100% Stainless

PICKLING HANDBOOK

Surface treatment of stainless steels

Avesta
Finishing Chemicals

INDEX

Author: Anders Bornmyr, Avesta Finishing Chemicals
Co-authors: Josef Toesch and Franz Winkler, Böhler Welding GmbH

Printed in Sweden by Centrumtryck, Avesta
First edition 1995
Second edition (significant updates) 2009


Before


After

Foreword

This manual is intended to increase awareness and understanding of the need to treat stainless steel surfaces. In particular, it aims to:

- Explain **why**, after welding and processing, stainless steel structures need cleaning in order to preserve their corrosion resistance.
- Show, through a survey of typical defects, **when** cleaning is important.
- Describe **how** to clean using different cleaning techniques.
- Give practical recommendations and instructions as to **what** to do in order to eliminate typical problems.

In this manual, Avesta Finishing Chemicals presents practical methods for pickling and cleaning stainless steels. Appropriate safety procedures when handling the products concerned are also set out.

Avesta Finishing Chemicals is a leading producer of superior pickling products for stainless steels and special alloys. The company is also part of the Böhler Welding Group, one of the world's largest manufacturers of welding consumables.

1.

Stainless steels and the need for cleaning

Figure 1: Before and after pickling

Figure 2: Treated and untreated stainless steel tanks

A good stainless steel surface is clean, smooth and faultless. The importance of this is obvious when stainless steel is used in, for example, façades or applications with stringent hygiene requirements. However, a fine surface finish is also crucial to corrosion resistance.

Stainless steel is protected from corrosion by its passive layer – a thin, impervious, invisible, surface layer that is primarily chromium oxide. The oxygen content of the atmosphere or of aerated aqueous solutions is normally sufficient to create and maintain ("self-heal") this passive layer. Unfortunately, surface defects and imperfections introduced during manufacturing may drastically disturb this "self-healing" process and reduce resistance to several types of local corrosion. Thus, as regards hygiene and corrosion, a final cleaning process is often required to restore an acceptable surface quality.

The extent of, and methods for, post-fabrication treatment are determined by a number of factors. These include: the corrosivity of the environment (e.g. marine); the corrosion resistance of the steel grade; hygiene requirements (e.g. in the pharmaceutical and food industries); and, aesthetic considerations. Local environmental requirements must also be considered. Both chemical and mechanical cleaning methods are available.

Good design, planning and methods of manufacture can reduce the need for post-treatment and thus lower costs.

When manufacturing to surface quality specifications, the impact of defects and, ultimately, the cost of removal must be borne in mind.

The cost of treating/cleaning is small compared to the initial capital expenditure on a piece of equipment. It is also small compared to the continuing operational cost of not cleaning.

There are two main elements in the economics of post-fabrication cleaning – the cost of cleaning and the benefits that cleaning brings as regards long-term performance. Fabrication can reduce the overall corrosion performance of a stainless steel to below its "normal" level. Furthermore, in real conditions, it is difficult, if not impossible, to complete the fabrication of a significant facility or piece of equipment without some surface contamination.

Because they generally have relatively poor corrosion performance, areas that have not been cleaned after fabrication are essentially the weak link in the chain. Depending on the extent of cleaning required, treatment after constructing a tank (for example) might cost as little as 1 – 3% of the total spent on materials and manufacture. Consequently, as it maximises the return on the investment, post-fabrication cleaning is not expensive (see also ref. 9).

Definitions

The following terms are often imprecisely used: cleaning; post-fabrication cleaning; precleaning; descaling; pickling; passivation; and, desmutting. For a better understanding of surface treatment and this publication, it is important to define these terms.

Cleaning includes all operations necessary to ensure the removal of surface contaminants from metals and:

- Maximise the metal's corrosion resistance.
- Prevent product contamination.
- Achieve the desired appearance.

Combinations of grinding, degreasing, pickling and passivation may be necessary to obtain a clean surface.

Post-fabrication cleaning is the process of cleaning after fabrication. Its purpose is to remove all contamination associated with the fabrication process.

Precleaning is the removal of grease, oil, paint, soil, grit and other coarse contamination prior to pickling or final cleaning.

Degreasing is the removal of grease prior to pickling or final cleaning.

Pickling is the use of chemicals to clean a metal by removing: defects; the surface film of inherent or thickened oxide; and, below this, some micrometres of the parent metal.

Overpickling is a too strong etching of a surface with pickling acids. This leaves a rough surface that may result in a lowering of the metal's properties.

NO_x is toxic nitric fumes (NO and NO_2) formed during the pickling process.

Passivation is the name applied to a number of different processes related to stainless steel. Unless otherwise specified, passivation in the present context is the chemical treatment of a stainless steel with a mild oxidant so as to remove free iron from the surface and speed up the process of forming a protective/passive layer. However, passivation is not effective for the removal of heat tint or oxide scale on stainless steel.

Smut is an undesired discoloration or deposit on a surface after pickling (can appear as a dark adhesive film). These dark spots can indicate that there are some remaining contaminants on the steel and that these have interfered with the pickling reaction.

Desmutting is the removal of smut. Desmutting is necessary if dark areas appear on a surface during pickling. This can be overcome by applying more pickling spray to these spots or by applying a passivator until they disappear. This must be done when the surface is still wet (i.e. "wet on wet"), just before the pickling spray is rinsed off.

Welding methods:

MMA	= manual metal arc
	= (SMAW = shielded metal arc welding)
MIG/MAG	= metal inert/active gas
	= (GMAW, gas metal arc welding)
TIG	= tungsten inert gas
	= (GTAW = gas tungsten arc welding)
SAW	= submerged arc welding
FCAW	= flux cored arc welding
MCAW	= metal cored arc welding

1.1 STAINLESS STEEL GRADES AND CLEANING

In any application, stainless steel grades are selected on the basis of required properties (e.g. corrosion resistance), design criteria and fabrication requirements. However, there are many different iron-carbon-chromium alloys that are collectively referred to as stainless steels.

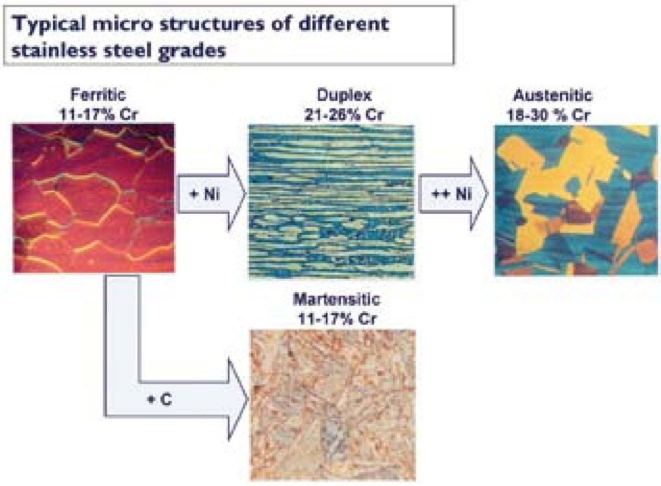


Figure 3: Microstructures

A steel's corrosion resistance, weldability, mechanical properties, etc are largely determined by its microstructure (see figure 3). This, in turn, is determined by the steel's chemical composition. As per EN 10088, stainless steels can be divided into the following, basic, microstructure-dependent groups:

Figure 4: A pickled, duplex 2304 storage tank

- Martensitic.
- Ferritic.
- Austenitic.
- Austenitic-ferritic (duplex).

As they are normally added to increase corrosion resistance, the various alloying elements have a large impact on the ease with which a stainless steel can be pickled (pickleability). It is the proportions of the different alloys that have a great effect on the pickleability of a stainless steel. As regards steel grades, the rule of thumb is: "The higher the alloy content (i.e. the corrosion resistance), the more difficult it is to pickle the steel".

The most basic grades are the iron-carbon-chromium alloys. These fall into two groups – martensitic and ferritic.

