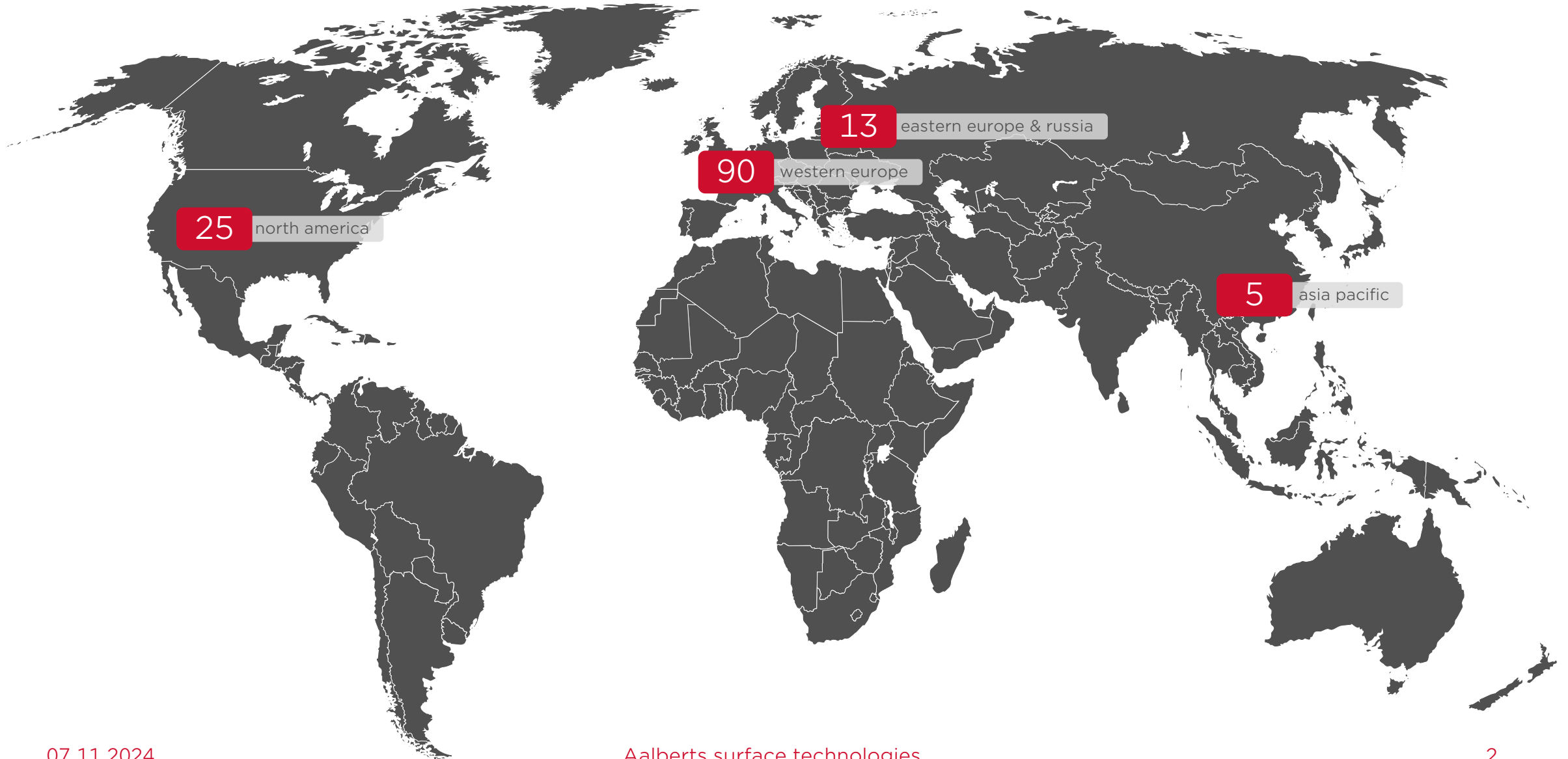


Stainihard

Surface Hardening of Stainless Steels

Jeroen Knippenberg

Alberts locations worldwide





our technologies impact everyday life

heat- & surface treatments:

Our aspiration is to deliver the highest quality. This not only applies to the processing of your products, but also to how we deal with you, our valued customer.

We maintain close cooperation with our customers and offer you tailor-made solutions for your specific requirements, anywhere in Europe.

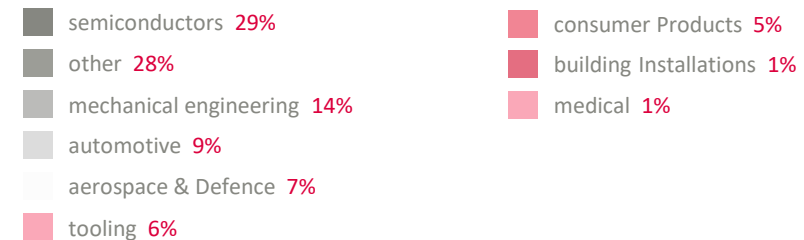
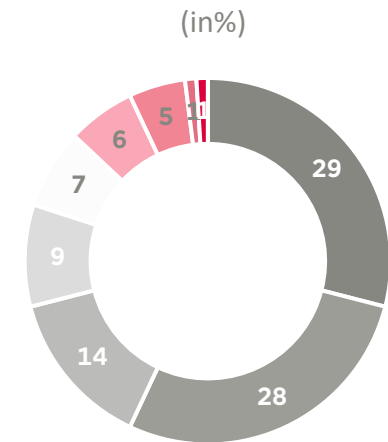


Heat treatments at our 23 locations in 7 European countries, we offer 52 different heat treatments based on our core technologies.



