AUSTENITIC STAINLESS STEELS

Introduction

1- Meaning of stainless steels for the food industry

Austenitic types of stainless steels offer rather **easy processing** as well as **good forming ability and corrosion resistance.** Austenitic steels possess a **great structure stability**, which allows their use in a large temperature range. These steels are not tempered but **cold-work strengthened**.

2- Surfaces states

Production lines for the food industry are often made from a **stainless steel sheet after cold rolling which has a high quality surface**: smooth and even bright. These surfaces named **2B and RB** are obtained by rolling and annealing and are suitable for transportation of solid or liquid food products. **Their low roughness allows for easy cleaning intended to eliminate bacteria, which considerably reduces service cost of lines.** This is a very important aspect of operation.

The quality of a stainless steel surface partly defines its corrosion resistance and in 23% of cases it can be the reason of its degradation (roughness, pollution, product retention…).

a- Precaution.

The molecular stratum of chrome oxide, impenetrable, about 50A, assures resistance to corrosion. This explains the passivation phenomenon: the chemically provoked or spontaneous formation of a hard surface film which inhibits further corrosion.
When this stratum is damaged due to a mechanical action (blows from tooling, scratch, etc), steel looses its stainless nature, at least locally and for some time.
This indicates that appropriate care is needed while using this type of material; lack thereof compromises the material's resistance to corrosion.

b- RA below 0,8 µm

Surfaces in contact with the product should have an acceptable roughness (Ra) value and be without imperfections such as point corrosion, cracks and irregularities (for Ra definition see ISO 458,1982).

For surfaces coming in contact with a product having a large area, the **Ra should be < 0,8 µm**. A roughness > 0,8 um can be accepted if test results prove that the required cleaning aptitude is reached thanks to other conception advantages.
It should be noted that cold rolled steel has an Ra = 0,2 to 0,5 µm and does not need to be polished to comply with wall roughness requirements, provided that surfaces coming in contact with the product doesn't have any point corrosion, cracks and irregularities.
Surfaces that are not coming in contact with the product should be also smooth in order to allow for easy cleaning.
See table: **Surface roughness**.

SURFACE ROUGHNESS

Treatment	Ra, µm
Stainless steel after cold rolling	**0.2-0.5**
Stainless steel after hot rolling	**>4**
Treatment with glass balls (according to dimensions of balls)	**1 - 1.2**
Descaling	**0.6-1.3**
Bright annealing	**0.4-1.2**
Etching	**0.5-1**
Electro brightening	*
Mechanical polishing With aluminum oxide or silicium carbide Grain abrasive number	
500	**0.1 - 0.25**
320	**0.15 - 0.4**
240	**0.2 - 0.5**
180	**≤ 0.6**
120	**≤ 1.1**
60	**≤ 3.5**

TUBES AND STANDARDS

Tube production

A At the beginning, parent sheet goes between forming rolls
B To produce any form of tube (square, rectangular) we start with a round tube that passes through "moulds" to get its final form
C Three welding types are used: TIG, HF, Laser.

1. TIG welding

Welding speed: 1 to 5 m/min.

Edges are approached and welded by electrodes.
- After T1G welding you have to come back to the welded seam because it is slightly thick
- Seam is finished by weld rolling

2. HF welding (High Frequency)

Welding speed: 40 to 90 m/min.

Edges are approached and welded by electric arc (1300° in the heated zone).
- After high frequency welding the seam contents a lot of ferrite (which is due to the welding type, zones which are too thick have to be mechanically polished inside and outside with special cutting tools).

3. Laser welding

Welding speed: 15 m/min.
- The advantage of laser welding is that the seam is very thin and doesn't need further finishing (deco tubes)
- Laser ray – 0,22mm, high quality of steam junction
- For production of food quality tubes, the problem occurs with rolling because one needs to find a mandrel resistant to laser temperature.

D Following welding, the tube is annealed in line:

It is introduced in an oven under a neutral atmosphere, at a temperature of 1150° degrees Celsius (with white annealing, no need to etch surface).

Advantages of annealing:
- Allows cold forming of tubes.
- Annealing permits to avoid carbide settling and risk of inter-granular corrosion.

E All tubes are controlled by Foucault current, which detects imperfections ≤ 0,9mm (but not big defects).
It should be noted that the cost of different quality control operations represents about 8% of tube costs.

F Grain polishing 220.

G Marking: Cast number,
Steel type
Ø and thickness
NFA 49249/ ISO2037
Manufacturer's logo

H Packing in plastic cover.

I Packing in wood case.

