STAINLESS STEEL IN MODERN DAIRY EQUIPMENT – ITS CARE AND MAINTENANCE[1]

R. B. Gunia

U. S. Steel Corporation, Pittsburgh, Pa.

Historically, the stainless steels are late arrivals on the scene when compared with other metals which have been in use for many years. No one knows precisely who should receive credit for the development of the stainless steels, but it is rather widely accepted that the earliest research work on these alloys occurred during the early 19th Century. Usually credit is given to the English and Germans who developed alloys, in the period from 1910 to 1915, which were very similar to those in use today. Comparatively few uses for these alloys developed until the mid 1920's when their commercial production began in this country. It is significant that most observers report that the first commercial sales in this country involved the application of stainless to dairy equipment. Indeed, several American stainless steel producers point with pride to dairy equipment that has been in continuous service for about 35 years.

In the best American tradition this is a fascinating story of ingenuity and inventiveness. From those small beginnings in about 1924 the United States stainless steel production has steadily increased until it now exceeds a million ingot tons annually. And this is only the opening chapter.

What Is Stainless Steel?

The American Iron and Steel Institute has defined stainless steels rather broadly as alloys of iron containing chromium above 4% and sometimes including other elements such as nickel, titanium, columbium or molybdenum. About 40 standard compositions comprise the steels to which this name is given. Metallurgically, these alloys can be divided into three broad classes: (*a*) the martensitic group which includes the alloys which are hardenable by heat treatment, (*b*) the ferritic group which are not hardenable by heat treatment, and (*c*) the austenitic group which are hardenable only by cold working. In the dairy industry the ferritic and austenitic steels are of the most interest (see Table 1).

Although these steels as a class are called "stainless" it is important to explain that this name must be taken only in a relative sense. The addition of about 10 to 12% of chromium to iron confers to these alloys a remarkable resistance to chemical attack. Nickel and molybdenum additions further improve the corrosion resistance. Many corrosive agents which readily damage ordinary steels have little or no effect on these alloys. Thus, it would be preferable perhaps to refer to these steels as "corrosion resistant" steels rather than as stainless steels.

What makes stainless steel stainless? A number of theories have been advanced to explain the superior corrosion resistance of these steels. The most generally accepted theory states that the development of a thin, transparent, impervious, surface film of oxide occurs almost instantaneously upon exposure of these alloys to oxidizing environments and is responsible for this remarkable behavior. This film is quite tenacious and has the marvelous ability to heal itself

[1]Presented before the St. Louis District Chapter of the Institute of Sanitation Management, St. Louis, Missouri, October 27, 1960.

Table 1—Standard AISI Compositions of Stainless Steels Used in the Dairy Industry

Name	AISI Type No.	C	Mn	P	S	Si	Ni	Cr	Others
USS 17-4-6	201	.15 max.	5.50/7.50	.080	.030	1.00 max.	3.50/5.50	16.00/18.00	N .025 max.
USS 18-5-8	202	.15 max.	7.50/10.00	.060	.030	1.00 max.	4.00/6.00	17.00/19.00	N .025 max.
USS 18-8	302	.15 max.	2.00	.045	.030	1.00 max.	8.00/10.00	17.00/19.00	
USS 18-8 S	304	.08 max.	2.00	.045	.030	1.00 max.	8.00/12.00	18.00/20.00	
USS 18-8 FM	303	.15 max.	2.00	0.20 max.	0.15 min.	1.00 max.	8.00/10.00	17.00/19.00	Mo. 60 max. Zr. 60 max.
USS 17	430	.12 max.	1.00	.040	.030	1.00 max.	—	14.00/18.00	

under proper oxidizing conditions. Incidentally, the air we breathe is a most powerful oxidizer.

These steels have a high degree of resistance to the oxidizing acids such as nitric acid. However, the so-called reducing acids, such as hydrochloric, dilute sulphuric, or hydrofluoric will attack stainless readily except under the most carefully controlled conditions.