Eindhoven

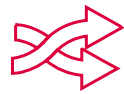
- Established as part of Philips
- Part of Aalberts Group
- ~60 FTE



Processen



Heat treatment



Vacuum Brazing



Thin Layer Deposition

PVD
CVD



Hot Isostatic Pressing



Thermochemical Processes

Nitrocarburizing
Nitriding

- Surface hardening of stainless steel while maintaining corrosion resistant properties.
- Austenetic Stainless steels
 - » Corrosion resistance
 - » Soft
 - Susceptible to wear
 - Galling
 - » Conventional hardening not possible due too low carbon content

Stainihard

- Low Temperature nitrocarburizing of Stainless Steel
 - » Carbon and nitrogen diffusion
 - » Hard, wear-resistant surface
 - » Improving fatigue life
 - » Maintaining corrosion resistance
- Stainless Steel types
 - » Austenitic (AISI 303, AISI 304, AISI 316 etc)
 - » Duplex 318LN
 - » Nikkelalloys (inconel)



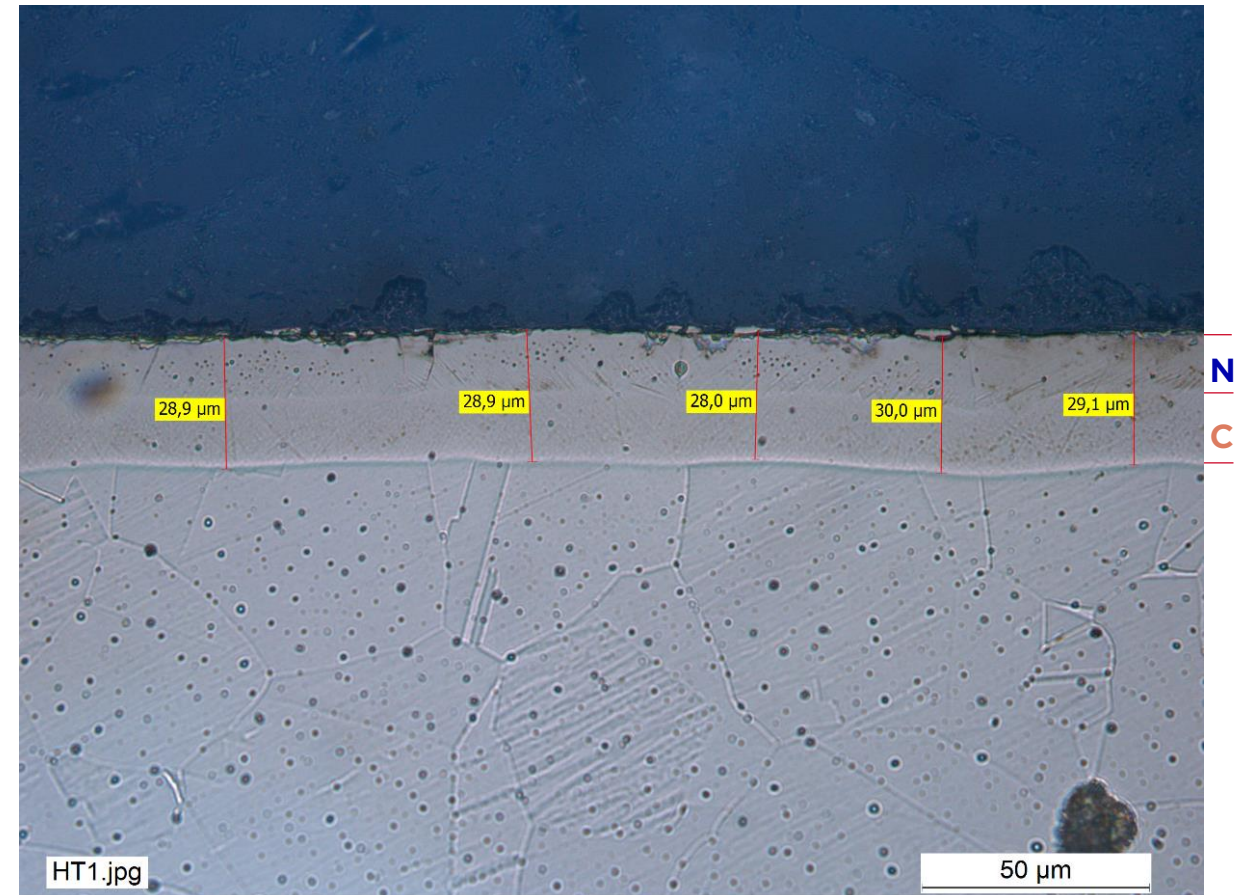
Stainihard

- Product sizes
 - » Retort Furnaces in different sizes
 - Smallest Ø 500x900 mm
 - Largest Ø 1600x2000 mm
- Type
 - » Focus on adaptability for large variation of customers and parts
 - Large singles/ small series
 - » Batch work (~100.000 pcs)



