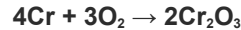


Passivation Guide

Protecting Stainless Steel Processing Equipment

What Is Passivation?

Stainless steel resists corrosion not through any bulk property of the metal itself, but through a nanometer-thin film of chromium oxide (Cr_2O_3) that forms when surface chromium reacts with atmospheric oxygen:



This invisible barrier prevents oxygen and moisture from reaching the iron beneath. Abrasion, welding, aggressive cleaning chemicals, and corrosive process fluids all degrade the layer faster than it naturally regenerates. Chemical passivation deliberately rebuilds it: acid first removes surface iron, then an oxidizing environment drives chromium at the surface to convert to the stable oxide form.

Why It Matters for Stainless Steel Equipment

Processing environments are demanding on stainless steel. Acidic products, caustic and acid CIP cycles, mechanical handling, welding repairs, and thermal cycling all create opportunities for the passive layer to degrade faster than it regenerates. Without periodic passivation, operations risk:

- Surface rust and iron contamination that affects product quality and flavor
- Progressive pitting corrosion that shortens equipment service life
- Sanitation failures where bacteria colonize pits that standard CIP cycles cannot reach
- Regulatory concerns if iron leaches into product

When to Passivate

Passivation frequency depends on how demanding your operating environment is. As a practical guide:

Situation	Recommended Frequency
Equipment installation	Before first use
After welding or grinding repairs	Immediately after repair
Normal operations	Annually at minimum
High-chloride water or aggressive process fluids	2 to 4 times per year
Visible surface rust or dull, dark appearance	Immediately

Note: Pharmaceutical facilities processing ultra-pure water typically passivate up to four times per year because high-purity water is itself aggressive on the passive layer. Operations running high-acid or high-salt products should take a similar approach.

Passivation Methods

Two acids are recognized for passivation in food, beverage, dairy, and pharmaceutical applications. Each has a distinct mechanism, safety profile, and practical trade-off.

Property	Citric Acid	Nitric Acid
Mechanism	Chelates and removes surface iron; passive layer forms by air oxidation after treatment	Dissolves iron AND oxidizes chromium directly; builds passive layer in one step
Concentration	4 to 10% by weight	20 to 50% by volume
Temperature	120 to 140°F (49 to 60°C)	Up to 160°F (70°C)
Contact time	1 to 2 hours	20 minutes to 2 hours
Safety	Lower hazard; biodegradable; food-safe	Strong mineral acid; fume hazard; respiratory PPE required
Effluent	Minimal environmental concern	Nitrogen-bearing discharge; check local regulations
Gasket compatibility	Generally compatible	Aggressive on aged or low-quality seals; plan to re-gasket after treatment
Best suited for	In-place CIP passivation of vessels and lines	Heavy iron contamination; new fabrications with significant free iron from machining or welding

A note on other acids

Oxalic acid is sometimes applied to remove surface rust and iron staining from stainless steel, but it is **not a passivation agent**. Because it is not an oxidizer, it cannot drive the chromium-to-chromium-oxide conversion that creates the protective layer. Similarly, phosphoric and hydrochloric acid have no recognized passivation role.

Dichromate salts are occasionally added to nitric acid to boost oxidation, but dichromate is toxic and prohibited in food plant effluent. GW Kent does not recommend dichromate-based treatments for food and beverage applications.

GW Kent recommends **citric acid as the default for most stainless steel passivation**: it is effective, considerably safer than nitric acid, generates minimal effluent concern, and is classified as a food ingredient.

Citric Acid Passivation: Step-by-Step Procedure

This procedure applies to tanks, vessels, and associated lines. It assumes a CIP system capable of maintaining 120 to 140°F (49 to 60°C). Plan for a full out-of-service day: the citric acid soak runs **1 to 2 hours at temperature**, followed by **48 to 72 hours of air-dry** before returning to service.

Important: Follow your product's instructions

The procedure below reflects accepted industry practice and is intended as a general guide. Always follow the specific instructions provided with whatever passivation agent, cleaner, or degreaser you are using. Concentration, temperature, contact time, and rinse requirements vary by product. Consult the product's label and Safety Data Sheet (SDS) before beginning.