Martensitic stainless steels generally contain only 11 to 17% chromium and have a higher carbon content than the ferritic grades. The steels in this group are characterised by high strength and limited corrosion resistance. They are mainly used where hardness, strength and good wear resistance are required (e.g. turbine blades, razor blades and cutlery).

Ferritic stainless steels are more corrosion resistant than the martensitic grades, but less resistant than the austenitic grades. Like martensitic grades, these are straight chromium steels with no nickel. The most common of these steels contain either 12% or 17% chromium – 12% steels are used mostly in structural applications and automotive applications (exhaust systems) while 17% steels are used for catalytic converters, housewares, boilers, washing machines and internal building structures.

Owing to the low chromium content, the corrosion resistance of the two steel groups above is lower than that of the two steel groups below. This lower resistance means they are "easier" to pickle. In other words, to avoid the risk of overpickling, they need a shorter pickling time or a less aggressive pickling agent.

The addition of nickel to the austenitic and austenitic-ferritic steels further improves their corrosion resistance.

Austenitic is the most widely used type of stainless steel. It has a nickel content of at least 7%. This makes the steel structure fully austenitic and gives it non-magnetic properties, good ductility and good weldability. Austenitic steels can also be used throughout a wide range of service temperatures. Applications for which austenitic stainless steels are used include: housewares; containers; industrial piping; tanks; architectural façades; and, building structures. This type of stainless steel dominates the market.

Austenitic-ferritic (duplex) stainless steels have a ferritic and austenitic lattice structure (hence duplex). To give a partly austenitic lattice structure, this steel has some nickel content. The duplex structure delivers both strength and ductility. Duplex steels are mostly used in the petrochemical, paper, pulp and shipbuilding industries.

Modern duplex steels span the same wide range of corrosion resistance as the austenitic steels. For more detailed information about the stainless steel grades, see the Avesta Welding Manual (Practice and products for stainless steel welding) and the Outokumpu Corrosion Handbook.

Nickel-base alloys are vitally important to modern industry as a complement to stainless steel. This is because of their ability to withstand a wide variety of severe operating conditions involving corrosive environments, high temperatures, high stresses and combinations of these factors. Nickel itself offers very useful corrosion resistance and provides an excellent base for developing specialised alloys. Special intermetallic phases can be formed between nickel and some of its alloying elements. This enables the formulation of very high-strength alloys for both low and high-temperature service.

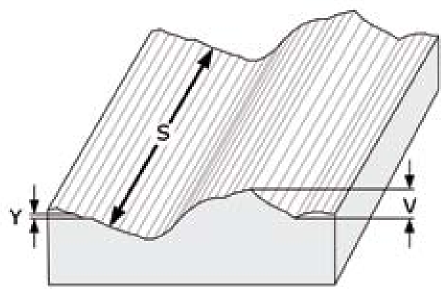
1.2 SURFACE FINISHES AND CLEANING

A smooth surface that is durable enough to resist cracking, chipping, flaking and abrasion cannot only resist the build up of contaminants but also be cleaned easily. Engineers and architects choosing stainless steel for a particular purpose have an extensive number of different grades to select from. There are also various surface finishes to choose from.

The decision as to what type of steel is best suited for any given purpose is largely based on the corrosivity of the environment. However, surface quality (surface finish) also affects sensitivity to corrosion and the ability to repel dirt and bacteria. This is of particular importance in the food/beverage industry and the pharmaceutical sector.

The importance of surface finish goes well beyond aesthetic considerations. The rougher a surface, the more easily contamination sticks to it and the more difficult it is to clean and pickle. Consequently, hot rolled surfaces with their rougher finishes are more difficult to clean and pickle than cold rolled surfaces with their smoother finishes.

Some basic definitions of surface finish criteria



Y = roughness, S = lay, V = waviness

Figure 5: Surface roughness

In considering the concept of surface finish, sporadic surface defects that have mechanical or metallurgical causes are disregarded in this manual. Instead, the focus is on the surface layer and the minute, evenly distributed irregularities that are characteristic of the different production and finishing methods used for steel products. Strictly defined, "surface finish" can be said to be a measure of deviation from the ideal flat surface. This deviation is normally expressed in terms such as roughness, lay and waviness. In turn, these may be defined as set out in the following.

Figure 6: A bright annealed (BA) finish after using Avesta Cleaner 401.

- Roughness is the size of the finely distributed surface-pattern deviations from the ideal smooth surface.
- Lay is the dominant direction of the surface pattern (e.g. grinding marks).
- Waviness is deviations that are relatively far apart.

Of these, waviness is the most difficult to detect by eye.

As shown in table 1, surface smoothness increases from hot rolled to bright annealed (BA).

Table 1: Stainless steel surface finishes

Description	ASTM	EN 10088-2	Surface finish	Notes
Hot rolled	1	1D	Rough and dull	A rough, dull surface produced by hot rolling to the specified thickness, followed by heat treatment and pickling.
Cold rolled	2D	2D	Smooth	A dull finish produced by cold rolling to the specified thickness, followed by heat treat-ment and pickling.
Cold rolled	2B	2B	Smoother than 2D	A bright, cold-rolled finish commonly produced in the same way as a 2D finish followed by skin passing. The most common surface finish. Good corrosion resistance, smoothness and flatness.
Cold rolled	BS	2R	Smoother than 2B, bright and reflective	BA finish produced by cold rolling followed by bright annealing in an inert atmosphere.

1.3 WELDING METHODS AND CLEANING

The different welding methods can result in problems that have different consequences for surface cleaning. Particular attention must be paid to preparation before pickling.

Table 2: **Welding methods**

Welding method	Possible problems*	Solution (before pickling)
MMA (SMAW)	Slag residues Tarnish (heat tint)	Brushing (grinding)
FCAW	Tarnish (heat tint) Slag residues	Brushing (while warm)
MIG (GMAW)	Heavy bead oxidation Slag residues Spatter	Grinding (brushing)
TIG (GTAW)	Small slag islands ("black spots")	Grinding (if possible)
SAW	Sometimes slag residues	Brushing (grinding)

*depending on filler metal, welding position, overheating, gas mixture, etc.

1.4 CORRECT HANDLING AND CLEANING

The correct handling of stainless steels limits surface defects and minimises the need for post-fabrication cleaning.

On delivery from the manufacturer, stainless steel plates, tubes and pipes are normally clean and passivated. In other words, the material has a natural corrosion-resistant film over its entire surface. It is important to maintain as much as possible of the stainless material's original appearance and corrosion resistance. Especially as regards exterior building components, the instructions below must be borne in mind at every stage from project design to production and installation.

- Do not use steel brushes or steel tools made of carbon steel.
- Do not carry out shot blasting using carbon steel blasting materials or blasting materials that have been used for carbon steels.
- Hydrochloric acid, or cleaners containing chlorides, must not be used for cleaning stainless steels.
- Do not use hydrochloric acid to remove cement or mortar residues from stainless steels.
- Throughout storage, avoid contact between stainless steel and carbon steel.
- When using forklifts, avoid direct contact between carbon steel forks and stainless steel.
- At installation, use fasteners (e.g. nails, screws and bolts) made of stainless steel.
- In areas exposed to moisture, avoid the risk of galvanic corrosion between stainless steel components and plain carbon steel components (e.g. by providing electrical insulation).
- Use clean tools that are free from residues of plain carbon steel (e.g. swarf and iron particles from previous work).
- Remove the protective plastic film only when it is no longer needed, i.e. when the construction phase is over and the local environment is free of debris and dirt particles. Some plastic films deteriorate in sunlight and can become difficult to strip.

1.5 INDUSTRIAL TRENDS AND CLEANING

Higher quality demands from industry in general are opening a growing number of applications for stainless steels. In the past, the use of stainless steels was mainly restricted to closed, corrosive environments in the chemical process industry. Now, the material has become more consumer oriented and can be found in many new applications such as those listed below.