Stainihard: Structure of the layer

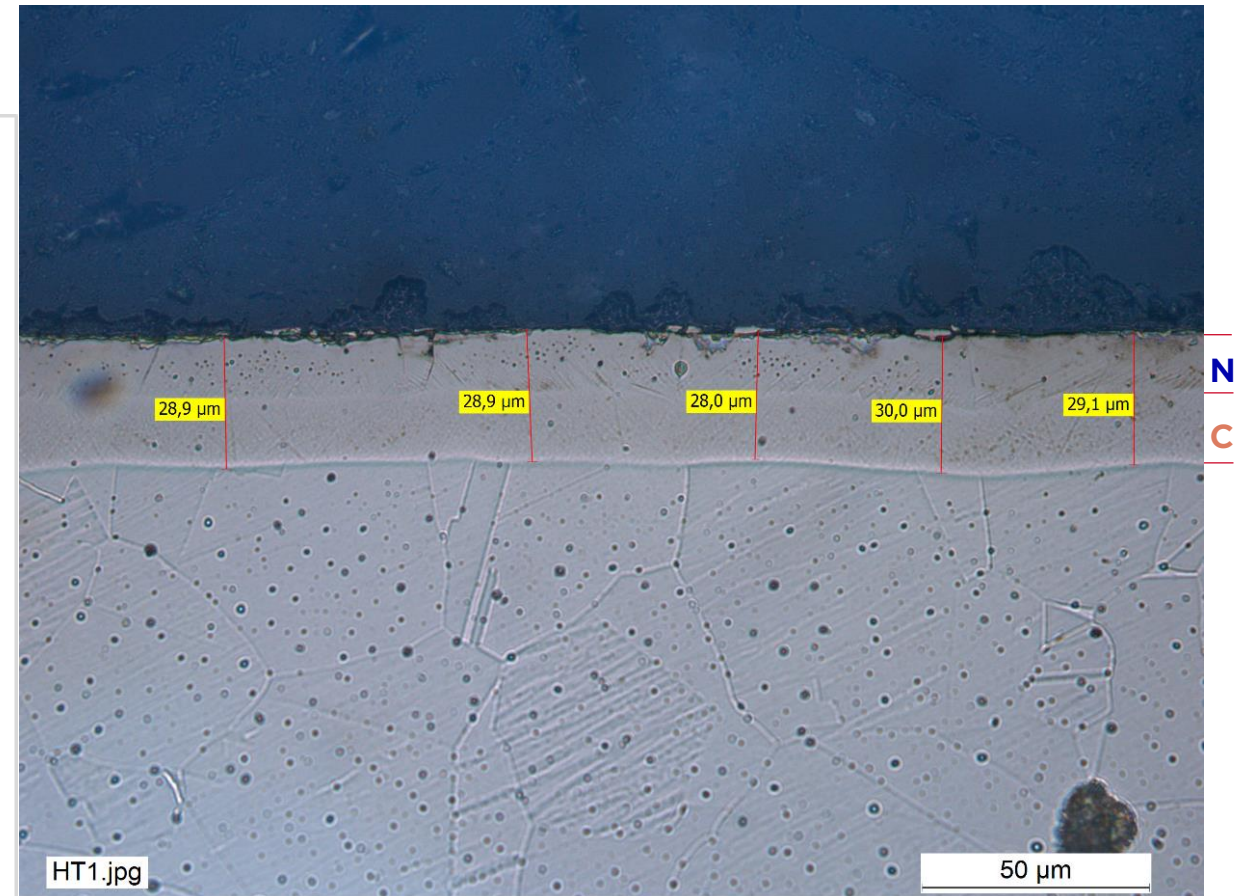
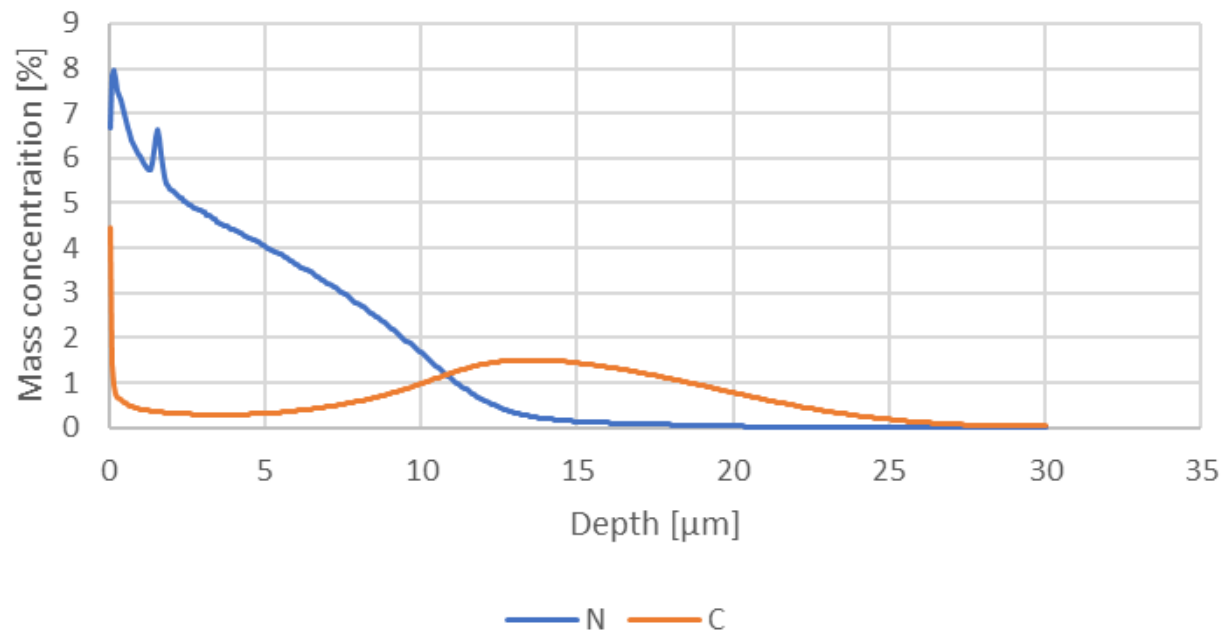
- Expanded Austenite surface
 - » Diffusion layer
 - Nitrogen
 - Carbon
 - » High compressive stresses
 - » Layerthickness
 - 15-30 μm
 - Dependent on Material and process