MANUFACTURE

The manufacture of stainless steel begins with the careful selection of the raw materials required. These are melted in electric arc furnaces under precisely controlled conditions. The molten metal is cast into ingot molds and allowed to cool. Then the ingots are reheated and rolled in heavy rolling mills to slab or billet form depending on the desired end product. The slabs, or billets, are permitted to cool and are then conditioned by grinding with rough abrasive wheels to remove certain surface imperfections that occur in these early stages of manufacture.

To produce sheet and strip, the slab, about 3″ to 4″ thick and 15′ to 18′ long, is again reheated and rolled on a hot strip mill into a coil about .150″ thick and several hundred feet in length. On a continuous annealing and pickling line the hot rolled strip is annealed and pickled. This operation puts the metal in the proper internal metallurgical condition for further processing and removes the heavy surface scale and oxide which develop during hot rolling and annealing. Next the steel is cold rolled, often in stages, to the desired thickness. After cold rolling the coil is given a final anneal and pickle to impart desired mechanical properties and surface qualities. Finally, the coil is cut to length, inspected, packaged, and shipped.

In our illustration we have simplified the actual operations for clarity. At every stage of processing, extreme care is taken and careful inspection is provided to make certain that the desired quality is truly "built-in" in the finished product.

Sheets processed as we have outlined are known in the trade as 2D finish sheets. A 2B finish is produced by subjecting the 2D finish to a "temper" pass on a cold mill. This light cold pass adds some surface smoothness and luster. Such sheets can be polished mechanically with abrasive belts to a variety of finishes such as No. 3 or No. 4 finish. Much of the sheet product employed by the dairy industry is used in the polished finishes.

In discussing the manufacture of stainless steel a typical "cold reduction" process has been used for illustration. Other methods are also used in the stainless industry and each will result in a product equally acceptable to the dairy industry.

TERMINOLOGY

As stated earlier, the ferritic and austenitic stainless steels are most widely used in dairy equipment. These are known as USS-17, Type 430 and USS-18-8, Type 302. These alloys are known more familiarly as "straight chromium" and "18-8," respectively. The familiar names derive from their chemical compositions which in the case of USS-17 contains 17% chrominimum and in the USS-18-8 a chromium content of 18% and a nickel content of 8%. In machined parts such as valves, Type 303, an 18-8 especially modified to improve its machinability, is used.

Some quantities of AISI Types 201 and 202 were used successfully in the dairy industry when nickel supplies were critically short during the Korean War. Type 201 has a nominal composition of 17% Cr, 6% Mn, 4% Ni; Type 202 has a nominal composition of 18% Cr, 8% Mn and 5% Ni. Both alloys also contain about 0.15% nitrogen which in combination with the higher manganese replaces some of the nickel.

CHARACTERISTICS AND USES

All of these types of stainless lend themselves readily to bending, drawing, spinning and welding. Thus, they can be easily fabricated into tanks, vats, vessels, pipe and coils.

The 17% chromium alloy is seldom, if ever, used in contact with milk or milk products. It is used principally as trim or for external vessel walls.

Milking machines, pails, cream separators, bulk milk tanks, trailer truck tanks, pasteurizers, milk coolers, and various other kinds of dairy equipment are available in stainless steel from leading manufacturers.

Stainless steel possesses many attributes that make it so widely used in the modern dairy industry. For many reasons stainless is the most nearly perfect material yet discovered for handling milk and milk products. It does not impair the flavor of the milk or dairy products with which it comes in contact. Its high polishability gives it a very sanitary surface which is relatively easy to clean and keep clean. It will not break or shatter. It requires no protective coating. It will not chip. It is tough and will stand up under the roughest usage on the farm and in the processing plant.

Even with all these excellent characteristics stainless does have some limitations as do all other products. Stainless is not corrosion-proof, but it is corrosion resistant. Under certain conditions it will corrode. The principal maintenance job with stainless steel is to see that environments that favor corrosion are avoided.

