenum provides excellent resistance to non-oxidizing media unequaled by most other alloys. This is particularly true of hot hydrochloric acid at all concentrations; hot strong phosphoric acid; and various strong chlorides provided they have no oxidizing tendencies.

Table I Composition*

	N-12MV	N-7M
Cr	1.0	1.0
Mo	26.0-30.0	30.0-33.0
Ni	balance	balance
Mn	1.0	1.0
Si	1.0	1.0
Fe	4.0-6.0	3.0
S	.030	.030
P	.040	.040
W	–	–
V	.20-.60	–
C	.12	.07**

*Single values are maximums.

**Limit is .03 max.

Table II Mechanical Properties

	N-12MV	N-7M
Tensile		
Strength psi	76,000	76,000
MPa	525	525
Yield		
Strength psi	40,000	40,000
MPa	275	275
Elongation %		
in 2 in (50 mm)	6.0	20.0

Chlorimet 3

Whereas Chlorimet 2 should not be used for corrosives having oxidizing characteristics, the chromium bearing Chlorimet 3 is recommended for many of these services. Chlorimet 3 consists essentially of nickel, molybdenum and chromium. It differs from Chlorimet 2 in that approximately one-half the molybdenum has been replaced with chromium. This combination of elements results in an alloy that has good resistance to reducing environments with the additional ability to resist oxidizing corrosives such as hypochlorite bleaches, chlorine dioxide and moist chlorine.

Because of Chlorimet 3's ability to handle reducing as well as oxidizing conditions it has much broader application than Chlorimet 2. As a result there have been many similar alloys developed over the years, making the selection of a Cr-Mo-Ni alloy a difficult decision. In ASTM A494 there are four of these cast alloys from which to choose: the original Hastelloy C (CW-12MW), Hastelloy C-4 (CW-2M), Hastelloy C-22 (CX-2MW), and Chlorimet 3 (CW-6M). However, the CW-12MW grade can be disregarded because of its inferior corrosion resistance, poor ductility and poor weldability. Therefore, the choice is limited to the three remaining grades. The composition and mechanical properties of the cast Cr-Mo-Ni alloys can be seen in Tables III and IV.

Table III Composition*

	CW-12MW	CW-6M	CW-2M	CX-2MW
Cr	15.5-17.5	17.0-20.0	15.0-17.5	20.0-22.5
Mo	16.0-18.0	17.0-20.0	15.0-17.5	12.5-14.5
Ni	balance	balance	balance	balance
Mn	1.0	1.0	1.0	1.0
Si	1.0	1.0	.8	.8
Fe	4.5-7.5	3.0	2.0	2.0-6.0
S	.030	.030	.030	.025
P	.040	.040	.030	.025
W	3.75-5.25	–	1.0	2.5-3.5
V	.20	–	–	.35
C	.12	.07*	.02	.02

*Single values are maximums.
**Limit is .03 max.

Table IV Mechanical Properties

	CW-12MW	CW-6M	CW-2M	CX-2MW
Tensile Strength				
psi	72,000	72,000	72,000	80,000
MPa	495	495	495	550
Yield Strength				
psi	40,000	40,000	40,000	45,000
MPa	275	275	275	280
Elongation % in 2 inches (50 mm)	4.0	25.0	20.0	30.0

Since the newer grades, CW-2M and CX-2MW, show lower maximums on some elements such as carbon they may be perceived as being superior to Chlorimet 3. However, just because an alloy has higher permissible limits does not necessarily mean it is being produced to those higher limits. In reality, Flowserve produces Chlorimet 3 to concentration limits tighter than the ASTM permissible maximums to enhance its corrosion resistance and to ensure meeting the mechanical properties. As a result, Chlorimet 3 has comparable corrosion resistance to the newer Hastelloys for many services.

Heat Treatment

All Chlorimet castings are provided in the solution annealed, water quenched condition which optimizes corrosion resistance and mechanical properties.

Specifications

Chlorimet 2 and Chlorimet 3 are produced to ASTM specification A494, Grades N-7M and CW-6M Class 1 which requires castings with major weld repairs to be given a post weld heat treatment.

Comparing the Cr-Mo-Ni Alloys

A common means of evaluating these alloys is to test them in boiling 10% hydrochloric acid and in boiling 50% sulfuric acid/ferric sulfate (ASTM G28 Practice A). The results of these tests can be seen in Table V. For the oxidizing G-28 test, Chlorimet 3 tested somewhat better than Hastelloy C-4 but both were inferior to Hastelloy C-22 which was specifically developed for severely oxidizing services. However, for reducing services such as boiling 10% hydrochloric acid Chlorimet 3 and Hastelloy C-4 are comparable and both are superior to Hastelloy C-22. Since neither of these tests are ones where these alloys would actually be used, more applicable testing was conducted for further comparison.

