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The New York Blower Company ● 7660 Quincy Street, Willowbrook, Illinois 60527-5530

STAINLESS STEEL SPECIFICATIONS FOR FAN EQUIPMENT

INTRODUCTION

Specifiers and users of air-moving equipment are often faced with the presence of corrosive, abrasive, or high temperature conditions which may be detrimental to the service life of standard mild steel fan equipment. Recognizing the limitless variety of stainless steel alloys or polyester resin-based materials of which fan components can be fabricated, and considering the multitude of special purpose paints and coatings currently marketed for such applications, the specification and selection of the single best combination can be a difficult task. The purpose of this Engineering Letter is to provide some general guidelines to assist in the process. Refer to Engineering Letters 16 and 18 for similar guidelines on corrosion-resistant coatings and fiberglass-reinforced plastic (FRP) fan construction.

STAINLESS STEEL ALTERNATIVES

Often, low first cost plays an important role in the selection of a particular type of corrosion-resistant construction; specialty coatings usually offer the lowest initial cost, followed by stainless steel alloy construction, and finally FRP construction. However, this method of selection does not take into account life cycle costing that could result in the least expense over the service life of the product.

Stainless steel and FRP are generally superior to specialty paints or coatings when it comes to corrosion resistance. FRP will usually exhibit the best corrosion-resistant characteristics and will handle certain corrosive agents or reagents that stainless steel will not, and in some sizes is as economical as stainless alloys. However, stainless steel alloys are capable of higher temperatures and will stand up much better to the impact of non-abrasive materials. Also, fabrication methods tend to limit the availability of FRP fan equipment and certain performance requirements may force the consideration of stainless steel alloy construction as an alternate to the superior corrosion-resistant qualities of FRP.

Neither FRP fan construction nor special duty paints or coatings applied to mild steel construction will provide any measure of prolonged service life in an abrasive application when compared to mild steel. Even stainless steel alloys with their seemingly "tough" close textured surface finish provide negligible improvement over mild steel in abrasive applications. There are, however, special alloy steels classified in the "abrasion resistant" or "AR" grouping. Such AR steels are usually made to a minimum 321 brinell hardness specification where, for example, 304 stainless steel is rated at only 124 to 147 brinell hardness while 316 stainless steel is only slightly harder.

TEMPERATURE CONSIDERATIONS

Typically, mild steel's strength decreases rapidly at elevated temperatures, affecting the maximum safe operating speed of the fan wheel and consequently reducing the effective performance range of the fan. Beyond 800°F., mild steel and even 304 stainless steel are not well suited for rotating parts. At temperatures up to 1000°F., 316 stainless steel should be considered first because of its cost and availability. Only where 316 stainless steel does not allow adequate speeds at the required temperature should 347 stainless steel wheel construction be specified. Refer to each fan line's bulletin for speed derate factors.

In all cases, the suitability of a particular fan to operate at the required temperature is solely dependent upon the individual fan design and construction. Maximum safe operating temperatures for fan equipment range to 1000°F. but are also dependent upon the proximity of motors or bearings to hot airstream surfaces. Only where the product literature expressly acknowledges the suitability of the basic fan construction for operation at the required temperature can stainless steel construction be used to obtain the required safe speeds.

STAINLESS STEEL TYPES

Assuming that stainless steel is needed for a specific application, the next step is to determine the best stainless alloy to use.

There currently exist more than 100 registered grades of stainless steel. Certainly, not all of these various alloys can be made available for all of the different sizes and types of fan equipment. To facilitate selection, specification, and production, the availability of stainless steel alloys for fan equipment must be selectively limited.

Basically, stainless steel can be divided into three categories; Martensitics - 12% chromium and iron with carbon in balanced proportion. Ferritics - with higher chromium content and carbon content held low. Austenitics - with nickel added. . . often referred to as 18-8 stainless which is approximately 18% chromium content and 8% nickel content.

Martensitics have the least tendency to work harden. The application of this alloy grouping is usually limited to that of precision parts such as surgical instruments, shear blades, and dies.