Stainihard: Structure of the layer

Glow Discharge Optical Emission Spectroscopy (GDOES)

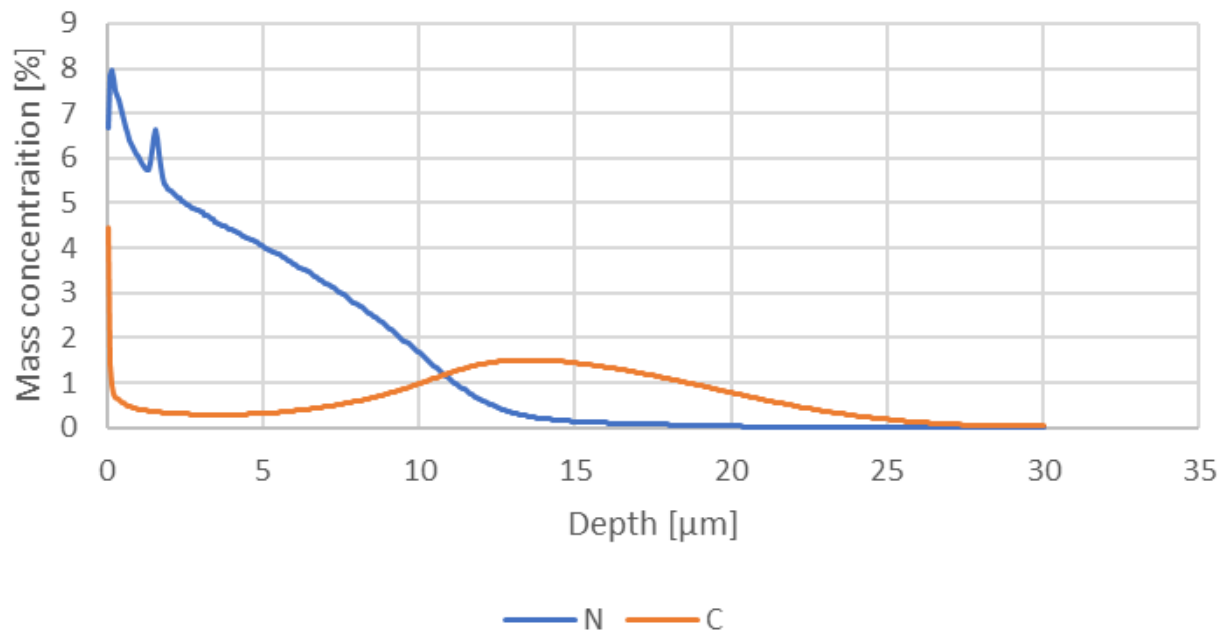
AISI 316L Stainihard NC



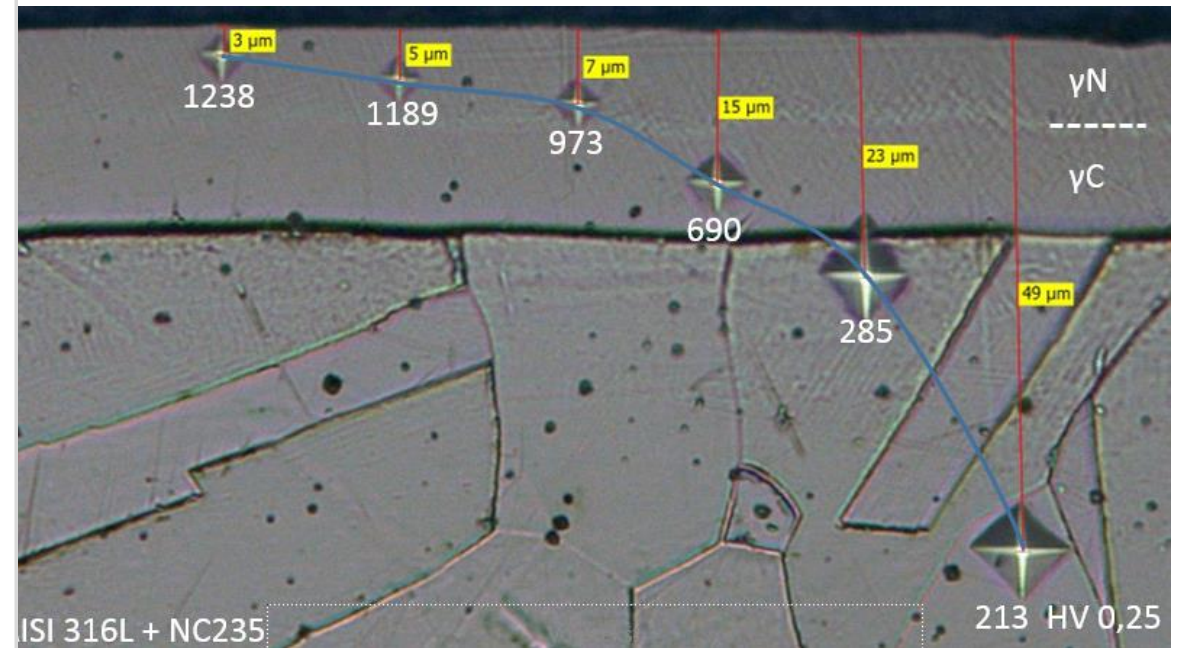
Stainihard: Structure of the layer

Glow Discharge Optical Emission Spectroscopy (GDOES)

