

The CIS Technician's Guide to Surgical Stainless Steel

ADAPTED FROM HSPA'S 2009 LESSON PLAN "A PRIMER ON SURGICAL STAINLESS STEEL" BY YAFFA RAZ
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LEARNING OBJECTIVES

1. Discuss the three main types of stainless steel used to manufacture surgical instruments
2. Identify material selection concerns for manufacturing surgical stainless steel
3. Understand the different types of corrosion seen on stainless steel instruments

Surgical instruments are often designed around surgeons' needs, and creating these instruments is a highly complex process. Design bioengineers and metallurgists (metal specialists) select the proper mixture of metals (called alloys) for each instrument, and highly technical fabricators create and finish the device. After selecting the stainless steel mixture, the development process can take up to 15 steps and several weeks, with many steps still performed by hand. This lesson covers the types of stainless steel used in surgical instrument manufacturing and how to identify and prevent different types of corrosion on the devices.

Objective 1: Discuss the three main types of stainless steel used to manufacture surgical instruments

Surgical steel is a low-carbon, iron-based material containing high concentrations of chromium. The chromium reacts with oxygen in the air to form a stable oxide bond that helps prevent rust. Surgical steel is also nonporous, making it more hygienic for clinical use. Additionally, surgical steel is chemically inactive and can be sterilized with reduced risk of corrosion or degradation.

Although stainless steel is corrosion-resistant, low-alloy stainless steel can produce a poorer cutting edge and does not retain its sharpness. The healthcare industry developed high-alloy stainless formulations. These alloy mixtures are inactive in the body and more resistant to damage from bodily fluids. With the addition of different alloys, three types of stainless steel most recognized in healthcare emerged:

- **Austenitic** – This type of stainless steel contains chromium and nickel and sometimes manganese and nitrogen. The most commonly used type of austenitic steel is type 304. This alloy mixture helps the steel resist oxidation (scaling) and corrosion and makes it more malleable and workable. Austenitic steel also

possesses a combination of properties that make it useful at cryogenic (very low) temperatures. Its low tensile strength reduces instrument strain and ruptures at low temperatures, while the instrument toughness is only slightly degraded.

Implants can be manufactured using austenitic steel because of its high corrosion resistance.

- **Ferritic** – This steel contains ferrite and chromium and is classified as a 400 series magnetic stainless steel. Ferritic steel resists molding or shaping and cannot be hardened by heat; however, it is more corrosion-resistant.
- **Martensitic** – This steel contains a small amount of carbon, allowing for tempering and building a sharp cutting edge. Martensitic steel is also in the 400 series and, like ferritic steel, is magnetic. The martensitic process produces hardness and a sharp cutting edge but can make the steel brittle.

Objective 2: Identify material selection concerns for manufacturing surgical stainless steel

Proper material selection is critical to cost-effective instruments. The material must perform as intended, and it must also be one that can be fabricated economically. Historically, enhanced-strength stainless steel (300 series) has been used for the tubular components of dental and surgical instruments. This alloy has worked well for instruments designed for use in confined spaces; however, it has some drawbacks that limit its usefulness, including loss of strength during welding, poor edge retention, improper wear resistance, and low galling resistance (adhesive wear caused by the microscopic transfer of material between metal surfaces during sliding motions).

Some instruments, such as trocars, that are not subjected to high stress and are not used for cutting or shaping can be made from basic stainless steel. Many newer instruments, however, require a material that provides strength and wear resistance (400 series). Long, slender instruments, such as drivers or laparoscopic instruments, will likely face high-use demands. They require increased strength and toughness, and some alloys provide the required hardness and resulting edge retention. Cutting and shaping instruments, such as shavers, rongeurs and biopsy punches, require a hard alloy with good edge retention. The wear and galling resistance of some alloys best ensures smooth operation of parts that move in relation to one another.

Magnetic permeability relates to a material's ability to carry magnetism. Again, all stainless steel, except the austenitic type, is strongly attracted to a magnet. Some procedures, such as magnetic resonance imaging (MRI) interventions, require non-magnetic instruments, so material selection for these types of procedures is crucial.