Phase 1: Degreasing (newly acquired equipment or heavy soil)

1. **Make CIP connections.** Ensure all ports, spray balls, and lines are in the circuit.
2. **Pre-rinse with water.** Flush to remove loose debris.
3. **Degrease.** Use a non-foaming alkaline degreaser per the manufacturer's instructions. Circulate at the recommended temperature and time. Manually scrub welds, manways, and corners that spray balls cannot reach.
4. **Rinse thoroughly.** Flush until discharge runs clear.
5. **Inspect.** Wipe the interior with a clean white cloth. If greasy residue remains, apply degreaser neat to cloth, wipe clean, and re-rinse.

Phase 2: Alkaline CIP Clean

1. **Pre-rinse with hot water.**
2. **CIP with alkaline detergent.** Use the concentration and temperature specified by your detergent supplier. A typical target is approximately 1% solution at 150°F for 30 to 40 minutes, but follow your product's label.
3. **Rinse until water-break-free.** Water should sheet freely and uniformly down vessel walls without beading or channeling. Re-clean if necessary.

Phase 3: Citric Acid Passivation

Follow the instructions for your specific citric acid passivation product. The parameters below reflect general industry guidance; your product may specify different concentrations, temperatures, or contact times.

1. **Prepare citric acid solution.** Target 4 to 6% by weight. Calculation: (gallons of water) x 8.34 lb/gal x 0.06 = lb of citric acid needed. Example: 15 gallons of water requires (15 x 8.34 x 0.06) = 7.5 lb of anhydrous citric acid.
2. **Verify pH.** The solution pH must be below 4. Check with a pH meter or test strips before circulating.
3. **Circulate at temperature.** Run at 120 to 140°F for 1 to 2 hours. Maintain temperature via heat exchanger or steam jacket throughout.
4. **Drain and rinse.** Drain completely, then rinse with clean water for at least 5 minutes.
5. **Verify rinse pH.** Rinse discharge should match your water supply pH before you stop rinsing.
6. **Air dry 48 to 72 hours.** Open all ports. The passive Cr₂O₃ layer completes formation during this air-exposure period. Do not rush this step.
7. **Sanitize before production.** Run your standard sanitization cycle before returning the vessel to service.

Reusing citric acid solution

You can carry solution from tank to tank to reduce chemical cost, provided the acid stays active. Check pH before each use: it must remain below 4. As the acid chelates iron, pH will rise and chelation capacity will fall. Discard when pH climbs above 4 or when the solution is visibly discolored.

Nitric Acid Passivation (Reference)

Nitric acid is appropriate when citric acid has not resolved heavy surface contamination, or for passivating new fabrications with significant free iron from machining and welding. Because it is both a strong mineral acid and a strong oxidizer, it accomplishes iron removal and Cr₂O₃ formation simultaneously in a single treatment.

Always follow the specific instructions provided with your nitric acid passivation product. The parameters below are general guidance only.

Parameter	General Range
Concentration	20 to 50% by volume
Temperature	Up to 160°F (70°C)
Contact time	20 minutes to 2 hours

Important: Gasket Compatibility

Nitric acid at passivation strength is aggressive toward elastomer gaskets, especially aged or soft seals. Plan to replace all gaskets in the passivated circuit after treatment. Perform passivation immediately before re-gasketing, not after.

Safety Requirements

Both procedures involve industrial-strength chemicals. Minimum required PPE:

PPE	Citric Acid	Nitric Acid
Safety glasses / face shield	Required	Required
Chemical-resistant gloves	Required	Required
Rubber boots	Required	Required
Rubber apron	Recommended	Required
Respirator	Not required	Required (acid fumes)

Always add chemical to water, never water to chemical. Have the SDS on hand for every product before beginning. Report all spills and incidents immediately.

Passivation and Cleaning Chemicals from GW Kent

GW Kent stocks **passivation chemicals and CIP cleaning products** specifically selected for food, beverage, and industrial stainless steel applications. Our team can help you select the right citric acid passivation agent, alkaline detergent, and degreaser for your equipment and process. Food-grade anhydrous citric acid (USP grade) is the appropriate form for passivation; pre-formulated passivation products are also available and typically include sequestrants and surfactants that improve wetting and iron chelation.

Always confirm with your supplier that the active acid in any passivation product is citric or nitric, and request the SDS before purchase. Whatever product you choose, **follow the manufacturer's specific instructions** for concentration, temperature, and contact time.

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