

WHAT SANITARIANS SHOULD KNOW ABOUT STAINLESS STEELS¹

H. L. MITTEN, JR.

*The Creamery Package Mfg. Company
Chicago, Illinois*

Stainless steels are very important metals in the food processing and handling industries for product contacting surfaces of equipment not only for their sanitary characteristics, but also for strength, durability and appearance. Stainless steels are so esteemed that 3-A Sanitary Standards, various sanitary codes, users' specifications and equipment manufacturers demand their use. Yet, there is considerable misunderstanding about stainless steels, and especially about those characteristics such as surface finish, composition, corrosion resistance and cleanability, which are generally regarded as affecting sanitation. It is the purpose of this paper to discuss some of these aspects from a background of experience in the manufacture of processing equipment.

TYPES OF STAINLESS STEELS

Stainless steels are alloys of three main groups: Martensitic, Ferritic and Austenitic. These are metallurgical terms descriptive of the characteristic solid solutions and crystalline structure of the alloys.

While the metallurgy, history and manufacturing procedures may be very interesting, such knowledge is not essential to the sanitarian. The important features to be associated with the three groups of stainless steels are these:

1. Martensitic stainless steels are chromium steels which are hardenable by heat treatment, have great strength under load and shock and are the lowest of the three groups in corrosion resistance. The most important of the stainless steels in this group in food equipment is Type 410. It is used for blades, knives, mill parts, nuts, bolts and other heat-hardened parts.

2. Ferritic stainless steels are also chromium steels, but contain higher amounts of chromium and are not hardened appreciably by heat treatment. Type 430 is probably the most important of this group used in food equipment. It is used for trim, mouldings, counters, exteriors, etc.

3. Austenitic stainless steels are chromium-nickel alloys. They are non-hardenable by heat treatment, have a very high corrosion resistance and are well suited to product contact use. The 300 series of 18-8 stainless steels are in this group.

4. A fourth group which might be added is the precipitation hardenable stainless steels which have corrosion resistance equal to types 302 and 304 and the ability to be hardened by heat treatment. There are several members of this group. In composition, they are chromium-nickel-copper, chromium-nickel-aluminum and chromium-nickel-molybdenum alloys. Of these, the chromium-nickel-copper is most useful in food equipment. It can be hardened throughout by a single heat treatment at temperatures varying from 850° to 1150°F for 1 to 4 hours. This low temperature heat treatment causes so little distortion and dimensional change that all machine work and most of the surface finishing can be done prior to hardening.

The copper in the steels of the fourth group, unlike that in the copper-bearing "white metals", is stable and not extracted by food products or sanitizing chemicals. Upon heat treating, the super-saturated solid solution of copper is precipitated giving a hard metal possessing a Martensitic-like structure interspersed with Ferrite stringers.

The corrosion resistance of 17-4-PH, a typical precipitation hardenable stainless steel of the chromium-nickel-copper type, is equal to that of Types 302 and 304 stainless steel. With dairy and food application environments, there is no tendency toward preferential corrosion when 18-8 and precipitation hardenable stainless steels are in contact with each other.

The precipitation hardenable stainless steels are used in food processing equipment where high strength and great hardness are required. Applications include shafts, pistons, bearings, bolts and nuts.

Table 1 gives standard compositions of several commonly used stainless steels and a precipitation hardening type. The compositions listed in Table 1 are from the *Steel Products Manual, Stainless and Heat Resisting Steels (10)*, except that for 17-4-PH which is from an Armco Steel Corporation Manual (1).

IDENTIFICATION OF STAINLESS STEEL

Often, the sanitarian believes he has need to identify a specific type of stainless steel or to distinguish stainless steel from another metal. Such identification is no simple matter, and the means are not suitable for the amateur metallurgist. If a positive identification of a certain type is necessary, a sample should be sent to a metallurgical laboratory for identification and analysis.

¹Presented at the 48th Annual Meeting of the INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS, INC., at Des Moines, Iowa, August 14-17, 1961.