- Civil constructions such as bridges (e.g. the Bilbao Bridge in Spain).
- Public transport such as buses and trains (e.g. the X2000 high-speed train).
- Kitchen equipment and fixtures (e.g. cookers, fridges and freezers).
- Fittings in public places (e.g. street furniture, railings and building façades).

Today's quality standards have resulted in stainless steels being introduced into a large number of applications, all of them with their own specific stipulations as regards surface treatment. They have also led to other trends and the development of new methods. The following are a few examples:

- The use of high-alloy steel grades (e.g. duplex) for construction of chemical tankers and 6% Mo grades for desalination plants.
- New welding methods such as FCAW, pulse MIG, automatic TIG and laser welding.

- Increased production of hot rolled plates (thanks to lower production costs).
- Great demand for bright finishes.

The need for industry to minimise any negative impact it has on the environment has put the surface treatment of stainless steels in the spotlight. A number of measures can easily be taken to comply with new local requirements:

- Changing to more environment-friendly pickling products.
- Upgrading pickling facilities.

1.6 TYPICAL DEFECTS

1.6.1 Heat tint and oxide scale

Caused by processes such as heat treatment or welding, high-temperature oxidation produces an oxide layer that, compared to the original passive layer, has inferior protective properties. There is also a corresponding chromium depletion in the metal immediately below the oxide. With normal welding, the chromium-depleted zone is very thin and can normally be removed together with the tint. However, to completely restore corrosion resistance, it is vital that this zone is removed.

1.6.2 Weld defects

Incomplete penetration, undercut, pores, slag inclusions, weld spatter and arc strikes are typical examples of weld defects. These defects have a negative impact on mechanical properties and resistance to local corrosion. They also make it difficult to maintain a clean surface. Thus, the defects must be removed – normally by grinding, although sometimes repair welding is also necessary.

1.6.3 Iron contamination

Iron particles can originate from: machining; cold forming and cutting tools; blasting grits/sand or grinding discs contaminated with lower alloyed materials; transport or handling in mixed manufacture; or, simply, iron-containing dust. These particles corrode in humid air and damage the passive layer. Larger particles may also cause crevices. In both cases, corrosion resistance is reduced. The resultant corrosion is unsightly and may also contaminate media used in/with the equipment in question. Iron contamination on stainless steels and welds can be detected using the ferroxyl test (see chapter 5).

1.6.4 Rough surface

Uneven weld beads and grinding or blasting too heavily give rough surfaces. A rough surface collects deposits more easily, thereby increasing the risk of both corrosion and product contamination. Heavy grinding also introduces high tensile stresses. These increase the risk of stress corrosion cracking and pitting corrosion. For many applications, there is a maximum allowed surface roughness (Ra value). Manufacturing methods that result in rough surfaces should generally be avoided.

1.6.5 Organic contamination

In aggressive environments, organic contaminants in the form of grease, oil, paint, footprints, glue residues and dirt can cause crevice corrosion. They may also make surface pickling ineffective and pollute products handled in/with the equipment. Organic contaminants must be removed using a suitable cleaner. In simple cases, a high-pressure water jet may suffice.

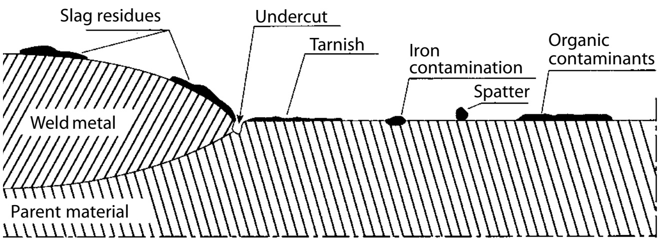


Figure 7: Surface defects

2.

Cleaning procedures

Figure 8: Typical stainless steel object ready for spray pickling.

As detailed on page 5, the extent of, and methods for, post-fabrication treatment are determined by a number of factors.

Different chemical and mechanical methods, and sometimes a combination of both, can be used to remove the defects mentioned. Chemical cleaning can be expected to produce superior results. This is because most mechanical methods tend to produce a rougher surface while chemical methods reduce the risk of surface contamination. However, chemical cleaning may be limited not only by local regulations on environmental and industrial safety, but also by waste disposal problems.

2.1 MECHANICAL METHODS

2.1.1 Grinding

Grinding is a common method of removing some defects and deep scratches. The grinding methods used must never be rougher than necessary. A flapper wheel is often sufficient for removing weld tint or surface contamination.

The following points must always be borne in mind when using grinding to clean stainless steels:

- Use the correct grinding tools. Iron-free discs must always be used for stainless steels. Never use discs that have previously been used for grinding low-alloy steels.
- Avoid producing a surface that is too rough. Rough grinding with a 40 – 60 grit disc must always be followed by fine grinding using, for example, a higher grit mop or belt to obtain a surface finish corresponding to grit 180 or better. If surface requirements are very exacting, polishing may be necessary.
- Do not overheat the surface. In order to avoid creating further heat tint or higher stresses, apply less pressure when grinding.
- Always check that the entire defect has been removed.

2.1.2 Blasting

Blasting can be used to remove high-temperature oxide as well as iron contamination. However, great care must be taken to ensure that the blasting material or media are perfectly clean. Thus, blasting material must not have been previously used for carbon steel. Similarly, because it becomes increasingly polluted (even if it has only been used for blasting contaminated stainless steel surfaces), media must not be too old. Surface roughness is a limiting factor for this method. In most cases, blasting will not remove the chromium-depleted zone.

2.1.3 Brushing

For the removal of heat tint, brushing using stainless steel or nylon brushes usually provides a satisfactory result. These methods do not cause any serious roughening of the surface. However, they do not guarantee complete removal of the chromium-depleted zone. The other mechanical methods present a high risk of contamination. Consequently, it is important to use clean tools that have not been used for processing carbon steels.

2.1.4 Summary

After a typical manufacturing programme, a final mechanical cleaning stage could be as set out below.

How to clean mechanically (when pickling has not been selected):*

1. Use grinding to remove welding defects.

2. Remove material affected by high temperatures and, if possible, remove iron impurities. The mechanical method chosen must not make the surface unacceptably rough.

3. Remove organic contaminants (see section 1.6.5).

4. A final passivation/decontamination should be carried out (strongly recommended).

* In most cases, pickling is essential for optimal corrosion resistance.

2.2 CHEMICAL METHODS

Chemical treatments can remove high-temperature oxide and iron contamination. They also restore the steel's corrosion-resistant properties without damaging the surface finish.

After the removal of organic contaminants, the normal procedures are commonly pickling, passivation/decontamination and/or electropolishing.

2.2.1 Pickling

Pickling is the most common chemical procedure used to remove oxides and iron contamination. Besides removing the surface layer by controlled corrosion, pickling also selectively removes the least corrosion-resistant areas such as the chromium-depleted zones.

Pickling normally involves using an acid mixture containing nitric acid (HNO_3), hydrofluoric acid (HF) and, sometimes, also sulphuric acid (H_2SO_4). Owing to the obvious risk of pitting corrosion, chloride-containing agents such as hydrochloric acid (HCl) must be avoided.

The main factors determining the effectiveness of pickling are as set out below.

• Steel grade

Table 3 shows the most common stainless steel grades and the matching welding consumables from Avesta Welding and Böhler Welding. Pickleability has been tested and the steels arranged into four groups. The groupings are based on the ease with which the steels can be pickled.

Steel group 1: Owing to the low chromium content, the corrosion resistance of this group is lower than that of the groups below. The lower resistance of the steels in this group means they are "easier" to pickle. In other words, to avoid the risk of overpickling, they need a shorter pickling time or a less aggressive pickling agent. Special care must be taken to avoid overpickling! The pickling result may be unpredictable.

Steel group 2: The steels in this group are standard grades and fairly easy to pickle.