A primary advantage of stainless steel is that it can be fabricated using standard manufacturing techniques. Most austenitic grades can be folded, bent, cold- and hot-forged, deep drawn, spun and roll-formed. The weldability of stainless steel varies by grade. Nearly all grades can be welded, but austenitic grades are some of the most readily welded of all metals. Examples of welded instruments include Frazier suction tips, Deaver retractors with formed handles, and some orthopedic reamers. Inspect all welded points to ensure the weld is intact and to prevent instrument failure during surgical procedures.

During manufacturing, stainless steel is often heat-treated, and the methods used depend on the type of stainless steel and the purpose of the treatment. Annealing (to make stainless steel less brittle), hardening and stress-relieving restore desirable features, such as corrosion resistance and ductility, to metals altered by fabrication. *Note: While austenitic stainless steel cannot be hardened by thermal treatments, it hardens rapidly by cooling to sub-zero temperatures.*

The desirable corrosion-resistant surfaces of stainless steel surgical instruments can be achieved only if proper cleaning and finishing operations are carried out after fabrication. Iron, cast iron, mild steel, carbon steel, or low alloy steel particles on the surface of stainless steel promote pitting corrosion where the "free" iron and stainless steel meet. This potentially serious (and unsightly) problem most often occurs from scraping the instrument with carbon steel tools or fixtures, or from grinding and polishing tools.

Passivation creates a protective film on the steel's surface. This process removes free iron by immersing the steel in an oxidant such as a nitric or citric acid solution.

Objective 3: Understand the different types of corrosion seen on stainless steel instruments

Stainless steel has special mechanical features: it is strong, hard and can absorb energy without breaking. Stainless steel is also resistant to high temperatures. The high chromium content that is beneficial for wet corrosion resistance contributes to the high-temperature strength and resistance to scaling.

Regardless of the type of stainless steel instrument used, corrosion protection remains vital. Despite its strength and versatility, steel will eventually rust. Steel corrosion can be defined as deterioration caused by electrochemical

reactions between the metal and its environment. Specifically, steel rusting occurs when the iron in the metal oxidizes. In most cases, for corrosion to occur, both oxygen and water must be present.

Several common causes of corrosion in surgical-grade instruments exist. Some of them include:

- **General corrosion** – A uniform removal of material usually caused by a strong acid.
- **Pitting corrosion** – Primary causes include the use of chlorides, saline and other harsh chemicals, dried blood and misuse. Pitting not only damages the instrument but can also harbor microorganisms inside the pitted area. Because pitting is often small, it is difficult to remove all microorganisms, creating an infection-control concern. Once formed, the pit can continue to grow, even if the surrounding steel was initially undamaged.
- **Crevice corrosion** – The breakdown of the protective oxide layer of the instrument; it occurs in crevices, making it more difficult to detect. Crevice corrosion can continue to grow in wide, shallow pits. It can be found under the insulated coating and box locks of surgical instruments.
- **Friction corrosion** – Occurs when one surface rubs against another. It occurs in hinged and sliding instruments and is first noticed as rubbing marks and very small cracks where two parts of an instrument rub together, such as in the box lock area.
- **Stress corrosion** – Occurs when tensile stress is applied to instruments, especially if the instruments have had contact with harsh chemicals. When force is applied to the instrument and the metal stretches, stress corrosion can occur. It is often caused by instrument misuse.

Some types of corrosion result from manufacturing defects. These include:

- **Intergranular corrosion** – A form of rapid and localized corrosion caused by a defect in the stainless steel that allows carbide particles to form. These particles deplete the surrounding chromium and reduce its corrosion resistance.
- **Galvanic corrosion** – Occurs from the contact of dissimilar metals. Galvanic corrosion can be prevented by avoiding mixed-metal fabrications or by coating or insulation.
- **Contact corrosion** – Occurs when small particles of foreign matter, such as blood or lipids, remain on a stainless steel surface. Often, these particles corrode away quickly; however, in severe cases, a pit may also form in the stainless steel.