TABLE I—COMPOSITIONS OF STAINLESS STEELS*

Type	C	Mn (Max.)	P (Max.)	S (Max.)	Si (Max.)	Cr	Ni	Others
302	0.15 Max.	2.00	0.045	0.030	1.00	17.00/ 19.00	8.00/ 10.00	
303	0.15 Max.	2.00	0.20	0.15 Min.	1.00	17.00/ 19.00	8.00/ 10.00	Mo 0.60 Max. ^b Zr 0.60 Max. ^b
304	0.08 Max.	2.00	0.045	0.030	1.00	18.00/ 20.00	8.00/ 12.00	
305	0.12 Max.	2.00	0.045	0.030	1.00	17.00/ 19.00	10.00/ 13.00	
316	0.08 Max.	2.00	0.045	0.030	1.00	16.00/ 18.00	10.00/ 14.00	2.00/3.00 Mo.
410	0.15 Max.	1.00	0.040	0.030	1.00	11.50/ 13.50	-	
430	0.12 Max.	1.00	0.040	0.030	1.00	14.00/ 18.00	-	
17-4-PH ^c	0.07 Max.	1.00	0.040	0.030	1.00	15.50/ 17.50	3.00/ 5.00	3.00/5.00 Cu 0.15/0.45 Ta

*Composition shown does not include iron which makes up remainder.

^bAdded at producer's option; reported only when added intentionally.

^c17-4-PH is not an AISI designation, but a designation of Armco Steel Corporation.

For rough identifications, there are a number of quick tests which can be made by almost any technician. Results from these tests should be used as guides only and not regarded as positive. A number of these tests are given in a booklet called *Working Data* published by the Carpenter Steel Company (11).

Among these quick tests is the nitric acid test which identifies stainless steels from non-ferrous alloys and ordinary steels. The testing solution is made by mixing equal parts of concentrated nitric acid and water. A drop of the solution is placed on a freshly ground spot on the specimen. Boiling action indicates attack. Stainless steels of the 18-8, 300 series are not attacked, but annealed forms of certain of the 400 series are, and further identification tests must be made.

Also among these tests is one which has been the favorite of sanitarians—the magnet test. The 18-8 or Austenitic stainless steels are non-magnetic in the annealed condition, but they are slightly magnetic when cold worked. This may occur during machining, spinning, bending and forming, and during use through vibrations and repeated impacts. Further, Type 316 stainless steel is slightly magnetic. Often stainless sheets are used as cladding over heavy structural steel. In this case the test is useless, for the strong magnetic pull of the structural member is felt through the stainless steel. With

modern fabricating methods and with stainless clad processing equipment, the test for magnetism is of little value.

Other quick tests for the refinement of identification probably have little value to the sanitarian.

Reliable equipment manufacturers make every effort to use the material best suited to the application. Inventory records of the various stainless steels are rigorously controlled to prevent the mixing of types. Many equipment manufacturers require a certified report of analysis for each lot of stainless steel purchased or have an independent analysis run.

SURFACE FINISH

Surface finish may be the most misunderstood of sanitary specifications for stainless steels. The various 3-A Sanitary Standards for Milk equipment nearly all require, "All product contact surfaces shall be at least as smooth as a No. 4 mill finish on stainless steel sheets, or 120 grit finish properly applied". Bakery Industry Sanitation Standards require, "To be smooth, a stainless steel, nickel alloy or similar corrosion-resistant surface shall be finished to at least a No. 2B mill finish", and for product contact surfaces of these metals "at least a No. 2B mill finish or 120 grit finish properly applied", is the requirement.

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the definition describing the steps to be taken and means to be employed in producing the finished surface. There is a considerable range of smoothness, sheen, color, light reflectivity, etc. within any finish. The range is normal, and is influenced by such factors as the type of stainless steel, the gage or thickness of the sheet, the condition of the belts carrying the abrasive grit, the lubrication used during finishing, and others.

The finish designations are standards of the steel industry and may be found in the *Steel Products Manual, Stainless and Heat Resisting Steels* (10). The finishes are distinguished by an arbitrary system of numbers. The unpolished finishes are No. 1, No. 2D and No. 2B, and the polished finishes are No. 3, No. 4, No. 6, No. 7 and No. 8. These are the only mill finishes defined. There is no No. 5 in this scheme. Since each finish contains a rather broad range and is, in fact, a category of finishes within itself, such terms as "No. 5" and "better than a No. 4", which are often used by sanitarians are meaningless.