Ferritics exhibit the greatest degree of corrosion resistance in this grouping but work harden quite readily and are usually limited to decorative applications such as interior architectural trim, kitchen trim or utensils, and fasteners.

Austenitics provide the best combination of corrosion resistance and ductility. The suitability of these alloys for welding and fabrication methods common to the fan industry reflect the standardization by fan manufacturers.

The Summary of Austenitic Stainless Steel Types on page 3 presents alloy composition, strength characteristics, and typical applications for the various stainless steel alloys in the Austenitic category.

Of the Austenitic alloys shown, some further limitations are placed on the fan manufacturer due to material availability, inventory needs and costs, and specific production methods.

Refer to Engineering Letters 16 and 18 for condensed guides to the corrosion-resistant characteristics of stainless steel alloys. Note that these are condensed references and do not present the full extent of the corrosion-resistant characteristics of any grade. Since the information is based on chemically pure reagents, customer in-plant testing of a particular stainless alloy in the actual environment is recommended to determine suitability.

MANUFACTURING CONSIDERATIONS

The typical fan manufacturer rarely has the opportunity to purchase an adequate quantity of duplicate parts in the same stainless alloy construction that would warrant direct purchases from the mill. Instead, “per job” purchases limit the fan manufacturer to those alloys which are most readily available from steel distributors.

Because of the dissimilar physical and mechanical properties of the stainless alloys, equipment fabrication methods often vary from the standards established for mild steel construction. For example, production equipment capable of handling 1/4" carbon steel may only be capable of handling 3/16" thick stainless. Likewise, the basic fan construction may involve heavy gauge components cut to size on standard flame burning equipment, but when stainless steel is required plasma-arc cutting equipment becomes necessary. Typically, fan construction involves spun-inlet venturi sections or spun wheel components. It may be more economical to furnish all such spinnings of one grade of stainless steel, allowing an interchangeable inventory. Similarly, castings may be furnished of one grade of stainless instead of maintaining 3 or 4 various grades and incurring added inventory expense.

Of the Austenitic alloys shown in the summary on page 4, 304, 304L, 316, 316L, and 347 stainless steels provide an adequate variety of corrosion resistance and strength characteristics and are readily available from steel distributor stock. These specific stainless steel alloys can be consolidated into versatile 304, 316, and 347 stainless steel construction groupings.

Recognizing the availability of these various stainless steel construction classifications, a determination can be made regarding the suitability of a particular group for a given application based on the following:

304 stainless steel - good corrosion resistance at a minimum price. Under this alloy grade, machined parts such as shafting could be furnished from 304 stainless steel. However, in order to optimize production, **nyb** only offers 316 stainless steel shafting. Welded parts such as housings or wheels must be fabricated from 304L stainless steel. Beyond 800°F., the strength characteristics of 304 stainless steel are not sufficient to warrant recommendation.

316 stainless steel - better corrosion resistance than 304 and good strength characteristics at elevated temperatures. Though higher in price, this alloy grade is the most versatile. Welded components must be fabricated from 316L stainless steel which is a low carbon grade stabilized for welding.

347 stainless steel - corrosion-resistant characteristics similar to 304 stainless steel but with the highest strength characteristics at elevated temperatures. Since it is the highest in initial cost and most difficult to obtain, 347 stainless steel should only be used where rotating speeds and elevated temperatures demand its use for wheel construction.

The corrosion-resistance guide on page 3 provides a reference to the corrosion-resistance characteristics of 304 and 316 stainless steel alloys. For the purposes of this guide, the corrosion-resistance of 347 stainless steel is considered similar to 304 stainless steel and should only be used if high temperature is a factor. Note that this is a condensed reference and does not represent the full extent of the corrosion-resistance characteristics of any grade. Because this information is based on chemically pure reagents, customer in-plant testing of a particular stainless alloy in the actual operating environment is recommended to determine suitability.