CARE OF STAINLESS STEEL EQUIPMENT

From this brief review it becomes clear that stainless steel can and does play a very important role in the modern dairy industry. And it is equally clear that the benefits to be reaped from the use of this marvelous metal can only be realized when such equipment is accorded proper care and maintenance. Fortunately, the maintenance and care of stainless steel is relatively simple. On the other hand, neglect can be disastrous. Manufacturers of dairy equipment continually emphasize that many years of profitable service can be expected of such equipment only if the ultimate user will faithfully follow the maintenance procedures that have been carefully developed by the equipment manufacturers in conjunction with the various dairy associations and steel producers. In this regard, we can quote with feeling the old adage, "an ounce of prevention is worth a pound of cure," we could also add that the penalty of neglect might well be the failure of some fine and costly equipment.

We know of no rigid Ten Commandments for the maintenance of stainless dairy equipment, but we would emphasize that the first and greatest commandment is *"Follow Directions and Keep it Clean!"*. Most equipment manufacturers believe that there are two principal causes for corrosion, (*a*) allowing chlorine solutions to remain on the surface too long and, (*b*) allowing other objects to come in contact with the surface too long. The problem with chlorine is always present because most cleaning compounds and germicides contain chlorine or its compounds. The contact corrosion is always present too because rubber hose, tools and other articles used on the farm and in the plant have the odd habit of being forgotten in the most unlikely places and all too frequently it happens that the bulk milk tank or the milk cooler provide convenient shelf space.

Equipment can be kept in top condition by following these recommendations:

(*a*) Immediately after each use, rinse equipment thoroughly with clean water to remove milk before it dries.

(*b*) Follow this rinsing, clean with hot water and a commercial dairy cleaner. Use the cleaner in strict accordance with the manufacturer's recommendations. The cleaning solution should be brushed over all surfaces.

(*c*) When detected, accumulations of milkstone or soil deposits should be removed immediately. Commercial milkstone removers used in accordance with manufacturer's recommendations are usually suitable for this purpose. Stubborn deposits may require the use of a *stainless steel* sponge. It is important to use only stainless steel sponge, ordinary steel wool may leave deposits of steel that will form nuclei for corrosive attack.

(*d*) After cleaning, rinse equipment thoroughly with hot water and allow it to dry. Some manufacturers and sanitarians recommend that equipment be sanitized with a chlorine solution after washing. If this practice is used or required, it is most important that the equipment be rinsed to remove this chlorine solution. Prolonged contact of chlorine will cause pitting and corrode the stainless surface.

(*e*) Other manufacturers and sanitarians recommend that stainless equipment be sanitized just prior to use. This is the most favorable procedure to avoid corrosion. The use of chlorine sanitizing solutions prior to the addition of the milk has been satisfactory and is quite safe when proper care is taken.

Often the question has been asked "What is the relative cleanability of the various finishes applied to stainless steel in dairy equipment?" Does number 7 finish possess greater cleanability than number 4, for example? Until recently the answers were usually based on personal opinion. Work just completed at the Michigan State University, Department of Microbiology and Public Health by Kaufmann and his associates (*1*) in this area is enlightening.

After exhaustive tests, Kaufmann and his coworkers, concluded that there is no significant differerence in the cleanability of No. 2B, No. 3, No. 4 or No. 7 finishes. These are the finishes that have been generally specified and most widely used in the dairy industry. The 2B finish is bright cold rolled, the No. 3 is finished on belts 80-100 grit, the No. 4 is finished on belts 120-150 grit and the No. 7 finish is applied using 325 grit belts plus buffing.

The Michigan State study showed that significant differences were observed only when the direct agar contact test was used, and the opinion was expressed that these differences might be attributable to the inefficiency of the test itself. Equally good cleanability of all finishes were observed in the direct surface agar plate test and the swab test, including in the latter the Duncan multiple range test.

Thus this study indicates that the cleaning operations listed above will provide surfaces on equipment in the four finishes that will meet current standards for cleanliness required by the American Public Health Association.

REFERENCES

1. Kaufmann, O. W., Hedrick, T. I., Pflug, I. J., Pheil, C. G. Relative Cleanability of Various Finishes of Stainless Steel in a Farm Bulk Tank. J. Milk and Food Technol., **23**: 377. 1960.