AISI 316L Stainihard NC



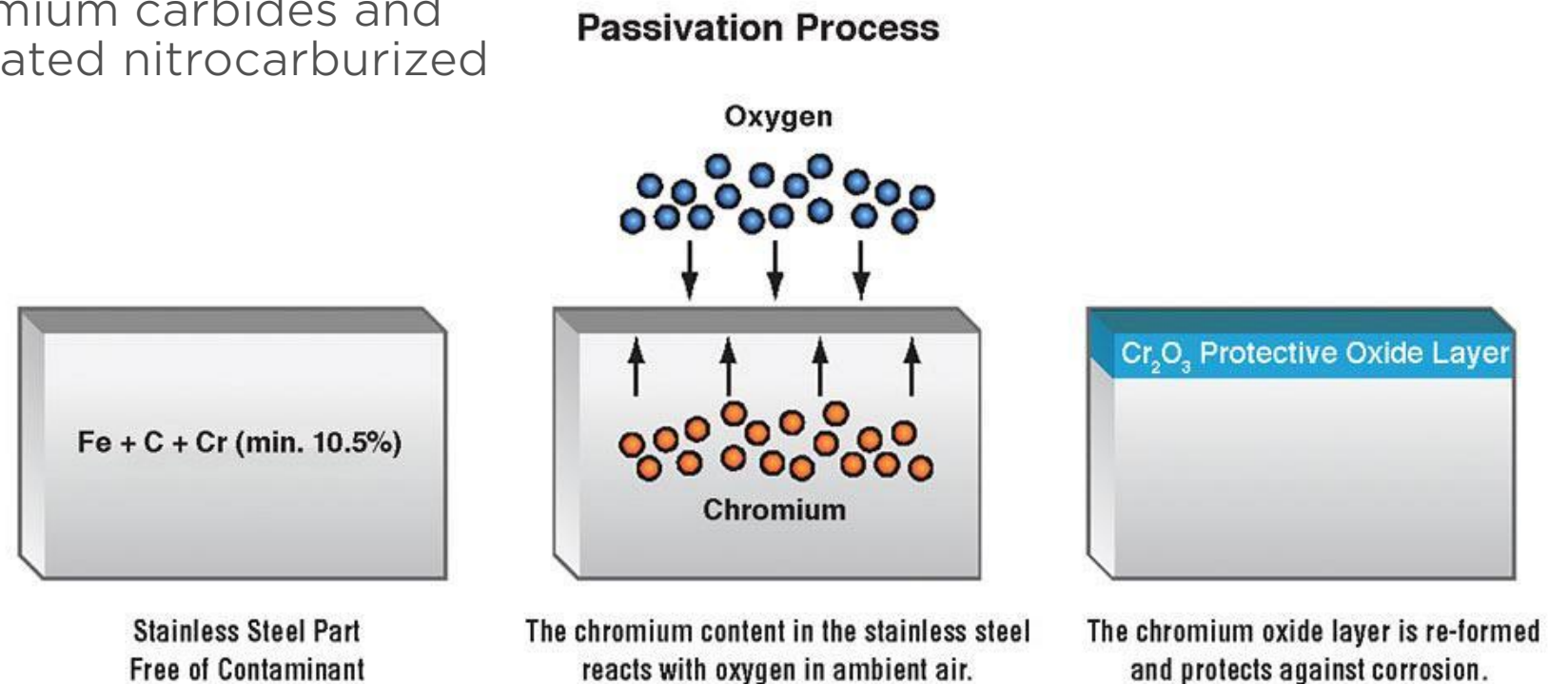
Surface Hardness
1000-1400HV



Hardness Gradient, no sharp transition

Stainihard: Challenges for the process

- Chromium Oxide layer acts as diffusion barrier
- Sensitization
 - » Process time and temperature limits
 - » Precipitation of chromium carbides and nitrides in supersaturated nitrocarburized surface layer



Stainihard: Challenges for the process

- Chromium nitride precipitation leads to chromium depletion at the surface
 - » Temperature restrictions limit diffusion speed