Miscellany

If a client claims that tube is rusted (tubing on a service installation):

- Get confirmation if the problem concerns only the tube or different accessories as well (elbows, tees, reducers).
- If it is the tube, get the following information:

Environment.
Product, process: Composition
Operation (pressure, temperature)
Cleaning product: Composition
Operation (pressure, temperature)

Installation date.
Storage environment before installation (adjacency with black steel is not recommended).
Welding type.
Request a sample with problem and number of cast.

Standards

Designation

France - NF	Association Française de Normalisation.
Allemagne - DIN	Deutsches Institut Normung.
tati - Units - ASTM	American Society for Testing and Materials.
Grande Bretagne-BSI	British Standard Institution.
Suéde-SMS	Swedish Metric Standard.

Generally used: **SMS - DIN.**

1- Industrial accessories.

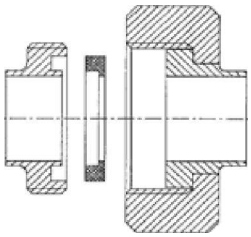
There is no standard in France, or other countries that defines the production of accessories for the Food industry. Standardization procedures are currently being attempted.

2- Unions for the Food industry SMS - RJT - ISS - PIN - MAÇON - CLAMP.

Unions for the Food industry are made from a welding end and male end which are connected by a nut with a round thread (or triangular thread)
Tightness of the connection is provided by the seal located in the center of the male end gouge that comes in contact with the welding end.

a- SMS 1145

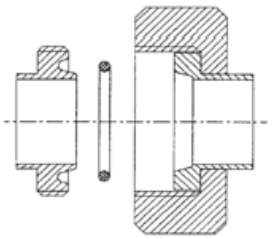
THREAD	-	round, according to NFE 03.003 and DIN 405
NUT	-	round exterior, with processed edges and cuts for fixation with key
SEAL	-	L-type, mounted on the male end gouge
MOUNTING	-	on the tube by welding edge to edge



***NB**: SMS connection can be dismounted without flaring pipes for devices installed in line. However, it doesn't provide an efficient centering of two union pieces, one to the other.*

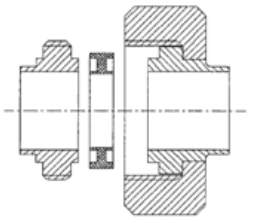
b- RJT 1864

THREAD	-	triangular, withworth
NUT	-	hexagonal exterior with a round option, with cuts for fixation with key
SEAL	-	round, mounted on the gouge of semi-circular profile from male end
MOUNTING	-	on the tube by welding(or by flaring, continuous fixing grooves or gouges in bore).
JUNCTION	-	cylindrical coupling with a flared tube exceeding threaded part.



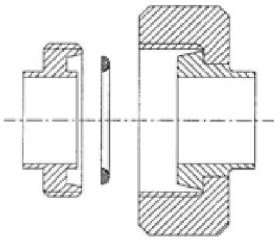
c - ISS 3382

THREAD	-	trapezoid Acme
NUT	-	hexagonal, round option, with cuts for fixation with key
SEAL	-	T-type, mounted between welding and male ends, without gouge, each side of T bears in O outside of end, vertical part of T creates the tightness
MOUNTING	-	of tube by flaring, continuous grooves in bore which gives the extension of tube to be fixed; maybe 2 ou 3 gouges
JUNCTION	-	without coupling



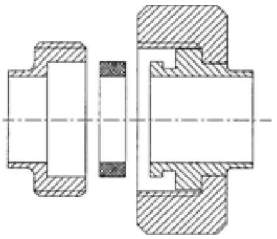
d - DIN 11851

THREAD	-	round, according to NFE 03.003 and DIN 405
NUT	-	round exterior, with slightly processed
SEAL		edges and cuts for fixation with key
MOUNTING	-	semi-round, mounted on the male end gouge
JUNCTION	-	by conical coupling with enough space