Steel groups 3 – 4: The steels in this group are high-alloy grades. Being more corrosion resistant, they need a more aggressive acid mixture and/or higher temperature (to avoid an excessively long pickling time). The risk of overpickling these steel grades is much lower (see table 3).

• Surface finish

A rough, hot rolled surface may be harder to pickle than a smooth, cold rolled one.

• Welding method and resultant thickness and type of oxide layer

Thickness and type depend largely on the welding procedure used. To produce a minimum of oxides, weld using an effective shielding gas that is as free of oxygen as possible. For further information, see the Avesta Welding Manual and the Böhler Welding Guide. Particularly when pickling high-alloy steel grades, mechanical pretreatment to break or remove the oxides might be advisable.

• Precleaning

The surface must be free of organic contamination.

• Temperature

The effectiveness of pickling acids increases with temperature. Thus, the pickling rate can be considerably increased by increasing the temperature. However, there are upper temperature limits that must also be

Table 3: Stainless steel grades and pickleability

Stainless steel grades		Welding method	Welding consumables	
EN	ASTM		Avesta designation	Böhler designation
Group 1: Very easy to pickle*				
1.4006	410	MMA	–	FOX KW 10
1.4016	430	MMA	–	FOX SKWA
1.4016	430	MMA	–	FOX EAS 2
1.4016	430	FCAW	–	EAS 2-FD
1.4313	410NiMo	MMA	–	FOX CN 13/4
1.4313	410NiMo	MCAW	–	CN 13/4-MC
Group 2: Easy to pickle				
1.4301	304	MMA	308L/MVR	FOX EAS 2
1.4301	304	MIG	308L-Si/MVR-Si	EAS 2-IG(SI)
1.4401	316	MMA	316L/SKR	FOX EAS 4 M-
1.4401	316	MIG	316L-Si/SKR-Si	EAS 4 M-IG(Si)
1.4404	316L	MMA V-joint	316L/SKR	FOX EAS 4M- TS
1.4404	316L	MMA	316L/SKR	FOX EAS 4M
1.4404	316L	MMA	316L/SKR	FOX EAS 4M-A
1.4404	316L	FCAW	316L/SKR	EAS 4M-FD
1.4404	316L	MIG	316L-Si/SKR-Si	EAS 4M-IG
1.4404	316L	MCAW	–	EAS 4M-MC
Group 3: Difficult to pickle				
1.4539	904L	MMA	904L	FOX CN 20/25 M
1.4539	904L	MIG	904L	CN 20/25 M-IG
1.4539	904L	MMA	P12–R	FOX NIBAS 625-
1.4501	S32760	MMA	2507/P100	FOXCN 25/9 CuT
1.4161	S32101	MIG	LDX 2101	–
1.4161	S32101	FCAW	LDX 2101	CN 24/9 LDX-FD
1.4362	S32304	MIG	2304	–
1.4362	S32304	FCAW	2304	CN 24/9 LDX-FD
1.4462	S32205	MMA	2205	FOX CN 22/9N
1.4462	S32205	MIG	2205	CN 22/9 N-IG
2.4605	N06059	MMA	–	FOX NIBAS C 24
2.4360	N04400	MMA	–	FOX NIBAS 400
Group 4: Very difficult to pickle				
1.4547	S31254	MMA	P12-R	FOX NIBAS 625
1.4547	S31254	MIG	P12	NIBAS 625-IG
1.4565	S34565	MMA	P16	FOX NIBAS C 24
1.4565	S34565	MIG	P16	NIBAS C 24-IG
1.4410	S32750	MMA	2507/P100	FOX CN 25/9 CuT

* Group 1 is very easy to pickle but, at the same time, difficult to treat. There is a risk of overpickling. Great attention must be paid to pickling time and temperature.

considered. Especially when using a bath, the risk of overpickling increases with high temperatures. When using pickling paste/gel/spray/solution at high temperatures, evaporation presents the risk of poor results. Besides an uneven pickling effect, this also leads to rinsing difficulties. To avoid these problems, objects must not be pickled at temperatures above 45°C or in direct sunlight.

- **Composition and concentration of the acid mixture**

- **Pickling method**

There are three different pickling methods.

Pickling with pickling paste/gel: Pickling paste (or gel) for stainless steels is suitable for pickling limited areas, e.g. weld-affected zones. It is best applied using an acid-resistant brush. Rinsing with water must be carried out before the paste dries. Even if, for environmental and practical reasons, neutralisation of the pickling paste is carried out on the metal surface, thorough rinsing with water is vital.

Pickling with pickling solution/spray: Pickling solution (or pickling gel in spray form) is suitable for pickling large surfaces, e.g. when the removal of iron contamination is also desired.

Pickling in a bath is a convenient method if suitable equipment is available.

2.2.2 Passivation and decontamination

This procedure is carried out in a manner similar to pickling. The passivator, applied by immersion or spraying, strengthens the passive layer. Because the passivator also removes free iron impurities from the surface, the treatment is more important after mechanical cleaning and operations involving a risk of iron contamination. It is for this reason that the method can also be referred to as decontamination.

2.2.3 Electropolishing

Electropolishing normally produces a surface that guarantees optimal corrosion resistance. It does not selectively remove areas of inferior corrosion resistance, but polishes microtips from the surface. The material gains a fine lustre and, most importantly, an even microprofile that meets extremely stringent hygiene requirements. For these reasons, electropolishing is normally used as a final treatment after pickling. This method is not covered in the present publication.

2.3 CHOICE OF METHOD

The choice of method and the amount of final cleaning required depend on: corrosion resistance requirements; hygiene considerations (pharmaceuticals, food, etc.); and, the importance of the steel's visual appearance. Removal of welding defects, welding oxides, organic substances and iron contaminants is normally a basic requirement and usually allows a comparatively free choice of final treatment.

Provided that the surface roughness so permits, both mechanical and chemical methods can be used. However, if an entirely mechanical cleaning method is decided on, the manufacturing stage has to be very well planned in order to avoid iron contamination. If it is not, decontamination, probably with nitric acid, will be necessary. Where surface finish and corrosion resistance requirements are exacting, the choice of method is more critical. In such cases, a treatment sequence based on pickling gives the best chances of superior results.

The figure below shows the results of a test where the samples (steel grade 1.4404/316L with MMA welds) were post-weld cleaned using three different methods. They were then exposed to a marine environment for two weeks.

Figure 9: Grinding

Polishing

Pickling

2.4 A COMPLETE CLEANING PROCESS

After a typical manufacturing programme, a complete cleaning process could be as set out below.

How to carry out a complete cleaning process

1. Inspect.
2. Pretreat mechanically.
3. Preclean.
4. Rinse.
5. Pickle.
6. Desmut.
7. Rinse.
8. Passivate.
9. Neutralise.
10. Inspect.

All these steps are discussed in greater detail in subsequent chapters.

2.4.1 CASE DETAILS

Landaluce, a company in Spain's Cantabria, has manufactured a total of 90 beer tanks for Heineken and its brewery in Seville. Made in ASTM 304 hot rolled stainless steel, the 4.5 m diameter tanks are 18 m long.

The beer tanks went through complete cleaning using the following Avesta Products:

- Cleaner 401.
- RedOne™ Spray 240 (tank exteriors).
- Pickling Bath 302 (tank interiors).
- FinishOne™ Passivator 630.

Figure 10: Stainless steel beer tanks ready for shipping after complete cleaning using Avesta products (photo courtesy of Landaluce)

3.

Chemical methods in practice

Figure 11: High-pressure rinsing after pickling.

3.1 AVESTA PRODUCTS

Avesta Finishing Chemicals offers a wide programme of cleaning preparations.

- Pickling paste
- Pickling spray
- Pickling bath
- Cleaner
- Passivator

3.2 GENERAL REQUIREMENTS

The choice of chemical cleaning process is primarily determined by: the type of contaminants and heat oxides to be removed; the degree of cleanness required; and, the cost. This chapter gives guidelines on suitable chemical cleaning procedures.