CORROSION-RESISTANCE GUIDE

Corrosive Agent	Stainless Steel Alloy		Corrosive Agent	Stainless Steel Alloy	
	304*	316		304*	316
Acetic Acid	S	E	Lactic Acid	S	E
Acetic Anhydride	S	E	Magnesium Carbonate	E	E
Acetone	E	E	Mercuric Chloride	N	N
Acetylene	E	E	Methyl Alcohol	E	E
Aluminum Acetate	E	E	Methyl Ethyl Ketone	E	E
Aluminum Chloride (dry)	N	S	Mineral Oil	E	E
Ammonia (dry)	E	E	Moisture	E	E
Ammonia (wet)	E	E	Naptha	E	E
Ammonium Sulfite	S	E	Nitric Acid	E	E
Aniline	E	E	Ozone	S	S
Barium Chloride	E	E	Perchloric Acid	N	N
Benzene	E	E	Phenol	E	E
Boric Acid	E	E	Phosphoric Acid	S	E
Bromine Water	N	N	Polyvinyl Acetate	E	E
Butane	E	E	Potassium Chloride	S	E
Calcium Chloride	S	S	Potassium Cyanide	E	E
Carbon Tetrachloride (dry)	S	E	Potassium Dichromate	E	E
Chlorine Gas (dry)	S	S	Potassium Hydroxide	E	E
Chlorobenzene	S	S	Pyridine	S	S
Citric Acid	E	E	Salt Spray	S	S
Copper Sulfate	E	E	Silver Nitrate	E	E
Cyclohexaone	S	S	Sodium Bicarbonate	E	E
Ethyl Acetate	S	E	Sodium Chloride	S	E
Ethyl Alcohol	E	E	Sodium Cyanide	E	E
Ethylene Dichloride	E	E	Sodium Dichromate	S	S
Ethylene Oxide	S	S	Sodium Hydroxide	E	E
Ferric Chloride	N	N	Sodium Hypochlorite	N	N
Ferric Nitrate	E	E	Sodium Sulfate	E	E
Fluorine Gas (dry)	E	E	Steam Vapor	E	E
Formaldehyde	E	E	Sulfamic Acid	T	S
Formic Acid	S	E	Sulfur Dioxide (dry)	S	E
Gasoline	E	E	Sulfur Dioxide (wet)	N	S
Glycerine	E	E	Sulfuric Acid	N	S
Hydrochloric Acid	N	N	Tannic Acid	S	E
Hyfrofluoric Acid	N	N	Toluene	E	E
Hydrogen Peroxide	E	E	Trichloroethylene	S	S
Hydrogen Sulfide (dry)	S	E	Xylene	E	E
Hydrogen Sulfide (wet)	N	S	Zinc Chloride	N	S
Iodine	N	N	Zinc Sulfate	E	E

E = Excellent S = Satisfactory N = Not Recommended T = Test data not available

* 347 stainless steel is considered to have the same corrosion-resistance characteristics as 304 stainless steel.

SPARK RESISTANCE

A common misapplication of stainless steel is in areas requiring non-sparking materials. Since stainless steels are basically alloys of chromium and iron, or of chromium, iron, and nickel, they are considered ferrous and sparking. As a result, the availability of SRC with stainless steel construction is very limited. In some cases, a Monel shaft and/or Monel buffers may be furnished to allow for some types of SRC construction. However, in other cases, all that is available are steps short of SRC construction which can be added to the fan to minimize the potential for generating sparks. The specific modifications vary depending upon the product, so consult **nyb** for availability.

SPECIAL ALLOYS

Under the general description of stainless steel, there are many other special alloys; some more corrosion resistant, and some more abrasion resistant. These specialized alloys require careful considerations of costs, availability, design suitability, and fabrication methods. Therefore, their selection and specification should be left to specific applications.