The finishes most often used for food processing equipment are No. 2B and No. 4. The No. 7 is required by some.

No. 2B

This is a bright cold rolled finish produced by cold rolling to a specified thickness, annealing and descaling. The descaled sheet receives a final light cold rolled pass on polished rolls. No. 2B finish may be used for all but deep drawing operations and is readily polished. No. 2B surfaces have a gray appearance, have a low reflectivity, and readily show up hand prints and soil.

No. 4

This finish is the result of following initial grinding with successively coarser abrasives, with sheets generally finished last with abrasives of approximately 120 to 150 mesh size. No. 4 is probably the most widely used finish for product contact surfaces in food and dairy equipment. Surfaces having a No. 4 finish are bright, have a relatively high light reflectivity, and maintain a good appearance through considerable use.

No. 7

This finish is produced by buffing a finely ground surface. Grit lines are not removed. No. 7 has a high degree of reflectivity. It is easily scratched and murred.

CLEANABILITY

There has been considerable attention given to the cleanability of the various finishes of stainless steel, for this is the factor which is most directly related to sanitation. The most recent series of researches on cleanability is that by Kaufmann *et al.* (5, 6, 7, 8).

The experiments were based on bacteriological methods. The results, in general, indicated that there was no significant difference in the cleanability of stainless steels with No. 2B, No. 3, No. 4 and No. 7 finishes. In another study using radioactive isotopes, Masurovsky and Jordan (9) found no significant difference in cleanability between No. 4 and No. 7 finishes.

These studies used standardized detergent solutions and, so far as possible, standardized procedures for applying the soiling medium and the cleaners. This is the way to get a scientific comparison of cleanability of finishes. Care should be exercised in the interpretation of results, if the conclusions are to be applied practically, for even though there were no significant differences under the conditions of the experiments, it does not follow that with actual processing conditions, a given cleaning procedure and detergent will give equally satisfactory results for each item of equipment and type of soiling medium. If there had been significant differences, it would not have meant that other detergents and other methods would fail to produce clean surfaces. The practical approach when encountering unsatisfactory sanitizing is to change the detergent, the temperatures and the procedures until proper sanitation is obtained.

GAGE OF STAINLESS STEEL

It is not uncommon for sanitarians and users to be concerned about the thickness of the stainless steel in certain applications, and the minimum gage or thickness is written into some of the sanitary standards and codes—nearly always without regard to other construction features.

While it is true that very thin metal walls which are only lightly supported may, under conditions of use, become damaged so as to interfere with proper sanitation, it is also true that various construction features may permit a greater margin of safety than afforded by an unsupported wall of greater thickness.

Sheet thickness is often stated in gage numbers, a system that is often confusing, even to those familiar with it. Table 2 relates sheet thickness in inches to the old U. S. Standard Gage Equivalent Thicknesses. The use of thickness in inches is being encouraged over gage number, and *The Steel Products Manual* (10) states, "It is common practice to specify sheets to the following thicknesses rather than to gage numbers:" (this is followed by a full table from 8 gage to 32 gage).

GALLING OF STAINLESS STEEL

One of the characteristics of stainless steel which limits its use in certain applications is its tendency to

TABLE 2—STAINLESS STEEL SHEET THICKNESS IN INCHES AND GAGE NO.*

Inches	Equivalent gage number
0.172	8
0.141	10
0.109	12
0.078	14
0.062	16
0.050	18
0.037	20
0.031	22
0.025	24
0.019	26
0.016	28

*Taken from *Steel Products Manual* (10)

gall or seize when two parts are under pressure and moving relative to one another. This tendency is accentuated when lubrication is inadequate.

The tendency to gall often makes it imperative for the designer to use another alloy, either harder or softer than the stainless steel and with a different crystalline structure, for one of the parts. Where turning stainless steel shafts must be supported within the product zone, it is often necessary to resort to white metal, nylon, or other material for the bearing.

CORROSION OF STAINLESS STEELS

Stainless steels of the 18-8 series have often been called the life-time metals, and claims are still being made in advertisements and trade paper articles that 18-8 stainless steel is corrosion proof. These are over optimistic statements.