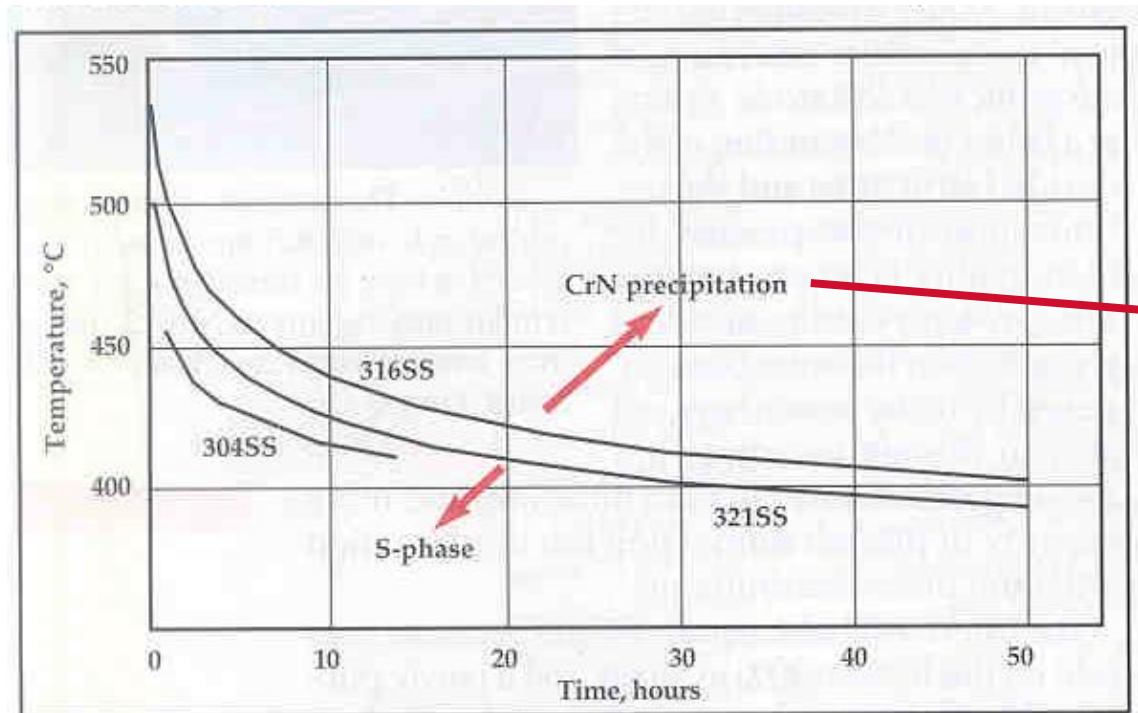
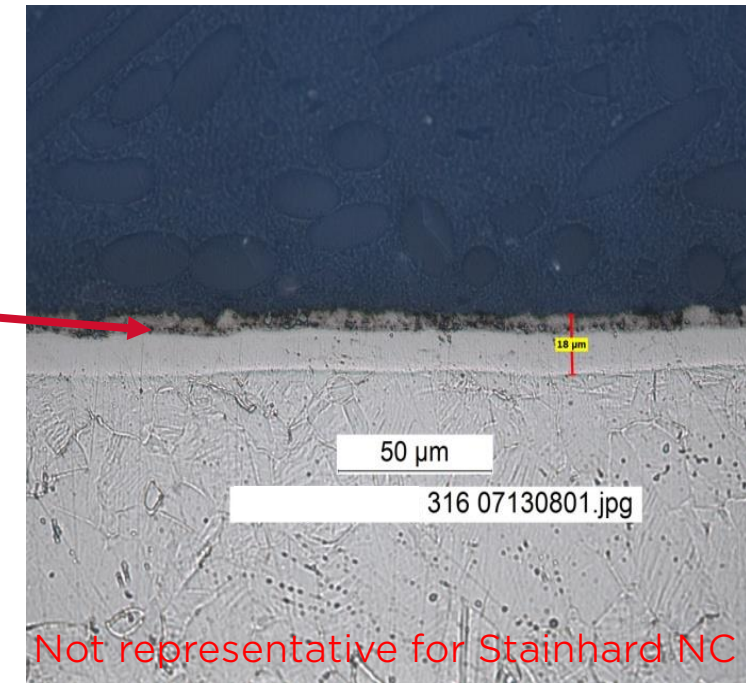