In order to avoid health hazards and/or environmental problems, pickling must be carried out in a special pickling area, preferably indoors. In this context, compliance with the recommendations below should be regarded as compulsory.

- Handling instructions and essential information (e.g. product labels, safety data sheets, etc.) for the various products must be available. Local and national regulations must also be available. See, additionally, section 6.1.
- The personnel in charge must be familiar with the health hazards associated with the products and how these must be handled.
- Personal safety equipment must be used. See also section 6.2.
- When pickling indoors, the workplace must be separate from other workshop operations. This is not only to avoid contamination and health hazards, but also to ensure a controlled temperature.
- The area must be well ventilated and provided with fume extraction apparatus.
- Walls, floors, roofs, tanks, etc. that are subject to splashing must be protected by acid-resistant material.
- A washing facility must be available, preferably including a high-pressure water jet.
- A first-aid kit must be available against acid splashes. See also section 6.1
- If the rinse water is recycled, care must be taken to ensure that the final rinse is performed using deion-

ised water. This is particularly important in the case of sensitive surfaces and applications.

- A storage facility must be available. See also section 6.3.

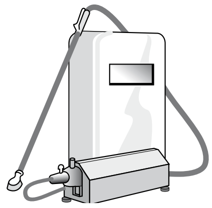
3.3 PRECLEANING/DEGREASING

Contamination on the surface can impair the pickling process. To prevent this, thorough cleaning prior to pickling is recommended. Where loose dust, fingerprints, shoeprints and tool marks are the contaminants, acid cleaning (e.g. Avesta Cleaner 401) is usually adequate.

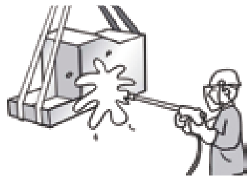
Figure 12: Surface rust – before and after removal using Avesta Cleaner 401.

How to use Avesta Cleaner 401

1. Inspect the surface to be treated and ensure that all non-stainless material has been protected.
2. Using an acid-resistant pump (Avesta SP-25), spray the product onto the surface. Apply an even layer that covers the entire surface. Do not apply in direct sunlight!



3. Allow the product sufficient reaction time, but avoid letting it dry. If the contaminants are stubborn (difficult to remove) and in thick layers, mechanical brushing with a hard plastic or nylon brush will help.
4. Preferably using a high-pressure water jet, rinse thoroughly with clean tap water. To reduce acid splashing, prewashing at tap-water pressure (3 bars) is recommended. Ensure that no residues are left on the surface. Use deionised water for the final rinsing of sensitive surfaces.



3.4 PICKLING

Pickling products can be applied in three different ways:

- Brushing, using a pickling paste/gel
- Spraying, using a pickling solution
- Immersion/circulation in/with a pickling bath

The different methods are presented in the following pages.

Figure 13: Brush pickling

3.4.1 Pickling with paste

Creating a better working environment, Avesta BlueOne™ Pickling Paste 130 is a unique pickling product. Using BlueOne™, there are virtually none of the toxic nitric fumes normally formed during pickling. Pickling Paste 130 can be used as a universal paste on all stainless steel grades.

3.4.2 Pickling with solution (spray-pickling gel)

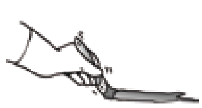
Creating a better working environment, Avesta RedOne™ Spray Pickle Gel 240 is a unique pickling product. Using RedOne™ 240, toxic nitric fumes are significantly reduced.

Combined Method: For some purposes, brushing and spraying methods can be combined. When only a mild pickling effect is required (on sensitive surfaces), pickling paste can first be applied to the weld joints and then an acidic cleaner (e.g. Avesta Cleaner 401) can be sprayed onto the surface.

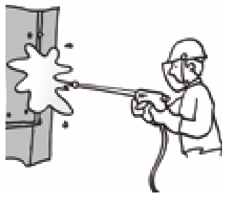
How to use Avesta pickling pastes/gels

1. Pretreat oxides, slags and weld defects mechanically. This should preferably be done while the welds are still warm and the weld oxides less hard.
2. After any welding, give the area to be pickled time to cool down to below 40ºC.
3. To remove organic contamination, degrease using Avesta Cleaner 401.
4. Before using, stir or shake the paste.

5. Using an acid-resistant brush, apply the pickling paste. Do not pickle in direct sunlight!



6. Give the product sufficient time to react (see table 4). At high temperatures, and when prolonged pickling times are required, it might be necessary to apply more of the product after a while. This is because the product can dry out and thus cease to be as effective.
7. Preferably using a high-pressure water jet, rinse thoroughly with clean tap water. Ensure that no pickling residues are left on the surface. Use deionised water for the final rinsing of sensitive surfaces.

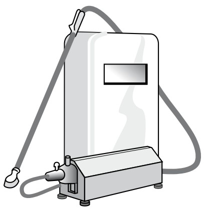


8. So that it can be neutralised, collect the waste water. See also chapter 4.

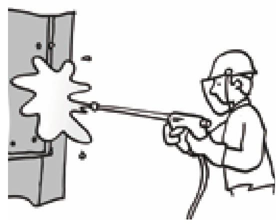
Figure 14: Spray pickling

How to use Avesta spray-pickling gel

1. Inspect the surface to be treated and ensure that all non-stainless material has been protected.
2. Pretreat oxides, slags and weld defects mechanically. This should preferably be done while the welds are still warm and the weld oxides less hard.
3. After any welding, give the area to be pickled time to cool down to below 40°C.
4. To remove organic contamination, degrease using Avesta Cleaner 401.
5. Before using, stir the spray gel well.
6. Using an acid-resistant pump (Avesta SP-25), apply the product as a spray. Gently apply an even layer of acid that covers the entire surface. Do not pickle in direct sunlight!



7. Allow the product sufficient pickling time.
8. Desmutting is necessary if dark areas appear on the surface. Apply either more solution or Avesta FinishOne™ to these spots until they disappear. This must be done when the surface is still wet (i.e. “wet on wet”), just before the pickling spray is rinsed off. Spraying FinishOne™ on top of the pickled surface also reduces the production of NO_x gases.
9. When pickling, the pickling spray must not be allowed to dry. Drying may cause discoloration of the steel surface. This means that at high temperatures, and when prolonged pickling times are required, it may be necessary to apply more of the product after a while.
10. Preferably using a high-pressure water jet, rinse thoroughly with clean tap water. To reduce acid splashing, prewashing at tap-water pressure (3 bars) is recommended. Ensure that no pickling residues are left on the surface. Use deionised water for the final rinsing of sensitive surfaces.



11. Passivation must be carried out directly after wet-on-wet rinsing. Spray Avesta FinishOne™ Passivator 630 evenly over the entire surface.
12. Leave to dry.
13. Carry out inspection and process verification.
14. All treated surfaces must be ocularly inspected for oil residues, oxides, rust and other contaminants.
15. So that it can be neutralised, collect the waste water. See also chapter 4.

Pickling equipment: To achieve a good spraying result, a suitable pump is necessary. The pump must be made of an acid-resistant material and must provide an even application pressure. Avesta Spray Pickle Pump SP-25 was specially designed to meet these requirements. It is a pneumatic, quarter inch pump of the membrane type and has an adjustable valve.

Figure 15: Avesta Spray Pickle Pump SP-25 with its unique spray handle.

3.4.3 Typical pickling times for brush and spray pickling

The pickling times given in table 4 must be seen as indicative only. They are stated as intervals because, for the same steel grade, the time required depends on the surface finish and the welding method (see also chapter 1). For hot rolled surfaces, pickling times should normally be increased. Similarly, depending on the shielding gas used, MIG welds might need longer than MMA or FCAW welds.