Corrosion is a natural process whereby metals and their alloys tend to revert to one or more forms in which they are found in their ores. Man prolongs the process by metallurgical skills and the control of the corrosive environment, but he cannot completely prevent corrosion. Stainless steels of the 300 series are the most corrosion resistant of the metals which are commonly used for food processing equipment. Luckily, these stainless steels are also very strong, quite hard, and can be welded, machined and formed. They are truly outstanding, but they have limits, and are readily attacked by certain corrosive environments.

Corrosion of the Austenitic stainless steels usually causes pits to form which makes the surface more difficult to clean. If the pitting can be halted while the pits are very shallow no real harm to sanitation is caused, but if pits are allowed to progress until they are steep-sided cavities penetrating deep into the metal, they may constitute a sanitation problem. It behooves the in-plant sanitarian to be alert to the beginning of accelerated corrosion and to take steps to prevent its effects.

In the food industries excessive corrosion of stainless steel originates most often from improperly cleaned surfaces and the misuse of chlorine sanitizers.

Corrosion of stainless steel is often the result of a Galvanic cell where dissimilar metals are connected by a metallic bridge on one hand and by an electrolyte on the other. Stainless steel is peculiar in that under certain conditions it possesses the characteristics of two dissimilar metals. The passive stainless steel at the cathodic end represents one and the active at the anodic end represents the other. Passivity of stainless steel is caused by a very thin protective oxide film on its surfaces. This film forms quickly when clean, dry stainless steel surfaces are exposed to air. When this film is interrupted by too severe scrubbing, scratching or pitting, and moisture is present at the point of discontinuity, an electrical potential exists between the active and passive areas. Current will flow through the stainless steel from the passive area to the active and back through the electrolyte to the passive (cathodic) area. At the same time, metal ions may be dissolved from the anode. This starts the pit. As more metal ions are removed, more active stainless is exposed. This is a type of Galvanic cell peculiar to stainless steel.

There are several forms of "cells" which cause corrosion. One, called an oxygen cell is very common. In this instance a particle of soil (it may be a food particle) may adhere to the surface. If moisture surrounds the particle, there will be a difference in the concentration of the dissolved oxygen at the surfaces beneath the soil particle and in the moisture surrounding it. This is enough to set up an electrical potential, and accelerated corrosion may result. Another type of cell, called a concentration cell, exists when an electrolytic solution flows over a soil particle which is adhering to the stainless. Because of the difference in the concentration of ions in the electrolyte in the main stream and that which wets the soil, an electrical potential exists and, again, a cell is formed which accelerates corrosion.

Chlorine and chlorides in general are extremely corrosive to stainless steels. Chlorine is a very active element which readily combines with many other elements. When freed from sanitizing solutions, chlorine gas is readily dissolved by moisture droplets and attacks the stainless steel to which these droplets adhere. The attack is accelerated if acid conditions exist and slowed if alkaline. Brines of sodium chloride and calcium chloride are also extremely corrosive and should not be used in contact with stainless steel unless absolutely necessary.

Other halogen sanitizers have corrosive characteristics similar to chlorine when their formulations are similar.

Sanitizers aware of concentrated chlorine solutions are quick to concentrate the effect of chlorine.

It is difficult to take plating and corrosion into account while stainless steel is a few resistances.

There is corrosion in the environment they are in which food guides, the entire food processing plant is a complex acid environment.

It is a common fact that many of the greater types of stainless steel must be state of the art.

passive between 304 and a corrosive or salts not usual.

Frequently equipment is to be passed through by you. The surface is an oxidized state.

Sanitarians and equipment operators should be aware of the extreme corrosiveness of chlorine sanitizers when making recommendations for use-solution concentrations. The available chlorine is dissipated quickly in the presence of organic material. If equipment is first cleaned, very low concentrations of chlorine will constitute effective germicides. On the other hand, if the equipment is not clean, concentrated solutions of chlorine will have little germicidal effect. In the latter case the chlorides formed can accelerate corrosion greatly.

It is very difficult to determine an exact cause for some occurrences of excessive corrosion, and it is difficult to predict whether or not corrosion will take place. A cautious observer will state only that conditions either favor or do not favor accelerated corrosion.

While an extensive discussion of the corrosion of stainless steels is not within the limits of this paper, a few comments concerning the relative corrosion resistance of the various stainless steels are in order.