The testing involved choosing points on the hydrochloric acid and sulfuric acid isocorrosion charts, Figures 1 and 2, where Chlorimet 3 should exhibit a maximum corrosion rate of 20 mpy. These data can be seen in Table VI. From these tests it is apparent that neither cast Hastelloy C-4 nor Hastelloy C-22 offer any advantage over Chlorimet 3 in these two common services.

One other strength of the Cr-Mo-Ni alloys is their resistance to crevice corrosion. This is determined by testing samples of an alloy between Teflon washers in a 6% ferric chloride solution of increasingly higher temperature until a 1 mil deep crevice forms on the sample. The temperature at which this occurs is called its critical crevice temperatures (CCT). These results can be seen in Table VII. (Please see page 5.) Hastelloy C-4 with its lower chromium and molybdenum content has the lowest CCT, as expected. Wrought Hastelloy C-22 which was designed for an optimum CCT has the highest rating. However, when made as a cast alloy its CCT is comparable to Chlorimet 3.

What these tests show is that newer alloys do not necessarily provide improved performance in all situations. When selecting alloys of a given family such as the Cr-Mo nickel base alloys, a user can expect similar performance from several of the grades in many services. Therefore by considering more than one specific grade for a service the user can most likely benefit from improved availability and lower cost for cast pumps and valves. To assist in this difficult task of alloy selection please contact your local Flowserve sales engineer or Corporate Materials Engineering Department at (937) 226-4475.

Table V Common Screening Tests at Boiling (mpy)

	Chlorimet 3	Cast Hastelloy C-4	Cast Hastelloy C-22
ASTM G-28A	184	231	54
10% HCL	337	306	445

Table VI HCL Tests (mpy)

	Chlorimet 3	Cast Hastelloy C-4	Cast Hastelloy C-22
5% HCL at 175°F	13	21	43
20% HCL at 148°F	11	13	20

H_2SO_4 Tests (mpy)

	Chlorimet 3	Cast Hastelloy C-4	Cast Hastelloy C-22
20% at 225°F	31	82	118
50% at 202°F	16	17	52
Conc. at 230°F	11	42	77

Table VII MTI Critical Crevice Temperature Above Which Crevice Corrosion is Observed in 6% $FeCL_3$, 24 Hour Exposure

Alloy	CCT (°C)
Chlorimet 3 (C)	62
Hastelloy C-276 (W)	69
Hastelloy C-4 (W)	36
Hastelloy C-4 (C)	30
Hastelloy C-22 (W)	83
Hastelloy C-22 (C)	67

(W) – Wrought
(C) – Cast

Hydrochloric Acid

Both Chlorimet 2 and Chlorimet 3 find their greatest usage in the handling of hydrochloric acid. It must be kept in mind, however, that the corrosion rate of Chlorimet 2 in hydrochloric acid is increased if oxidizing contaminants are present. This includes oxidizing chlorides such as ferric chloride, cupric chloride, hypochlorites, etc., or other oxidizing media such as nitric acid, or even aeration. Despite having less inherent resistance to pure hydrochloric acid than Chlorimet 2, Chlorimet 3 is normally suitable for hydrochloric acid containing oxidizing contaminants. For example, Chlorimet 3 should not normally be used above 120°F (50°C) whereas Chlorimet 2 is suitable for all concentrations to the boiling point. However, Chlorimet 3 is suitable for use in hydrochloric acid containing ferric chloride, as is often the case with muriatic acid. Chlorimet 3 is also extensively used for dilute HCl such as encountered in acid brine solutions.