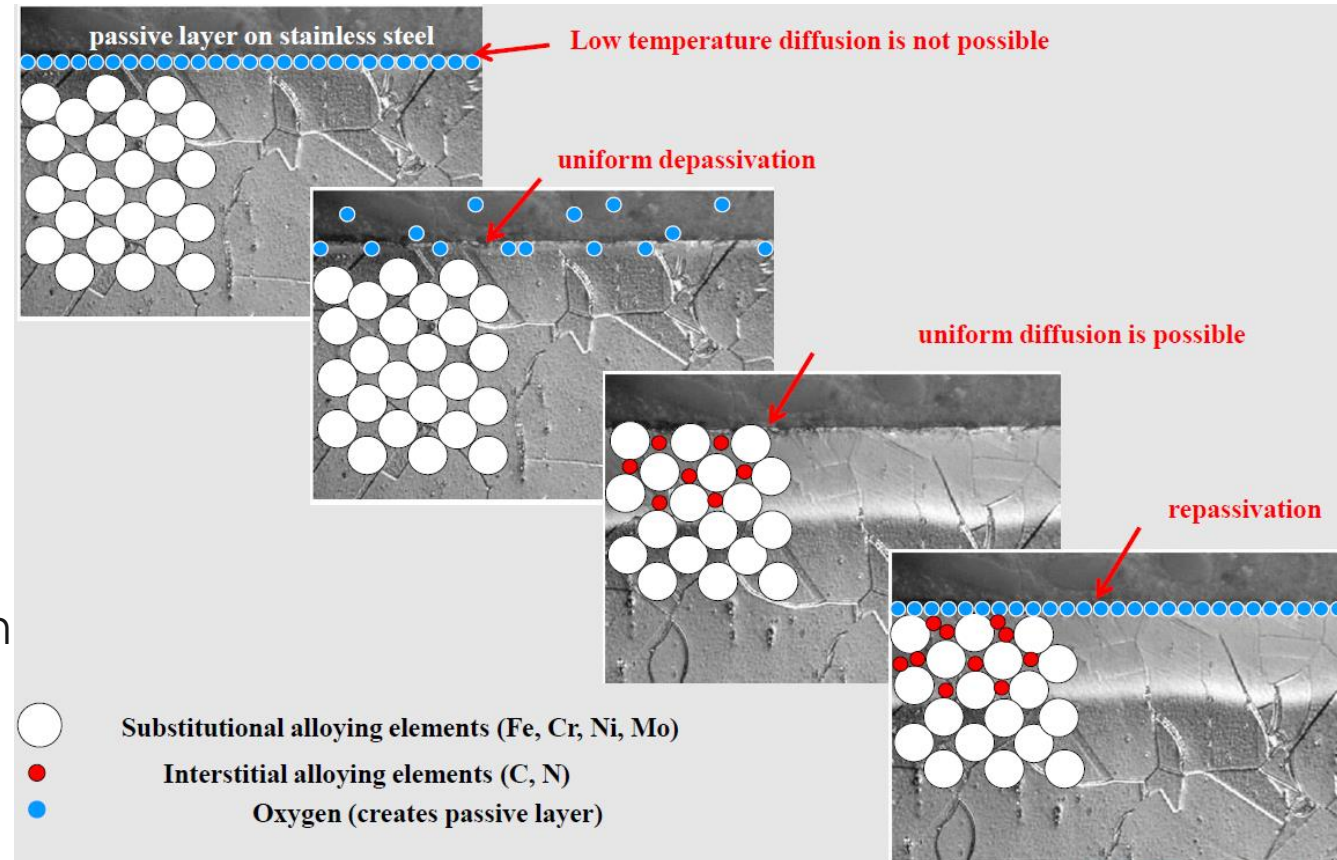
Fig. 3 — Threshold temperature (T) vs. time (t) curves for the three austenitic stainless steels. Chromium nitrides start to form above the curve.



Not representative for Stainihard NC

Stainihard: Nitrocarburizing of Stainless Steel

1. Activation: removal of oxide film to allow for diffusion
2. Diffusion of C+N via gasatmosphere
 - » Nitrogen donorgas and carbon donorgas
 - » 20-40h
 - » Lower temperature and longer time than 'classical' Nitrocarburizing
3. Re-passivation of the surface for corrosion resistance
 - » Clean surface, rich in free-chromium