Proper care and handling are essential for corrosion control and the satisfactory performance of surgical instruments. Water used for processing is one of the most important factors in preventing device damage. Natural water contains different kinds of salts that, at higher temperatures, are not soluble in water and tend to form a hard scale. Tap water may contain chlorides that can cause severe corrosion. Water pH is another critical factor in instrument integrity. ANSI/AAMI ST108:2013 specifies pH ranges based on water type and its use in medical device processing. High acidity can corrode instruments and plumbing, affecting processing quality and instrument integrity. Acidic (pH levels 0 to 6.9) or alkaline (7.1 to 14.0) water may also influence the properties of cleaning agents. To avoid damage, only approved detergents that have been measured carefully per the manufacturer's instructions for use (IFU) should be used on instruments. Sterilization methods and temperatures should also be monitored. Using the wrong sterilization method or increased sterilization and drying times can damage instruments.

Conclusion

Modern stainless steel alloys allow the manufacture of surgical instruments that can perform tasks required by surgeons; however, these devices can be damaged if they are not handled correctly.

CIS technicians who understand the basics of surgical steels can apply this knowledge to help ensure processing procedures prolong, rather than shorten, the useful life of the instruments for which they are responsible. P

CIS Self-Study Lesson Plan Quiz:
The CIS Technician's Guide to Surgical Stainless Steel

Lesson No. CIS 319 (Instrument Continuing Education – ICE) · Lesson expires December 2029

1. Stainless steel is used for many surgical instruments because it is:
   a. Resistant to rust
   b. Nonporous
   c. Chemically inert
   d. All the above

2. Which type of stainless steel should be used when sharp cutting edges are required?
   a. Ferritic
   b. Austenitic
   c. Martensitic
   d. Galvanitic

3. Which is a severe form of pitting corrosion?
   a. General corrosion
   b. Stress corrosion
   c. Crevice corrosion
   d. Sulfide stress corrosion

4. Which type of corrosion results from a manufacturing defect?
   a. Stress corrosion
   b. Galvanic corrosion
   c. Crevice corrosion
   d. Contact corrosion

5. What causes general corrosion of instruments?
   a. Use under high temperature
   b. A manufacturing design problem
   c. Exposure to high levels of salt in water
   d. Reaction to strong acid

6. Stainless steel's ability to resist oxidation depends on its content of:
   a. Nickel
   b. Magnesium
   c. Nitrogen
   d. Chromium

7. All stainless steel is strongly attracted to a magnet.
   a. True
   b. False

8. Which stainless steel is most useful at cryogenic temperatures?
   a. Martensitic
   b. Ferritic
   c. Austenitic
   d. No stainless steel performs well at cryogenic temperatures

9. The annealing process makes stainless steel:
   a. Hard
   b. Sharp
   c. Erosion resistant
   d. Less brittle

10. The presence of low-alloy steel particles on the surface of stainless steel can cause:
   a. Annealing
   b. Contact corrosion
   c. Excessive wear in the welding and hinged areas
   d. None of the above

11. Passivation:
   a. Makes stainless steel sharp
   b. Allows stainless steel to resist cracks
   c. Provides a protective film on stainless steel surfaces
   d. Is not appropriate for stainless steel

12. Water used for processing:
   a. Should be distilled
   b. Is safest for instruments when it has a high pH
   c. Is not a critical factor in device damage
   d. Is an important factor in device damage and integrity

13. Most new instruments are made from basic stainless steel.
   a. True
   b. False

14. Wear and galling resistance of some alloys:
   a. Facilitates smooth operation of certain moving parts
   b. Causes premature device wear
   c. Can cause severe corrosion
   d. Helps identify magnetism

15. Regardless of the type of stainless steel instruments in use:
   a. All will require replacement within one year of use
   b. Extended dry times will help prevent surface rusting
   c. Corrosion can occur
   d. Severe corrosion can be reversed

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