Durcomet 100

CD4MCuN

Bulletin A/7l

Durcomet 100

Introduction

Durcomet 100 is a duplex stainless steel produced to ASTM specification A995 or A890, Grade CD4MCuN (1B). It is indicated by the Flowserve casting symbol CD-4M. The original non-nitrogen bearing version of this alloy was developed by the Ohio State University Research Foundation in conjunction with Flowserve Corporation, while under contract with the Alloy Casting Institute. Flowserve continued to refine the composition by adding nitrogen to further improve the corrosion resistance and mechanical properties of the alloy. Today, only the nitrogen bearing grade is recognized in the ASTM specifications.

The alloy was originally developed to address the demand for a higher strength casting alloy possessing ductility and hardness combined with corrosion resistance equal or superior to the various 18% chromium-8% nickel stainless steels. Additionally, improved resistance to erosion and velocity conditions was sought. Durcomet 100 has not only met these demands, but has proven superior even to Alloy 20 in certain corrosive media, with and without solids in suspension.

Flowserve has poured thousands of tons of Durcomet 100. The successful application of Durcomet 100 pumps and valves attests to the complete suitability of this alloy for many corrosive and erosive-corrosive media.

Chemical Composition

The composition listed in Table I shows why Durcomet 100 exhibits outstanding corrosion and erosion-corrosion resistance. The high chromium content combined with balanced quantities of nickel, copper, and molybdenum is responsible for imparting the outstanding corrosion resistance. The addition of nitrogen, in combination with the molybdenum and chromium, is responsible for the improved pitting and crevice corrosion resistance.

Seldom do you encounter an iron-base alloy with relatively low quantities of nickel, copper and molybdenum that possesses outstanding corrosion resistance to such a broad range of corrosives. Durcomet 100 is produced to a 0.04% maximum carbon content, and this, combined with a high chromium content, practically eliminates potential dangers from intergranular corrosion.

This composition also results in a duplex structure of approximately 50% to 60% ferrite and 40% to 50% austenite. The high ferrite content makes this alloy magnetic.

Table I Chemical Composition

Element	Percent
Chromium	24.5-26.5
Nickel	4.7-6.0
Copper	2.7-3.3
Molybdenum	1.70-2.30
Silicon	1.00 max.
Manganese	1.00 max.
Nitrogen	0.10-0.25
Carbon	0.04 max.
Phosphorus	0.04 max.
Sulfur	0.04 max.
Iron	Balance

Mechanical and Physical Properties

The chemical composition indicates Durcomet 100 would have outstanding mechanical properties and this is verified by actual test data. Compared to the more common CF8, CF8M, and CN7M alloys (cast equivalents of 304, 316 and Alloy 20, respectively), the yield strength is 2 to 3 times greater and there is an accompanying increase in tensile strength. The alloy possesses appreciable ductility in addition to such high strength and, at the same time, is approximately twice as hard as CN7M. The nominal mechanical properties of Durcomet 100 are shown in Table II.

Though secondary to mechanical properties when considering fluid handling chemical process equipment, physical properties cannot be overlooked. The physical properties of Durcomet 100 closely resemble other stainless steels. Table III lists the physical properties of this alloy.

Table II Mechanical Properties

Tensile Strength, ksi (MPa)	100	(690)
Yield Strength, ksi (MPa)	70	(485)
Elongation, % in 2"	16	
Typical Hardness, Brinell	224	
Typical Impact Strength, Charpy v-notch ft-lbs (Joules)	40	(53)

Table III Nominal Physical Properties

Density, lbs/cu in (g/cc)	0.280	(7.79)
Melting point, °F, approx. (°C)	2700	(1483)
Specific Heat, Btu/lb/°F @ 70°F (21°C)	0.11	
Specific Electrical Resistance microhms/cm^3 @ 70°F (21°C)	75	
Thermal Conductivity,		
Btu/hr/ft^2/ft/°F @ 212°F	8.8	
(Watts/m-K @ 100°C)		(15.9)
Btu/hr/ft^2/ft/°F @ 1000°F	13.4	
(Watts/m-K @ 540°C)		(24.2)
Coefficient of Thermal Expansion		
in/in/°F x 10^{-6}, 32 to 212°F	6.5	
(cm/cm/°C, x 10^{-6}, 0 to 100°C)		(11.7)

Heat Treatment

Maximum corrosion resistance is obtained in Durcomet 100 by employing a quench anneal heat treatment on all castings. This heat treatment consists of uniformly heating Durcomet 100 to 1900°F (1040°C) minimum, and then quenching in water.