Table 4: Typical pickling times for brush and spray pickling (cold rolled surfaces)

Stainless steel grades		Welding method	Welding consumables		Pickling paste		Picking spray	
EN	ASTM		Avesta designation	Böhler designation	Avesta designation	Recommended time (minutes)	Avesta designation	Recommended time (minutes)
Group 2: Easy to pickle								
1.4301	304	MMA	308L/MVR	FOX EAS 2	BlueOne™ 130	30 – 60	RedOne™ 240	45 – 90
1.4301	304	MIG	308L-Si/MVR-Si	EAS 2-IG(SI)	BlueOne™ 130	30 – 60	RedOne™ 240	45 – 90
1.4401	316	MMA	316L/SKR	FOX EAS 4 M-	BlueOne™ 130	30 – 60	RedOne™ 240	45 – 90
1.4401	316	MIG	316L-Si/SKR-Si	EAS 4 M-IG(Si)	BlueOne™ 130	30 – 60	RedOne™ 240	45 – 90
1.4404	316L	MMA V-joint	316L/SKR	FOX EAS 4M- TS	BlueOne™ 130	30 – 60	RedOne™ 240	45 – 90
1.4404	316L	MMA	316L/SKR	FOX EAS 4M	BlueOne™ 130	30 – 60	RedOne™ 240	45 – 90
1.4404	316L	MMA	316L/SKR	FOX EAS 4M-A	BlueOne™ 130	30 – 60	RedOne™ 240	45 – 90
1.4404	316L	FCAW	316L/SKR	EAS 4M-FD	BlueOne™ 130	30 – 60	RedOne™ 240	45 – 90
1.4404	316L	MIG	316L-Si/SKR-Si	EAS 4M-IG	BlueOne™ 130	30 – 60	RedOne™ 240	45 – 90
1.4404	316L	MCAW	–	EAS 4M-MC	BlueOne™ 130	30 – 60	RedOne™ 240	45 – 90
Group 3: Difficult to pickle								
1.4539	904L	MMA	904L	FOX CN 20/25 M	BlueOne™ 130	90 – 180	RedOne™ 240	120 – 240
1.4539	904L	MIG	904L	CN 20/25 M-IG	BlueOne™ 130	90 – 180	RedOne™ 240	120 – 240
1.4539	904L	MMA	P12-R	FOX NIBAS 625-	BlueOne™ 130	90 – 180	RedOne™ 240	120 – 240
1.4501	S32760	MMA	2507/P100	FOXCN 25/9 CuT	BlueOne™ 130	90 – 180	RedOne™ 240	120 – 240
1.4161	S32101	MIG	LDX 2101	–	BlueOne™ 130	90 – 180	RedOne™ 240	120 – 240
1.4161	S32101	FCAW	LDX 2101	CN 24/9 LDX-FD	BlueOne™ 130	90 – 180	RedOne™ 240	120 – 240
1.4362	S32304	MIG	2304	–	BlueOne™ 130	90 – 180	RedOne™ 240	120 – 240
1.4362	S32304	FCAW	2304	CN 24/9 LDX-FD	BlueOne™ 130	90 – 180	RedOne™ 240	120 – 240
1.4462	S32205	MMA	2205	FOX CN 22/9N	BlueOne™ 130	90 – 180	RedOne™ 240	120 – 240
1.4462	S32205	MIG	2205	CN 22/9 N-IG	BlueOne™ 130	90 – 180	RedOne™ 240	120 – 240
2.4605	N06059	MMA	–	FOX NIBAS C 24	BlueOne™ 130	90 – 180	RedOne™ 240	120 – 240
2.4360	N04400	MMA	–	FOX NIBAS 400	BlueOne™ 130	90 – 180	RedOne™ 240	120 – 240
Group 4: Very difficult to pickle								
1.4547	S31254	MMA	P12-R	FOX NIBAS 625	BlueOne™ 130	120 – 240	RedOne™ 240	150 – 300
1.4547	S31254	MIG	P12	NIBAS 625-IG	BlueOne™ 130	120 – 240	RedOne™ 240	150 – 300
1.4565	S34565	MMA	P16	FOX NIBAS C 24	BlueOne™ 130	120 – 240	RedOne™ 240	150 – 300
1.4565	S34565	MIG	P16	NIBAS C 24-IG	BlueOne™ 130	120 – 240	RedOne™ 240	150 – 300
1.4410	S32750	MMA	2507/P100	FOX CN 25/9 CuT	BlueOne™ 130	120 – 240	RedOne™ 240	150 – 300

The pickling was preceded by mechanical pretreatment of the weld joints and precleaning using Avesta Cleaner 401.

3.4.4 Pickling in a bath

Figure 16: Bath pickling (photo courtesy of Kurt Jensen)

The stainless steel grade and the type of heat oxide determine the acid mixture and the bath temperature (20 – 65ºC). Pickling low-alloy stainless grades at excessive temperatures, or for a long period of time, presents the risk of overpickling. This gives a rough surface.

The effectiveness of pickling is affected not only by acid concentration and temperature, but also by the free metal content (mainly iron) in the bath. For pickling times to be the same, the temperature in a bath with an elevated iron content has to be higher than that in a bath with a lower iron content. A rough guideline is that the free iron (Fe) content measured in grams per litre must not exceed the bath temperature (ºC). When metal contents in the bath reach excessive levels (40 – 50 g/l), the bath solution should be partially or totally emptied out and fresh acid added.

Avesta Pickling Bath 302 is a concentrate that, depending on the steel grade being cleaned, can be diluted with water.

The ferritic and martensitic steels in group 1 are normally not pickled in a bath. Thus, they are not mentioned here. The pickling acid must be added to the water, not the other way round.

Group 2 steels: 1 part 302 into 3 parts water
Group 3 steels: 1 part 302 into 2 parts water
Group 4 steels: 1 part 302 into 1 part water

Temperature, composition and circulation need to be controlled to get the best results. The composition of the bath is controlled through regular analysis. Together with new mixing instructions to optimise the effect of the bath, Avesta Finishing Chemicals can offer such analyses.

The pickling times given in the table below must be seen as indicative only. They are stated as intervals because, for the same steel grade, the time required depends on the surface finish and the welding method (see also chapter 1). For hot rolled surfaces, pickling times might be increased by 50%. Similarly, depending on the shielding gas used, MIG welds might need longer than MMA or FCAW welds.

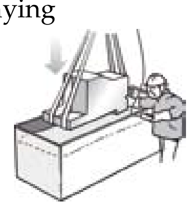
Table 5: Typical pickling times when using Avesta Bath Pickling 302

Stainless steel grades		Welding method	Welding consumables		Typical pickling times (minutes)		
EN	ASTM		Avesta designation	Böhler designation	20°C	30°C	45°C
Group 2: Easy to pickle*							
1.4301	304	MMA	308L/MVR	FOX EAS 2	30	15	10
1.4401	316	MMA	316L/SKR	FOX EAS 4M	40	20	10
1.4404	316L	MMA	316L/SKR	FOX EAS 4M	40	20	10
Group3: Difficult to pickle**							
1.4539	904L	MMA	904L	–	120	90	60
1.4362	S32304	MMA	2304	–	120	90	60
1.4462	S32205	MMA	2205	FOX CN22/9N	120	90	60
Group 4: Very difficult to pickle***							
1.4547	S31254	MMA	P12-R	FOX NIBAS625	240	120	90
1.4410	S32750	MMA	2507/P100	FOX CN25/ 9CuT	240	120	90

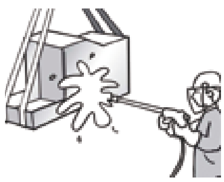
* 1 part 302 into 3 parts water
** 1 part 302 into 2 parts water
*** 1 part 302 into 1 part water

How to use Avesta bath pickling

1. Pretreat oxides, slag and weld defects mechanically.
2. After any welding, give the area to be pickled time to cool down to below 40°C.
3. To remove organic contamination, degrease using Avesta Cleaner 401.
4. Check the bath temperature (refer to table 5).
5. Immerse the object in the bath. Typical pickling times are shown in table 4. Avoid overpickling. This can produce a rough surface.
6. Allow the product sufficient pickling time.
7. If dark spots appear on the surface, desmutting is necessary. Apply either more solution or Avesta FinishOne™ to these spots until they disappear. This must be done when the surface is still wet (i.e. "wet on wet"), just before the pickling spray is rinsed off. Spraying FinishOne™ on top of the pickled surface also reduces the production of NO_x gases.
8. When lifting the object, allow time for the bath solution to flow off above the bath.