There are a great number of tables outlining the corrosion resistance of the stainless steels to various environments. These are often misleading because they are very specific and based on standard tests which may not be related to environments found in food processing applications. One of the best guides, in the author's opinion, is one published by the International Nickel Company, Inc. (2). It includes a discussion of corrosion resistance to organic compounds including acetic acid, formic acid, lactic acid and foods.

It is not uncommon for Type 316 to be regarded as a "wonder metal". While it does have more corrosion resistance in most environments and to certain acids and chlorides, it is not enough better for many food equipment applications to off-set its greater costs. In the Galvanic series of metals, Type 316 stainless steel is next to Type 304 on the least corroded side for both the passive and active states. The potential between the active and the passive states of Type 316 is almost the same as that between the active and the passive states of Type 304. If the passive film is penetrated on either type, and a corrosive environment exists, both may pit or corrode. Except for foods containing active acids or salts or both of these, Type 316 stainless steel is not usually necessary.

Frequently, after pitted areas in processing equipment are cleaned and polished out, there is a desire to passivate the surface. A method outlined by United States Steel Corporation (3) uses a 20-30% (by volume) solution of nitric acid at 140 to 160°F. The surface is immersed for about 30 minutes, then thoroughly rinsed with clean hot water. Nitric acid is an oxidizing agent and aids in producing the passive oxide film, but its most important function is

to dissolve any free iron contamination that may be on the surface of the stainless steel. Such contamination may originate from some machine tools, shot blasting and mechanical cleaning with ordinary wire brushes, steel wool or abrasives containing iron.

A warning on in-the-field passivating should be observed. Nitric acid is dangerous to handle, surfaces are often difficult to completely submerge, and nitric acid, itself, may corrode the stainless steel. Passivation of stainless steel by nitric acid is seldom successful when done in the field by inexperienced personnel. If surfaces are refinished with materials which are free of iron, then cleaned carefully with standard detergents, and dried, the stainless steel will be passivated quickly by exposure to the air. This is a surer, safer and less costly means of passivating.

THE CARE OF STAINLESS STEEL PROCESSING EQUIPMENT

Stainless steel manufacturers, processing equipment manufacturers, detergent manufacturers, plant sanitarians and others issue instructions for the care and cleaning of stainless steel equipment. A little booklet, *How to Protect Stainless Steel Dairy Equipment from Corrosion* (4), published by the National Association of Dairy Equipment Manufacturers is a guide which should be useful to sanitarians as well as to users of equipment. It not only gives instructions, but also lists reasons for them.

SUMMARY

Sanitarians should know that stainless steel is the best material available at present for the majority of applications as product contact surfaces in food processing equipment. There are many types of stainless steels with varying degrees of corrosion resistance and characteristics. Because of processing demands peculiar to a given application, some of the hardenable, straight chromium stainless steels must be used even though they are not as resistant to corrosion as the 18-8, Austenitic types.

The identification of specific types of stainless steel in equipment is difficult for the amateur metallurgist and quick tests are of limited value. While Austenitic stainless steels are non-magnetic in the annealed condition, they are often slightly magnetic after fabricating due to cold working. For positive identification, samples should be sent to a metallurgical laboratory for analysis.

Stainless steel sheet finishes are defined, rather than measureable finishes. There is no significant difference in the cleanability of stainless steels having No. 2B, No. 3, No. 4 and No. 7 finishes.

Although stainless steels are highly corrosion-resistant when compared to most other metals, they do corrode in certain environments, usually with the formation of pits. Various corrosive cells are in-

volved in pit corrosion, but the mechanism is similar to that of the Galvanic cell. To prevent accelerated corrosion, surfaces should be kept clean and dry when not in use. Chemical detergents and bactericides should be used with care. Chlorine bearing materials are especially corrosive and should be used at as low a temperature and concentration for the minimum exposure as compatible with bactericidal results required.