Welding

Durcomet 100 castings can be welded using the same techniques employed to weld other stainless steels. Preheating is not required, but after welding the castings should be re-heat treated to restore optimum corrosion resistance and eliminate the possibility of post-weld embrittlement. Electrodes or filler metal should have the same composition as the base metal. It is more important for the weld metal composition to match the base metal with this alloy than with other stainless steels because the high tensile properties of Durcomet 100 are influenced critically by chemical composition.

Specifications

Durcomet 100 is produced to the chemical and mechanical requirements of ASTM A995 or A890, Grade CD4MCuN (1B).

Corrosion Resistance

For any alloy to find application in chemical process equipment it must exhibit corrosion resistance to a wide variety of media. Durcomet 100 has exceeded original expectations in its range of applicability. Though originally developed for highly oxidizing applications in which solids are in suspension, the alloy has also shown excellent results in reducing environments.

Being a high chromium-bearing alloy it is not surprising that Durcomet 100 has outstanding resistance to nitric acid. See Figure 1.

Sulfuric acid is the most widely used chemical in industrial applications today so it was a pleasant surprise to learn Durcomet 100 is superior to the 18% chromium-8% nickel type alloys in sulfuric acid applications. In dilute concentrations it is even superior to the widely accepted sulfuric acid resistant material Durimet 20 (CN7M). As would be expected, Durcomet 100 is less resistant to deaerated sulfuric acid than it is to aerated acid. Figure 2 is an isocorrosion curve for

Corrosion Resistance
continued

Durcomet 100 in deaerated sulfuric acid. Also shown on this curve is Type 316 stainless steel and Durimet 20. Aeration or the presence of oxidizing contaminants such as nitric acid, ferric sulfate, or copper sulfate would extend the range of applicability of Durcomet 100 in sulfuric acid applications.

Durcomet 100 also has excelled in fertilizer production. In the wet process of producing phosphoric acid, the phosphate rock normally contains fluorides. In addition, several stages of the operation also may contain varying quantities of sulfuric, hydrofluoric, fluosilicic and phosphoric acids as well as solids. With or without the presence of solids CD4MCuN, with its superior erosion resistance, has become the most economical choice over Alloy 20 for this type of application.

In most instances the presence of sulfuric acid, hydrofluoric acid, fluosilicic acid and/or solids will have a pronounced effect of the corrosion and/or erosion-corrosion rate of Durimet 20 and Durcomet 100 equipment. However, experience has shown the accelerating effect is far less drastic on Durcomet 100 than it is on Durimet 20. For purposes of comparison, Figure 3 is an isocorrosion curve of Durcomet 100 and Durimet 20 in commercially pure phosphoric acid.

Pitting and Crevice Corrosion Resistance

Pitting and crevice corrosion are localized forms of corrosion that can occur with stainless steels in acid chloride solutions, seawater, bleach and oxidizing salts such as ferric chloride or cupric chloride. Pitting corrosion occurs on random areas of wetted surfaces and has the appearance of small, sharp cavities (pits). Crevice corrosion, as the name implies, occurs under crevices such as gaskets or under deposits.

An alloy's resistance to pitting and crevice corrosion is related to its composition, specifically the chromium, molybdenum and nitrogen contents. To measure the effect of these alloying elements a formula known as the Pitting Resistance Equivalent Number (PREN) was developed. This formula:

$$PREN = \%Cr + 3.3(\%Mo) + 16(\%N_2)$$

can be used to rank the pitting and crevice corrosion resistance of alloys. The higher the number, the greater the resistance to pitting and crevice corrosion.