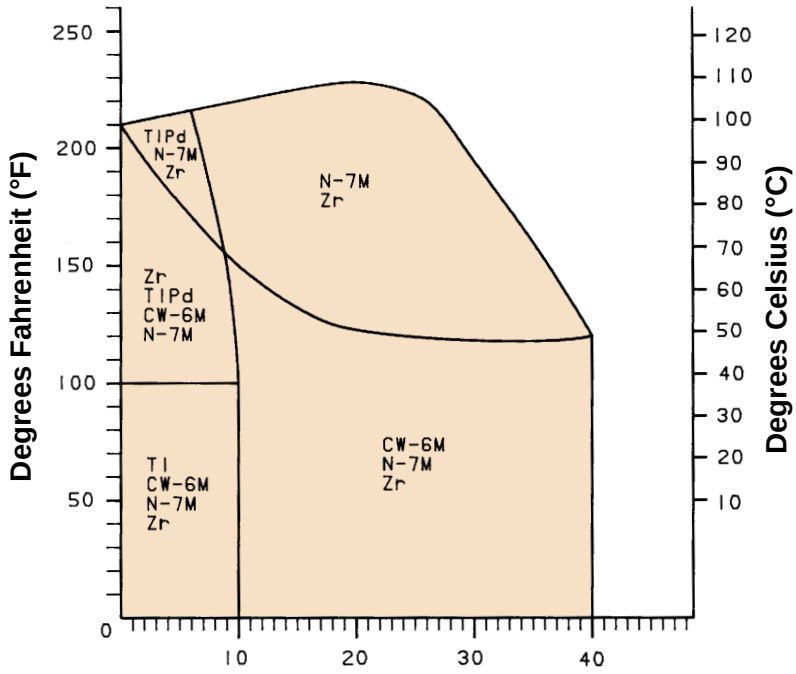
Sulfuric Acid

Both Chlorimet 2 and Chlorimet 3 have excellent resistance to all concentrations of sulfuric acid within the temperature limitations shown in Figure 2. As with hydrochloric acid, the presence of oxidizing contaminants renders Chlorimet 2 unsuitable in sulfuric acid.

Less expensive alloys such as Durcomet 100 (Bulletin A/7) and Durimet 20 (Bulletin A/1) are sufficiently resistant to many conditions of sulfuric acid and these alloys are naturally selected whenever possible. But contamination of sulfuric acid with fluorides, chlorides, or other reducing species may necessitate the selection of Chlorimet 2 or 3. In non-oxidizing sulfuric acid solutions up to 50 percent concentration, Chlorimet 2 is the most resistant alloy available next to noble metals (gold, platinum, etc.), high silicon iron (Bulletin A/2), and refractory metals such as tantalum and zirconium.

Hydrochloric Acid Isocorrosion Chart*

Figure 1

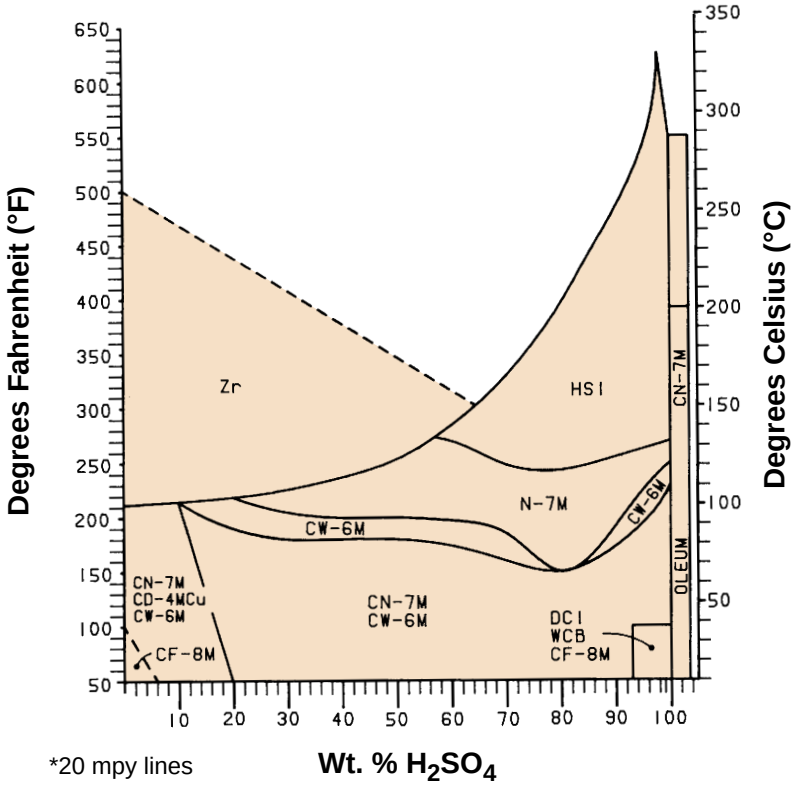


*20 mpy lines

Wt. % HCl

Sulfuric Acid Isocorrosion Chart*

Figure 2



*20 mpy lines

Wt. % H_2SO_4

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