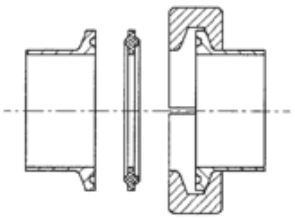
e - MAÇON

THREAD	-	triangular, according to NFE 03.001
NUT	-	round outside, with slightly processed edges and cuts for fixation with key
SEAL	-	leather, plate, to be mounted in male part bore
MOUNTING	-	on tube by welding (or by flaring, 2 or 3 gouges give the extension of tube to be fixed)
JUNCTION	-	by cylindrical coupling



f - CONICAL CLAMP UNIT E 29521

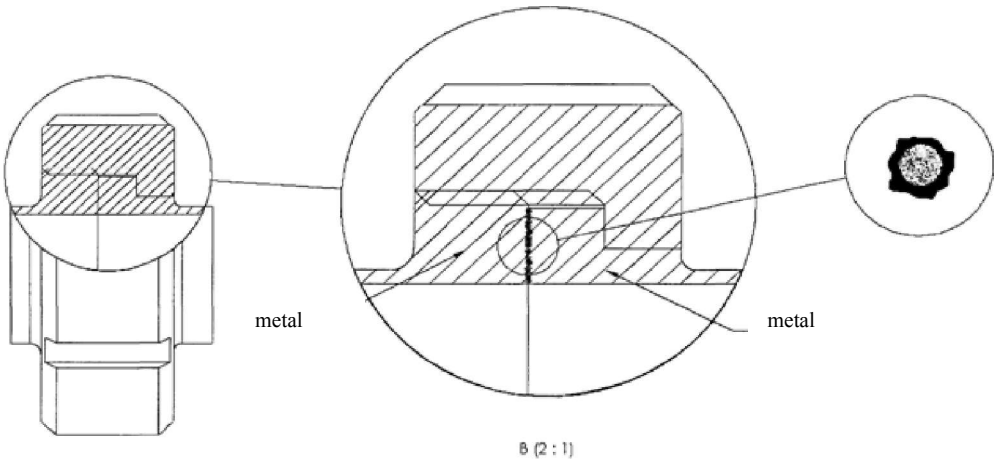
THREAD	-	by s/s clamp, with 2 parts connected by hinge and threaded system to provide fixing and regulation
SEAL	-	cross-shaped, between 2 same ends
MOUNTING	-	on tube by welding on the edge
JUNCTION	-	without coupling



Bores of these unions meet tube dimensions of given standards. However, it is impossible to couple 2 unions of different standards because there are not compatible when assembled.

3- Metal – Metal Unions

Metal – metal unions (not welded types) are made by deformation of metal surfaces coming in contact. The result is permanent damage to these surfaces, making it more difficult to provide tightness after each dismounting. Even when these unions do not have visible leaks, bacteria contamination is still possible. Furthermore, the obtained tightness is probably not on the product side. There exists a risk that the leak-tight zone is not homogenous between interior and exterior surfaces. The product will be retained in this convolution. Therefore, metal – metal unions cannot be used in a hygienic line.



Chapter 3

CONTROLS OF HYGIENIC WELDING SEAMS

Pipeline made of austenitic stainless steel 316L/304L.

316L/**304L** pipeline and unions should have the inside **roughness Ra < 0,8 µm**.

TIG welding TIG (Tungsten Inert Gas), also defined as GTAW (Gas Tungsten Arc Welding) must be used. Other types of welding don't suit hygienic application.

It is recommended to invite qualified welders, who are certified for example to work with vessels under pressure (BS 5500, ASME VIII or other national standards)

Pipeline should be designed in such a way that the **junction is the only welded construction**. It is better to proceed to pre-assembling of sections in a controlled environment before making the final installation.

Welding should fill the space between pipe/union edges, in a welded zone there should be no penetration (leakage) neither defects (such as inclusions, porosity, not enough fusion, cracks).

During welding, the interior surface should be protected by gas, the best is argon but nitrogen can be also used.

Tube edges should be scraped with s/s brush in the fusion zone and treated **with a dissolvent to remove dirt and fat.**

Tube edges should be cut in angle to tube axle, mechanical tools are used (not manually), without barbs or deformations**.** If a supporting materiel is requested, for example for wall with width more than 3mm, tube edges can not be cut manually.

The use of finished couplings is required (tees, elbows etc) and these should comply with tube standards.

Tube diameters should be marked; otherwise the smaller one has to be extended with a special tool in order to the creation of a bearing and a loose seam.

Alignment accuracy should be limited at 20% of wall width.

Test passage/test pieces are necessary to obtain best conditions adapted to the real width of the wall.

Weld seams can be removed from the inspected line if it was foreseen in advance.

WELDING DEFECTS AFFECTING HYGIENIC SECURITY

There are a number of common defects that occur while welding and can create microbiologic problems, provoke bad cleaning and product retention.

In summary, this includes the following surface deformations:

1- alignment defects.

***2*- cracks.**

3- porosity and inclusions.

4- incorrect penetration.

5- inadequate fusion.

6- lack of protective gas.

Roughness measurements of TIG weld seams are 3 to 4 µm in high quality seams and Ra 7 to 8 µm in "industrial quality" seams.