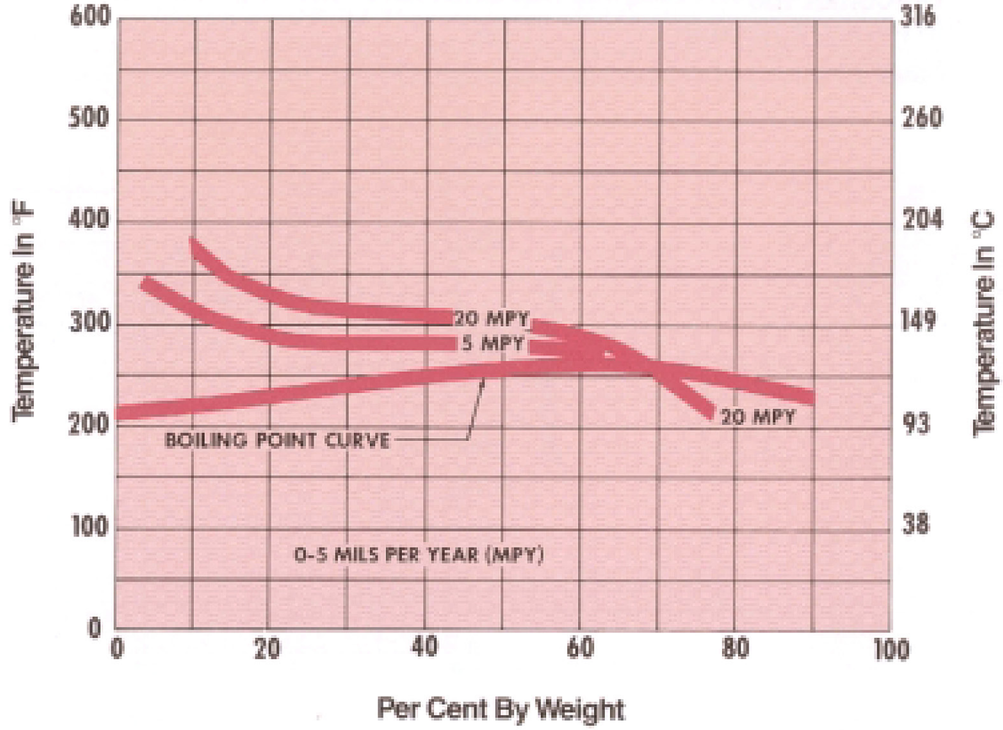
CD4MCuN has greater crevice and pitting resistance than Alloy 20, cast 316 and cast 317. The improved crevice and pitting resistance will increase Durcomet 100's tolerance for chlorides without resorting to more expensive alloys like the high molybdenum austenitics and nickel based alloys. For specific services please contact your Flowserve Sales Engineer or the Materials Engineering Group at (937) 226-4476.

Table IV Alloy PREN Ranking

Alloy	PREN
CW6M (DC3)	74
CK3MCuN (254SMO)	41
CD4MCuN (Durcomet 100)	33
CG8M (317)	29
CF8M (316)	25
CN7M (D20)	25