9. Rinse thoroughly using a high-pressure water jet. Ensure that no pickling residues are left on the surface. Use deionised water for the final rinsing of sensitive surfaces.
10. So that it can be neutralised, collect the waste water. See also chapter 4.
11. As the pickling acid in the bath is being constantly consumed and metals precipitated, analysis of bath contents is important. Bath contents affect the pickling reaction.



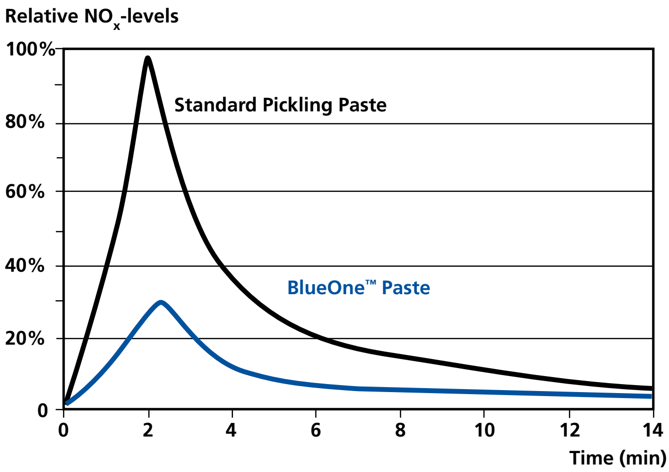
3.4.5 Fume reduction during pickling

Environmental impact:

The toxic nitric fumes generated during pickling have a number of effects.

- Health: High nitric fume levels may lead to respiratory problems (e.g. infections). In the worst case, inhalation may cause lung oedema.
- Environmental: Acidification of groundwater and damage to plants.

Using modern pickling products such as Avesta BlueOne™ Picking Paste 130 and Avesta RedOne™ Spray 240, toxic fume levels can be reduced by up to 80%.



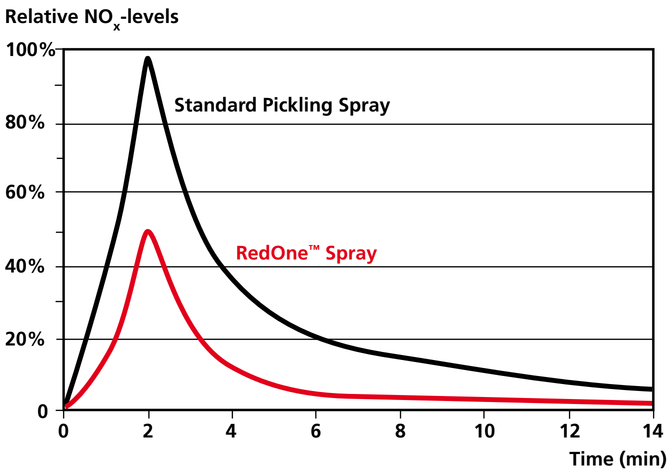


Figure 22: Fume reduction using Avesta pickling products
— BlueOne™ Pickling Paste
— RedOne™ Pickling Spray

Figure 17: Passivation of what will be part of a chemical tanker bulkhead in duplex stainless steel

Figure 18: Smut

3.5 PASSIVATION AND DESMUTTING

Avesta Finishing Chemicals' Avesta FinishOne™ Passivator 630 is a passivating agent that is free of nitric acid and has a low environmental impact. Because it is neutral after passivation, there is no need for a neutralisation stage. The product can passivate, desmut and reduce fumes.

Passivation is strongly recommended after mechanical treatment (to remove remaining iron contamination) and, in some cases, after spray pickling.

Desmutting removes the dark spots caused by excessive iron left on the surface by faulty cleaning.

Fume reduction: While bath pickling, spraying Avesta FinishOne™ Passivator 630 on the pickled object while lifting it from the bath reduces the toxic nitric fumes generated during bath pickling.

How to use Avesta FinishOne passivator

- To passivate after mechanical treatment, first use Avesta Cleaner 401 to preclean the surface. Next, rinse with water and apply the passivator "wet on wet". Leave it to react for 3 – 5 minutes.
- To desmut or avoid smut formation during spray pickling, the passivator must be applied before rinsing while the surface is still wet ("wet on wet"). Leave it to react for 10 – 15 minutes.
- To use for fume reduction after bath pickling, lift the object over the surface of the bath and spray FinishOne™ as a mist on the object's surface ("wet on wet").
- To passivate after spray pickling, first rinse off the pickling spray and then apply the passivator. Leave it to react for 20 – 30 minutes.
- Using an acid-resistant pump (Avesta SP-25), apply the product as a spray. Apply an even layer of acid that covers the entire surface.
- Using an acid resistant pump (Avesta SP-25); apply the passivator as an even layer that covers the entire surface.
- Preferably using a high-pressure water jet, rinse thoroughly with clean tap water. Ensure that no acid residues are left on the surface. Use deionised water for the final rinsing of sensitive surfaces.
- There is no need to neutralise the waste water (it is neutral and acid free).

4.

Neutralisation and waste treatment

4.1 NEUTRALISATION

The waste water from pickling is acidic and contaminated with heavy metals (mainly chromium and nickel that have been dissolved from the steel). This waste water must be treated in accordance with local regulations. It can be neutralised using an alkaline agent (slaked lime, or soda) in combination with a settling agent.

1. Adjusting the pH value of the waste water causes the heavy metals to be precipitated as metal hydroxides. Precipitation is optimal at pH 9.5.

The heavy metals form a sludge that can then be separated from the neutralised clear water. This sludge must be treated as heavy metal waste and disposed of accordingly.

4.2 WASTE TREATMENT

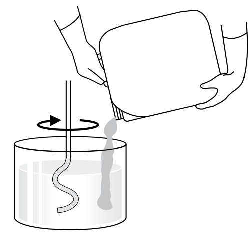
Pickling creates waste that requires special treatment. Besides what comes from the chemicals themselves, the packaging must also be considered as waste.

The sludge obtained after neutralisation contains heavy metals. This sludge must be sent away for disposal in accordance with local waste regulations.

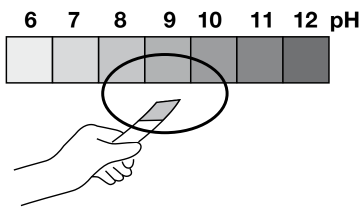
All materials used in the packaging (plastic containers, cardboard boxes, etc.) of Avesta Finishing Chemicals' products are recyclable.

How to neutralise

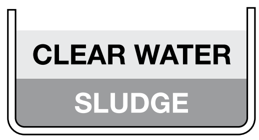
1. Stirring all the time, add the neutralising agent to the rinse water.
2. The neutralising reaction takes place instantly.



3. Using litmus paper (for example), check the pH of the mixture. Precipitation of the heavy metals is optimal at pH 9.5.



4. When the waste water has reached an acceptable pH value, wait for the sludge to sink to the bottom and for the water to become clear. Adding a special settling agent improves the precipitation of heavy metals.



Clear water and sludge

5. If analysis shows that the treated water satisfies local regulations, it can be released into the sewage system. To increase the degree of treatment, an extra filter can be inserted before the water reaches the sewage system.
6. The sludge contains heavy metals and must be sent to a waste-treatment plant.