REFERENCES

1. Armco Precipitation Hardening Stainless Steels, Product Data. Armco Steel Corp., Middletown, Ohio. March 16, 1959.
2. *Corrosion Resisting Properties of the Austenitic Chromium-Nickel Stainless Steels*. The International Nickel Company, Inc., New York, New York. 1949.
3. *Fabrication of Stainless Steel, 3rd Ed.* United States Steel Corp., Pittsburgh, Pa. 1960.
4. How to Protect Stainless Steel Dairy Equipment from Corrosion. Nat. Assn. of Dairy Equip. Mfgs., Washington. D. C. May, 1958.
5. Kaufmann, O. W., Hedrick, T. I., Pflug, I. J., and Pheil, C. G. Relative Cleanability of Stainless Steel Tubing and Milk Dispenser Cans Having Various Finishes. Mich. Agr. Exp. Sta. Quart. Bull., 43(3):508-517. (Feb.) 1961.
6. Kaufmann, O. W., Hedrick, T. I., Pflug, I. J., and Pheil, C. G. Relative Cleanability of Various Finishes of Stainless Steel in a Farm Bulk Tank. J. Milk and Food Technol., 23: 377. 1960.
7. Kaufmann, O. W., Hedrick, T. I., Pflug, I. J., Pheil, C. G., and Keppeler, R. A. Relative Cleanability of Various Stainless Steel Finishes After Soiling with Inoculated Milk Solids. J. Dairy Sci., 43:28-41. 1960.
8. Kaufmann, O. W., Hedrick, T. I., Pflug, I. J., Pheil, C. G., and Keppeler, R. A. The Relative Cleanability of Dairy Processing Equipment Having Various Finishes. Mich. Agr. Exp. Sta. Quart. Bull., 43 (1):122-128. (Aug.) 1960.
9. Masurovsky, E. B., and Jordan, W. K. Studies on the Relative Cleanability of Milk Contact Surfaces. J. Dairy Sci., 41:1342. 1958.
10. *Steel Products Manual, Stainless and Heat Resisting Steels*. Am. Iron and Steel Institute. New York, New York. June, 1957.
11. Working Data for Carpenter Stainless and Heat Resisting Steels. The Carpenter Steel Co., Reading, Pa. 1955.

NEWS AND EVENTS

USE OF ELECTRONICS EXPANDING IN FOOD FIELD

After more than a decade of experiments, scientists in many laboratories the world over are finding an increasing number of successful applications of ultrasonics in the food field.

That was the highlight of a report made here recently to the Market Milk Conference, meeting at Rutgers University, by Dr. Alfred Lachmann, food industry consultant to the Electronic Assistance Corporation. The firm has several research projects under way looking to more uses of high frequency sound waves in the food field. One of them is being conducted by the food department of Rutgers — a two-year study into the promise of ultrasonics in the freeze drying technique of food preservation.

Dr. Lachmann reported that, although ultrasonic cleaning is widely used in many dairy plants, scientists are still working on the challenge of "in place" cleaning of pipes in dairy plants by ultrasonic techniques. After the conference, he showed attendants how to clean dairy pipes in EAC's new ultrasonic tank.

Dr. Lachmann reported that, as a result of work started at the University of Wisconsin in 1949, three scientists — A. W. Fitzgerald, W. C. Winder and G. R. Ringo — had just developed a patented method of determining the solid non-fat and butter-fat content of fluid raw or pasteurized milk by measuring

the velocity of sound in milk ultrasonically at various temperatures. He said that the technique permitted fast determination of the composition of milk.

Dr. Lachmann also observed that since the price structure of milk is based on its composition, the improved analytical method promises real economic advantage to milk producers.

Other Wisconsin dairy scientists have used ultrasonic sound waves for the de-aeration of milk on the theory that removal of the oxygen would improve the milk's keeping quality. A project to speed up the aging of cheese by means of ultrasonic sound waves was also reported from that school.

Meanwhile, in England, a technique has been perfected to stabilize frozen milk through the application of ultrasonic energy. Dr. Lachmann said that when the milk is treated ultrasonically before freezing, it can be kept for 18 to 24 months with no separation or stratification of its components, such as occurs when it is frozen without ultrasonic treatment. Known as "Frosconic Milk," the product is widely used on ships at sea. The process is also in use in other parts of the Commonwealth and in Europe.

German experiments have shown two successful techniques, Dr. Lachmann said. One group demonstrated that the use of ultrasonics permits the use of cream with a lower fat content in the making of butter. Another group showed that ultrasonic sound waves could disperse the moisture in butter in droplets so fine that micro-organisms could not grow on

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