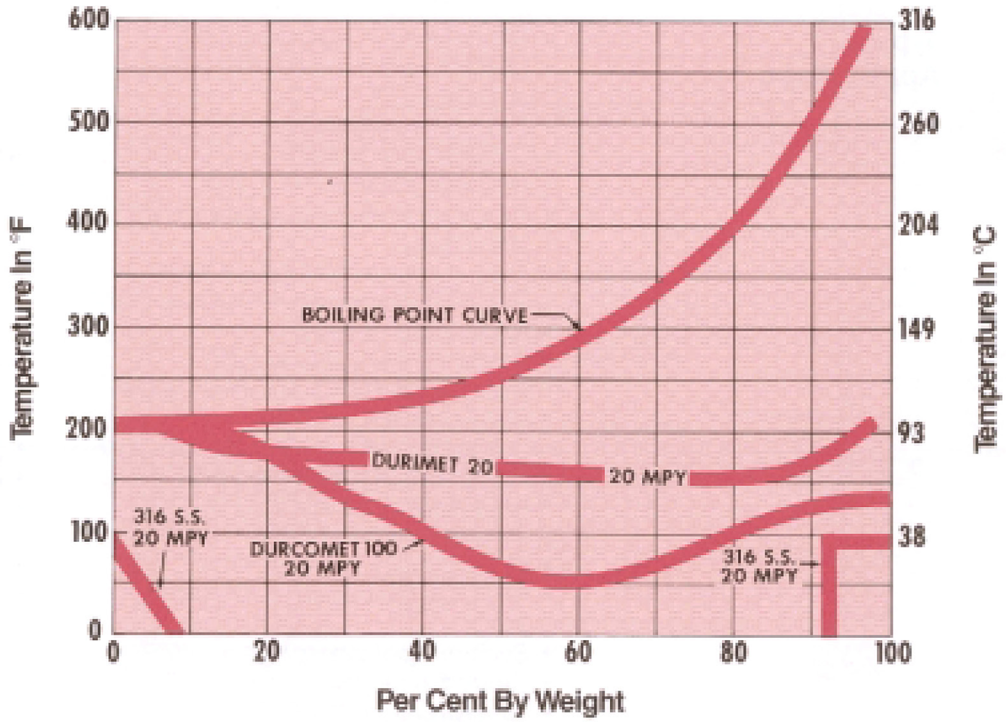
Durcomet 100 in Nitric Acid

Figure 1



Durcomet 100 in Sulfuric Acid

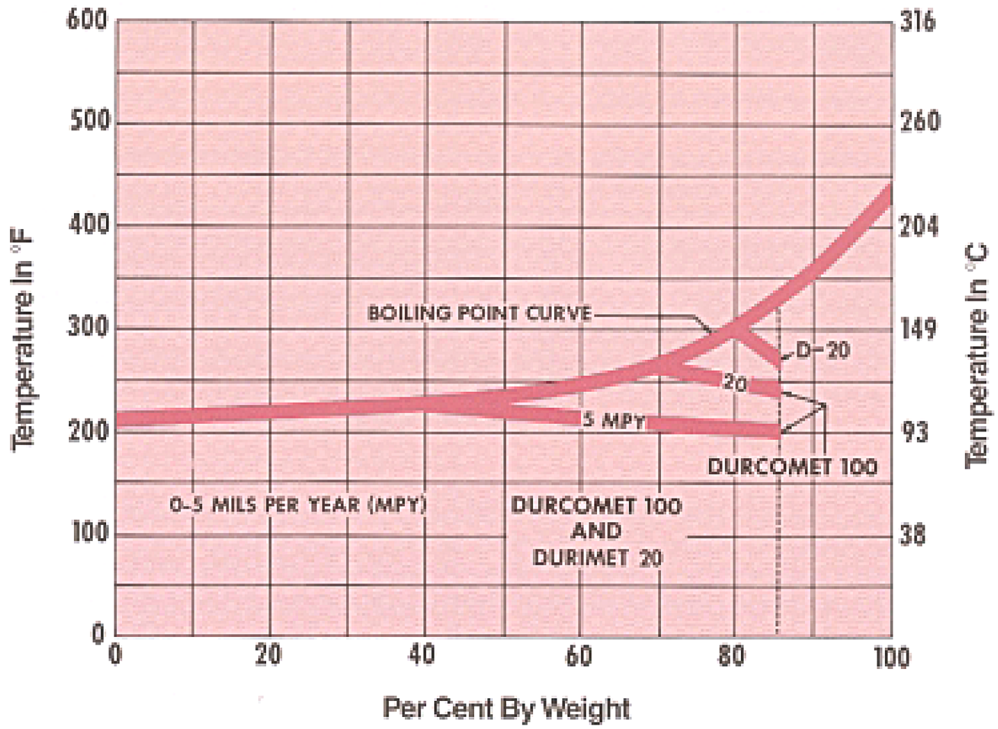
Figure 2



Durcomet 100

Durcomet 100 In Phosphoric Acid

Figure 3



Typical Applications

- *Sour water and lime slurry at 80°F*
- *1.5-5.0% H_2SO_4 +20% $(NH_4)_2SO_4$ solids at 150°F*
- *Corn syrup at 140°F*
- *Carbon slurry at 180°F*
- *Fatty acids with solids to 300°F*
- *Nitric-adipic mixtures to boiling point.*
- *Mica slurry*
- *Alum slurries with H_2SO_4 to 180°F*
- *Heavy black liquor, 50% solids at 210°F*
- *Green liquor at 180°F*
- *Pure and crude H_3PO_4 to 200°F*
- *Wet process H_3PO_4 slurries to 200°F*
- *Starch solution, ambient*
- *Ore slurries with dilute H_2SO_4 to 175°F*
- *Potash-ore slurries up to 200°F*
- *Weak acid slurry with FeO at 210°F*
- *Lime mud slurry at 212°F*
- *Sugar refining refuse at 180°F*
- *NaCl, $CaCl_2$ solutions & slurries to 300°F*
- *Sodium tripolyphosphate at 140°F*
- *Crude and pure glycerine to 170°F*
- *46% $NaClO_3$ at 115°F*
- *Dye slurries at 68°F*
- *Sodium cyanide at 100°F*
- *Sulfamic acid + alkaline detergent at 150°F*
- *Cyclohexanol at 120°F*
- *17% Cadmium sulfate, ambient*
- *Maleic anhydride at 140°F*
- *50% NaOH + 3% salt slurry at 200°F*
- *92-98% H_2SO_4 at ambient*
- *10% NaOH, 3% $KMnO_4$, & 50 ppm NaOCl at 110°F*
- *73% NaOH at 225°F*
- *Chrome waste liquor, ambient*
- *Cu $(NO_3)_2$ solution at 210°F*
- *Methanol & benzene at 120°F*
- *Dilute H_2SO_4, HNO_3, & HF at 90°F*
- *NaF and $NaHF_2$ solution at 160°F*
- *Uranium oxide scrubber solution*
- *Hot oil at 600°F*
- *Scrubber solution with Al_2O_3 and HF*
- *$NaNO_3$ + Mg slurry with heptane at 120°F*

Corrosion Chart

The following corrosion chart can be used as a guide in comparing Durcomet 100 to Alloy 20 and CF8M. The ratings are not a blanket recommendation or warranty, expressed or implied, for any of the materials for any media. These ratings are the compilation of extensive laboratory, field tests and operating experience.