Although these values top ideal ones, the welding zone is relatively small.

Ra > 8 µm is usually is not accepted.

HYGIENIC CONCEPT

1- Hygienic concept criteria.

While designing, producing and installing open or closed type equipment, we should keep in mind thefollowing basic criteria:
→ Surface and geometry.

Surfaces in contact with product should not have defects such as irregularities, and consequently:
→ avoid direct metal – metal coupling without welding (sulfides and microorganisms could be retained in metal – metal contact zone).

Concerning equipment for aseptic use, metal – metal couplings will not stop bacteria penetration.
→ avoid asperities due to a bad alignment of equipment and tube couplings

While using seals be sure that they don't have irregularities where dirt and/or bacteria can accumulate and propagate.
Except for deforming seals in order to obtain static seal in contact with product, we should avoid the use of toric seals in contact with product in hygienic equipment and pipelines.
There should be no contact of product with thread. It is better to have the fillet (rounding) of radius ≥ 3mm. Avoid acute angles (<90°). If acute angles can not be less then 3mm, the design should compensate losses during cleaning.
Surfaces connected at an angle >180°, if they are placed on a seal, should be carefully polished to provide tightness as close as possible to seal/ product interface. Edges should be carefully cut.

2- Liquid drain and falls (downslopes placement).

Interior and exterior surfaces of each equipment and pipelines should be auto-drained and easily cleaned.
To avoid horizontal surfaces, surfaces should always be sloping to one side.
On exterior surfaces sloping should be done in a direction that gets liquid flowing in the opposite side to main production zones.

3- Remarks.

Stainless steels type AISI316 (DIN Werkstoff №1.4404 or AFNOR Z6 CND 17 611) are mostly recommended for equipment and pipelines with presence of chlorides and medium service temperature (60°). Honeycomb corrosion due to chlorine action does not emerge on AISI 316 stainless steel at 60° to 150° temperature. AISI 316 stainless steel is recommended for valves, pumps bodies, rotor and shafts production; whereas AISI 316L stainless steel is recommended for pipelines and vessels production because of its high adequacy to welding.

4- Elastomers.

For production of seals and gaskets for the food industry, different types of elastomers are used. The following ones are advisable:

- **Ethylene propylene diene monomere (EPDM)**
- **nitrile**
  nitrile/ butyle (\BR)
- **silicone**
- **fluoroelastomers (VITON)**

No contact of any holder with product is admissible except when coupling between elastomer and product completely excludes product penetration.

5- Hygienic welding requirements.

To get a high quality weld seam stainless steel of a small thickness with TIG (Tungsten Inert Gas) welding or gas Tungsten Are Welding (GTAW) is used.

Special attention should be given to pipeline welding because once the welding is done it is impossible to proceed to additional treatment from the product side. The automation of welding is an effective way to reduce its defects.

It is proved that orbital welding (automated specifically for TIG piping) actually provides a good weld seam of high hygienic quality.

Hygienic concept of equipment is based on 3 main principles:

1. **product should circulate free inside the equipment, without retention**
2. **installation has to be cleanable and consequently disinfectable**
3. **interior surface of equipment has to be protected from the exterior environment**

Therefore, weld seams should meet the same requirements. A bad seam can have a serious negative influence on hygiene.
For example product can be retained for many reasons: irregularities, dead zones or rough surfaces, all parts which are badly washed or not washed at all during standard CIP cycles.

Product that was retained is contaminated and inhabits with microorganisms a healthy product. This way an incorrect weld seam compromises product quality in a line which is designed to be otherwise hygienic.

CONCLUSION

CRITERIA PRINCIPLES OF HYGIENIC CONCEPT FOR SURFACES IN CONTACT WITH PRODUCT

In service conditions, materials should be non-toxic, non-absorbent and resistant to

chemical cleaning and disinfecting solutions.

Plastics and reinforced elastomers should not allow product leakage.

Elastomer compression should be controlled.

Surfaces should provide a drain (inclination > or = 3°).

Surface roughness Ra > or = 0.8 µm.

TO BE AVOIDED

Metal - metal unions (except for welded types).
Irregularities in alignment.
Rough edges.
Toric seals, unless these are stable or put on the same level (with tube, tank bottom etc).
Acute angles (recommended radius > or = 6 mm, minimum 3 mm).
Dead zones.

If it is impossible to respect all criteria, modifications are permitted. In that case, the design should compensate for losses in cleaning ability, pasteurization, sterilization and for aseptic equipment bacteria tightness.

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