5.

Inspection and troubleshooting

The final step after pickling and prior to delivery should be inspection and testing of the results of the cleaning process.

5.1 TEST METHODS

• Test for free-iron contamination

One frequently used test is to repeatedly wet the surface with tap water and allow it to dry so that the surface remains dry for a total of 8 hours in a 24-hour test period. Any residual iron rust is visible after the test cycle.

The ferroxyl test (ASTM A-380) is another highly sensitive method for the detection of iron contamination.

• Test for organic contamination

As previously stated, the water-break test is a simple way of assessing the effectiveness of degreasing. A thin sheet of water applied to a surface breaks around any surface contamination.

• Test for pickling-agent residues

The pH value of the final rinse water gives a rough indication of acid residues. The pH value must be > 7 (compare with the pH of incoming rinse water). Particular attention must be paid to tight corners, narrow crevices, etc. These may hide residues.

5.2 TROUBLESHOOTING

Inspection of a surface may reveal some remaining defects. The examples below show the most common types.

Figure 19: Dried-on pickling chemicals

Figure 20: Smut

Figure 21: Water staining

Figure 22: Discoloration

Table 6: Surface defects and corrective actions

Surface defects	Caused by	Corrective action	Precautions
Residual weld oxides	Insufficient precleaning/pickling	• Better pretreatment/repickling	Avoid overpickling.
Rough surface	Overpickling	• Mechanical treatment/repickling	Avoid both excessive pickling times and pickling in direct sunlight.
Rough surface	Mechanical cleaning	• Mechanical polishing	
Smut/discoloration	Poor cleaning/pickling	• Desmutting (Avesta FinishOne 630) or repickling or mechanical treatment	
Smut/discoloration	Dried-on pickling chemicals (e.g. pickling residues in crevices)	• Rinsing with high-pressure water jet and then repickling	
Smut/discoloration	Surface contaminants (e.g. iron particles)	• Passivation/decontamination or repickling	
Smut/discoloration	Insufficient cleaning	• Spot removal	
Smut/discoloration	Poor rinsing	• Spot removal using a cleaning agent • Using deionised water for final rinse	
Smut/discoloration	Trapped pickling acid "bleeding" from narrow gaps	• Repickling	
Smut/discoloration	Contaminated rinse water	• Passivation/decontamination • Using deionised water when surface requirements are severe • Rinsing with high-pressure jet	
Water stains	Contaminated rinse water	• Using clean rinse water and/or repickling	Work in dust-free environment.
Water stains	Dust	• Using clean rinse water and working in dust-free environment	Work in dust-free environment.

6.

Safe handling and storage of pickling products

Figure 23: Personal protection equipment

Figure 24: Storage of pickling products

6.1 SAFETY RULES

Pickling products are hazardous substances and must be handled with care. Certain rules must be followed to ensure that the working environment is good and safe:

1. Pickling chemicals must only be handled by persons with a sound knowledge of the health hazards associated with such chemicals. This means that the material safety data sheet (SDS) and the product label must be thoroughly studied before the chemicals are used.

2. Eating, smoking and drinking must be forbidden in the pickling area.

3. Employees handling pickling chemicals must wash their hands and faces before eating and after finishing work.

4. All parts of the skin that are exposed to splashing must be protected by an acid-resistant material, according to SDS. This means that employees handling pickling chemicals (including during rinsing) must wear protective clothing as stipulated in the SDS for the product in question.

5. A First Aid kit containing calcium glucontate gel, Hexaflourine® (Avesta First Aid Spray) or other products suitable for an immediate treatment/rinsing of acid splashes caused by pickling products, should be easy available. For more information check the SDS for the Avesta Pickling Products.

6. The pickling area must be ventilated.

7. To avoid unnecessary evaporation, the containers/jars must be kept closed.

8. To minimise the environmental impact, all pickling residues must be neutralised and all heavy metals separated from the process water and sent to a waste treatment plant.

6.2 PERSONAL SAFETY

Health hazards can be avoided by the use of breathing equipment and skin protection. If a high degree of personal safety is to be ensured, we strongly recommend that the following measures be regarded as compulsory.

For personal safety, a face mask (equipped with breathing apparatus) must always be worn in connection with pickling.

Pickling acids are aggressive and, on contact, can burn the skin. This can be avoided by protecting all exposed skin with acid-resistant clothing.

All cleaning chemicals from Avesta Finishing Chemicals are supplied with:

- Product information (PI) with reference numbers.
- Safety data sheets (SDSs) as per ISO 11014-1 and 2001/58/EC.

These documents give the information necessary for the safe handling of the product. They must always be consulted before using the product in question.

6.3 STORAGE

Pickling chemical containers must be stored indoors at 10 – 35°C. They must be kept in an upright position with the lids tightly closed. The storage area must be clearly defined and inaccessible for unauthorised persons. Pickling chemicals are sensitive to high temperatures.

Caution: Because they accelerate the ageing process and destroy the product, storage temperatures above 35°C must be avoided. Pickling chemicals are perishable goods. They give the best pickling results when they are fresh. This means that they must not be kept on the shelf longer than necessary. It is better to buy small amounts frequently rather than large amounts occasionally. Product composition and pickling efficiency deteriorate with age and exposure to heat.

All Avesta Finishing Chemicals' products are delivered in UN certified PE containers that are approved for the delivery of hazardous goods. Only recyclable materials are used for product packaging.

References

1. “Outokumpu Corrosion Handbook for Stainless Steels”, 2004.
2. “Standard Practice for Cleaning and Descaling Stainless Steel Parts, Equipment and Systems”, ASTM A-380.
3. “Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts”, ASTM A 967.
4. “Code of Practice for Cleaning and Preparation of Metal Surfaces”, BSI CP 3012.
5. “Rahmenvorschrift für die Oberflächenbehandlung austenitischer CrNi-Stähle, Chromstähle, Nickellegierungen”, KWU Arbeitsvorschrift RE-AVS 8.
6. “Beizen von nichtrostenden austenitischen Stählen”, Hoechst AG, Praxis WN 87-0417.
7. “Traitement de Surface”, Framatome RCCM F-5000-6000.
8. ”Cleaning & Maintenance. An Owner’s Manual for Stainless Steel in Chemical Tankers”, B. Leffler, Outokumpu Stainless.
9. “Post Fabrication Cleaning: Benefits and Practicalities”, International Conference, Stainless Steel America 2004, Houston, USA Oct 2004, C Baxter, A Bornmyr and R Stahura.
10. Tappi Tip, “Post-fabrication cleaning of stainless steel in the pulp & paper industry”, 2007, Chris Baxter (Outokumpu Stainless), Elisabeth Torsner (Outokumpu Stainless), Anders Bornmyr (Avesta Finishing Chemicals) and Ralph Davison (Technical Marketing Resources).
11. Outokumpu website.
12. “The Avesta Welding Manual – Practice and products for stainless steel welding”.
13. “The Böhler Welding Guide”.
14. “STAINLESS – stainless steels and their properties”, Béla Leffler, Outokumpu Stainless.

Disclaimer

Information given in this manual may be subject to alteration without notice. Care has been taken to ensure that the contents of this publication are accurate but Böhler Welding Group Nordic and its subsidiary companies do not accept responsibility for errors or for information which is found to be misleading.

Suggestions for or descriptions of the end use or application of products or methods of working are for information only and Böhler Welding Group Nordic and its affiliated companies accept no liability in respect thereof. Before using products supplied or manufactured by the company the customer should satisfy himself of their suitability.

Avesta Finishing Chemicals
Lodgatan 14
SE- 211 24 Malmö, Sweden
Tel: +46 (0) 40 28 83 00
Fax: +46 (0) 40 93 94 24
info@avestafinishing.com
www.avestafinishing.com

Avesta Finishing Chemicals

Member of the Böhler Welding Group

I002523:6EN-GB Centrumtryck, Avesta 2009