	Durcomet 100	Durimet 20	Durco CF8M
Acetate solvents	E	E	E
Acetic acid, all strengths	G	G	S
Acetic anhydride	G	G	G
Alum	G	G	S
Aluminum chloride	S	S	P
Aluminum sulfate & H_2SO_4	G	G	S
Ammonium chloride	S	G	P
Ammonium fluoride with sodium bisulfate	G	G	S
Ammonium hydroxide	E	E	E
Ammonium nitrate	G	E	G
Ammonium phosphate	G	G	G
Ammonium sulfate	G	G	S
Ammonium sulfate & H_2SO_4	G	G	S
Aniline dyes	G	G	G
Aniline hydrochloride	S	S	P
Anodizing solutions	G	G	S
Antimony trichloride	S	S	P
Arsenic acid	G	G	G
Barium chloride	G	G	P
Barium nitrate	G	E	G
Barium sulfate	G	G	G
Benzoic acid	E	E	G
Black liquor	G	G	G
Boric acid	G	G	G
Brine, alkaline	E	E	S
Bromine, dry	S	S	P
Butyric acid	E	E	G
Cadmium sulfate	E	E	G
Calcium bisulfite	G	G	G
Calcium bisulfite & H_2SO_4	G	G	S
Calcium chlorate	S	G	S
Calcium chloride	S	E	P
Calcium hypochlorite	P	P	P
Calcium phosphate	G	G	G
Carbolic acid	E	E	E
Carbon bisulfide	G	G	G
Carbonic acid	E	E	G
Carbon tetrachloride	G	G	S

	Durcomet 100	Durimet 20	Durco CF8M
Cellulose acetate	G	G	G
Chloroacetic acid	P	P	P
Chlorinated water	S	S	P
Chlorine gas, moist, at room temperature	P	P	P
Chromic acid	S	S	P
Citric acid	E	E	G
Copper nitrate	G	E	G
Copper silver nitrate	G	G	G
Copper sulfate	E	E	S
Copper sulfate + 10% H_2SO_4	G	G	S
Cupic chloride	P	P	P
Cuprous chloride	G	G	P
Ethylene dichloride	S	S	P
Fatty Acids	E	E	G
Ferric Acetate	E	E	G
Ferric chloride	P	P	P
Ferric ferro-cyanide (prussian blue)	G	G	G
Ferric nitrate	G	E	G
Ferric sulfate	E	E	G
Ferric sulfate + 10% H_2SO_4	G	G	S
Ferrous sulfate	E	E	S
Ferrous sulfate + 10% H_2SO_4	G	G	S
Formaldehyde	E	E	G
Formic acid (& with acetic Acid)	G	G	S
Glycerin, crude	G	G	G
Hydrochloric acid (below 150°F)	P	P	P
Hydrofluoric acid	S	G	P
Hydrofluosilicic acid	S	G	P
Hydrogen peroxide	G	G	G
Hypochlorite bleach	P	P	P
Iodine, dry	P	S	P
Lactic acid	G	G	G
Lead acetate	G	G	G
Lead nitrate	G	E	G
Lead sulfide	G	G	G
Lithophone	E	E	G
Magnesium chloride	S	S	P
Magnesium sulfate	G	G	G