SUMMARY

Any equipment is only as good as its weakest component. If the corrosive gas stream requires that 316 stainless steel be specified, 304 or 347 stainless steel should not be substituted because of limited corrosion resistance. If 304 stainless steel is all that is necessary to combat the corrosion and 316 stainless steel wheel construction is adequate to obtain the safe speed at the required temperature, there is no reason to substitute the more expensive 347 stainless steel alloy. The 347 stainless steel alloy grade should never be specified based solely upon its corrosion-resistant characteristics; its only advantage over 316 is higher rotating speeds at elevated temperatures.

SUMMARY OF AUSTENITIC STAINLESS STEEL TYPES

Type 301. A 17% Cr., 7% Ni. grade used primarily in structural applications and where high strength plus high ductility is required. Corrosion resistance is slightly less than Type 302.

Type 302. The basic 18% Cr. 8% Ni. possesses excellent corrosion resistance to many organic and inorganic acids and their salts at ordinary temperatures. Also has good resistance to oxidation at elevated temperatures. Can be readily fabricated by all methods usually employed with carbon steels. Cr-Ni grades are nonmagnetic in the fully annealed condition and cannot be hardened by conventional heat treatment. Type 302 is subject to carbide precipitation due to welding.

Type 303. The basic 18-8 composition with the addition of one or more other elements, usually phosphorus, sulfur and/or selenium to improve machinability. Also used when minimum galling and seizing is desired. Corrosion resistance under certain conditions may be somewhat lower than Type 302. Special precautions are necessary in welding Type 303.

Type 304. Similar to Type 302 in chemical analysis except carbon is .8% max. The lower carbon decreases susceptibility to carbide precipitation in the 800°F. to 1550°F. temperature range, making it useful over a wider range of corrosive conditions than Type 302.

Type 304L. An extra low carbon analysis similar to Type 304 except carbon is .3% max. Carbide precipitation does not occur if material is not held over two hours in the 800°F. to 1550°F. temperature range. Thus corrosion resistance is not affected by normal welding and stress relieving applications.

Type 305. A modified Type 304 grade of lower chromium, higher nickel content to reduce tendency to work harden when severely cold worked. Particularly well suited for difficult forming, perforating, etc., where rapid work hardening makes fabrication difficult.

Type 308. A 20% Cr. 10% Ni. grade providing somewhat better corrosion resistance than the 18-8 grades. Because of its higher alloy content, it is less susceptible to carbide precipitation than Type 304.

Type 309. A 24% Cr. 12% Ni. steel combining excellent resistance to oxidation with high tensile and creep strength at elevated temperatures. It resists oxidation at temperatures up to 2000°F. under normal conditions.

Type 310. A 25% Cr. 20% Ni. analysis having slightly higher oxidation resistance and creep values than Type 309. Lower Coefficient of Expansion gives less tendency to warp and throw scale in fluctuating temperatures.

Type 314. Essentially Type 310 with the addition of approximately 2.50% silicon to increase resistance to oxidation and to retard carburization.

Type 316. A modified 18-8 grade containing approximately 2.50% molybdenum. It is more resistant to corrosive action of most chemicals, especially sulfuric acid and fatty acids. Type 316 is less susceptible to pitting and pin hole corrosion by acetic acid vapors, chloride solutions, etc. The tensile and creep strength at elevated temperatures are also superior to the other Cr-Ni types. Type 316 is subject to carbide precipitation due to welding.

Type 316L. Similar to Type 316 in analysis except carbon is .3% max. It is immune to harmful intergranual corrosion providing it is not held in the 800°F. - 1550°F. temperature range for over two hours.

Type 317. A modified 18-8 stainless containing approximately 3.50% molybdenum. Resistance to corrosion is somewhat better and susceptibility to carbide precipitation is slightly less than Type 316.

Type 321. A modified 18-8 analysis with titanium (five times carbon content minimum) added to make it immune to harmful carbide precipitation. The corrosion resistance of Type 321 is the same as Types 347 and 304.

Type 347. A modified 18-8 formulation with columbium (two times carbon content minimum) added to make it immune to harmful intergranular corrosion. The corrosion resistance of Type 347 is the same as Type 304.