E=Excellent–Virtually unattacked under all conditions. G=Good–Generally acceptable with a few limitations. S=Satisfactory–Suitable under many conditions; not recommended for remainder. Consult Flowserve Corporation for details. P=Poor–Unsuitable under all conditions.

Corrosion Chart
continued

	Durcomet 100	Durimet 20	Durco CF8m
Maleic acid	G	G	G
Malic acid	G	E	G
Manganese chloride	G	G	P
Mercuric chloride	P	P	P
Mercuric nitrate	G	E	G
Mercuric sulfate	E	E	S
Mercurous sulfate	G	E	S
Metal plating solutions	S	S	P
Mine water	G	G	G
Mixed acid	G	G	S
Nickel chloride	S	S	P
Nickel ammonium sulfate	E	E	G
Nicotine sulfate	E	E	G
Nitric acid, all strengths	G	G	S
Nitric acid + 3% to 5% HF	S	S	P
Nitrobenzene	E	E	E
Oleic acid	E	E	G
Oleum	S	G	S
Oxalic acid	G	G	S
Phenol	E	E	E
Phosphoric acid, all strengths	E	E	G
Phosphoric acid + 2% H_2SO_4 + 1% HF	E	G	P
Picric acid	E	E	G
Phthalic acid	G	G	G
Potassium bisulfate	E	E	G
Potassium chlorate and Hydrochloric acid	P	P	P
Potassium chloride	G	G	P
Potassium hydroxide	G	G	S
Potassium iodide	G	G	G
Potassium nitrate	E	E	E
Potassium sulfate	E	E	G
Pyridine sulfate	G	G	G
Pyrogallic acid	E	E	G
Pyroligneous acid	G	G	G
Sea water	G	S	S
Sodium bicarbonate	E	E	E
Sodium bichromate	G	G	G

	Durcomet 100	Durimet 20	Durco CF8m
Sodium bisulfate	E	E	G
Sodium bisulfite	E	E	G
Sodium chlorate	G	G	G
Sodium chloride	G	G	S
Sodium ferricyanide	G	G	G
Sodium hydroxide	G	G	S
Sodium hydroxide, fused	P	P	P
Sodium hypochlorite	P	P	P
Sodium nitrate	E	E	E
Sodium perchlorate	G	G	S
Sodium phosphate	G	G	G
Sodium sulfate	E	E	G
Sodium sulfide	G	G	G
Sodium sulfite	E	E	G
Sodium thiosulfate	E	E	G
Stannic chloride	P	P	P
Stannous chloride	S	G	P
Stearic acid	E	E	G
Sulfite liquors (calcium and sodium bisulfite)	G	G	G
Sulfite liquors + H_2SO_4	S	G	P
Sulfur	G	G	G
Sulfur chloride	G	G	P
Sulfur dioxide	E	E	G
Sulfuric acid, up to 100°F	S	G	P
Sulfuric acid, 5% to boiling	G	G	P
Sulfuric acid, 60-100% up to 176°F	P	G	P
Sulfuric acid, saturated with SO_2	P	P	P
Sulfurous acid	S	G	S
Sugar solutions	E	E	E
Tannic acid	G	G	G
Tanning liquors	G	G	G
Tar and ammonia	G	G	S
Tartaric acid	G	G	G
Titanic sulfate	G	G	G
Toluene	E	E	E
Zinc chloride	S	G	P
Zinc sulfate	E	E	S

E=Excellent–Virtually unattacked under all conditions. G=Good–Generally acceptable with a few limitations. S=Satisfactory–Suitable under many conditions; not recommended for remainder. Consult Flowserve Corporation for details. P=Poor–Unsuitable under all conditions.

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