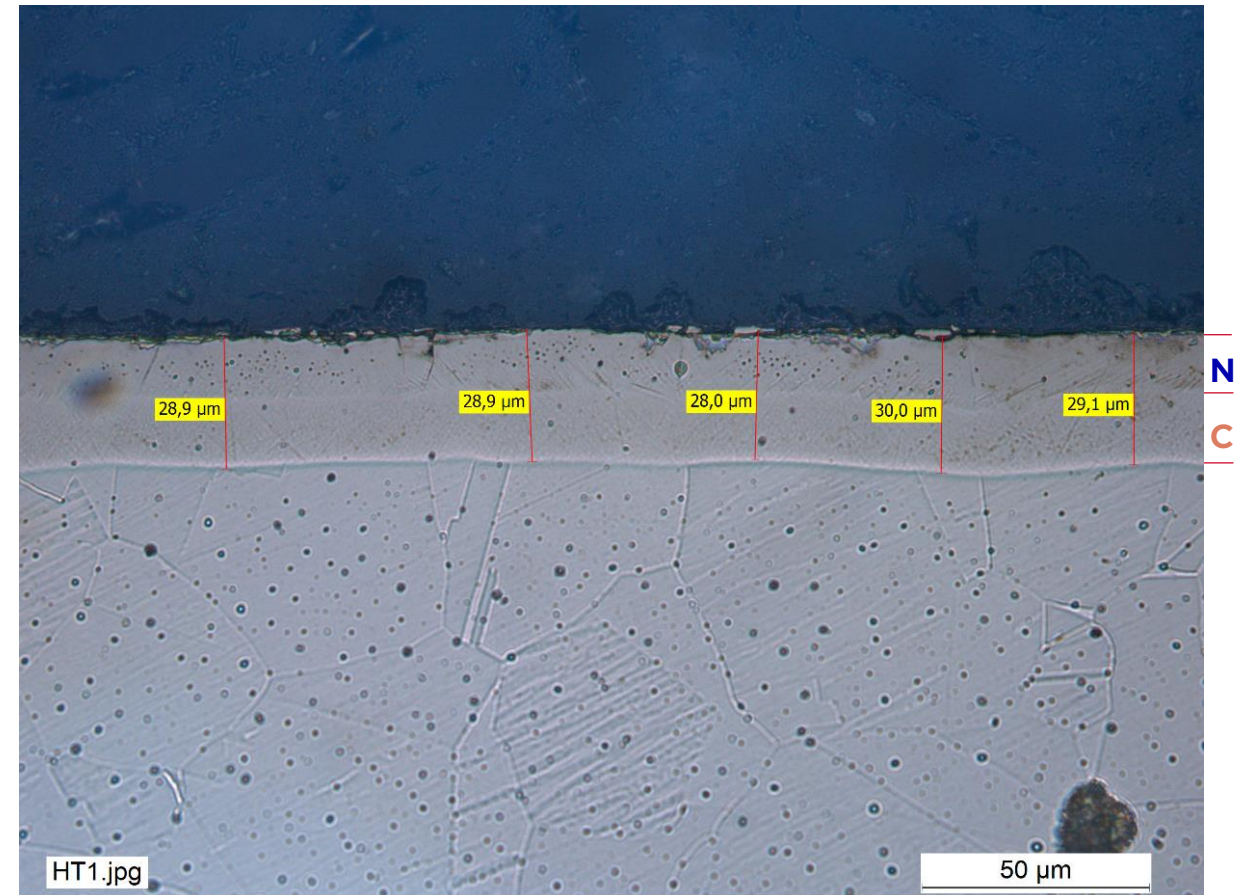
Stainihard: Pre and post processing

- Precleaning
 - » Degreasing, removing contaminants
- Post cleaning
 - » Removing sooth residual
 - » Allow stable chromium oxide layer to form
- Roto-finish (optional)
 - » Improved corrosion resistance and surface finish



Stainihard: Structure of the layer

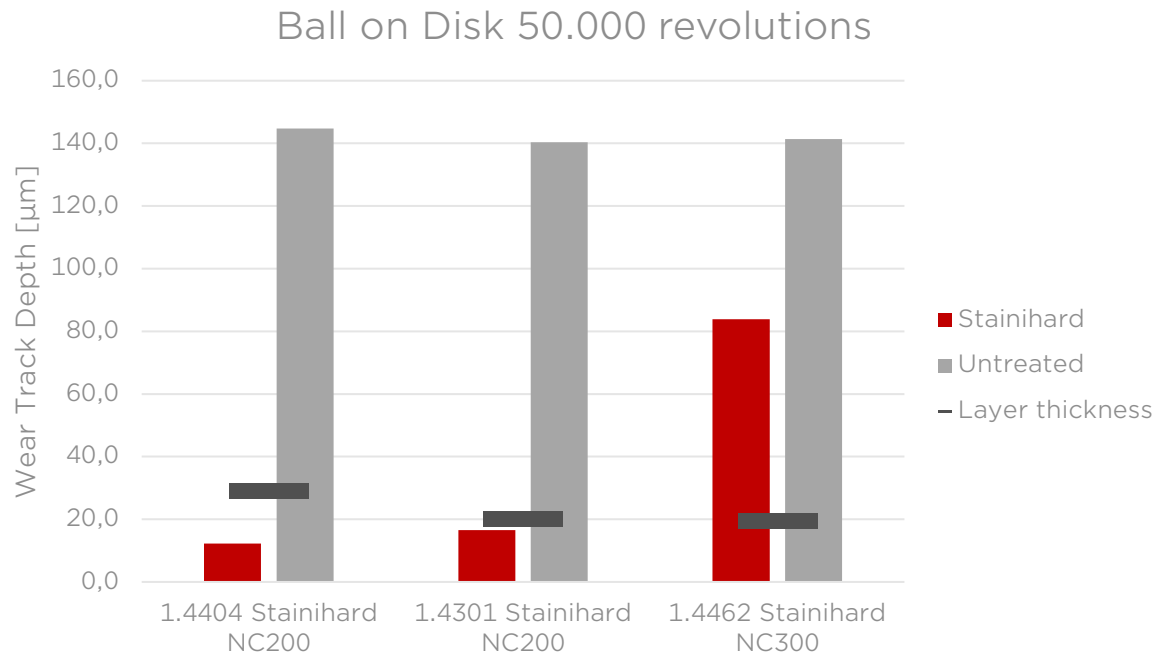
- Expanded Austenite surface
 - » Diffusion layer
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 - » Layerthickness
 - 15-30 μm
 - Dependent on Material and process
 - » Surface Hardness
 - 1000-1400HV



Stainihard: Wear Resistance

» Ball on disc test 50.000 revolutions

- AISI 316
- AISI 301
- AISI 318LN



1 HT1

Standard parameters

Gerät

- Standard tribometer
- Serial number: 01-04372
- Tribometer / Version 7.2.6
- Date of measurement: 22.03.2021 11:12:21

Statischer Partner

- Schicht: Al2O3
- Substrat: Korund
- Reinigung: isopropanol
- Dimension: 6,00 [mm]
- Geometry: Kugel

Probe

- Schicht: keine
- Substrat: Stahl
- Reinigung: isopropanol

Umgebung

- Temperature: 20,10 [°C]
- Atmosphere: Luft
- Humidity: 26,90 [%]

Sequence

- Sequence count: 1
- Single-way mode
- Radius: 5,49 [mm]
- Lin. Speed: 10,00 [cm/s]
- Datenerfassungsrate: 50,0 [Hz]
- Cycles sampled: 1/100
- Pause: 0 [s]
- Homing at begin: Nein
- Normallast: 10,00 [N]
- Unload at end: Nein
- Stop condit.: 50000,0 [Umdrehung]
- Effectiver Stop: Runden

Stainihard: Corrosion Resistance

Salt spray Corrosion test result after 168h



Element Materials Technology P 714 892 1961
 15062 Bolsa Chica F 714 892 8159
 Huntington Beach, CA T 888 786 7555
 92649-1023 USA info.hb@element.com
 element.com

Contact: Vince Lomax
 Tech Mold, Inc.
 1735 West 10th Street
 TEMPE, AZ 85281

TEST CERTIFICATE — EAR-CONTROLLED DATA

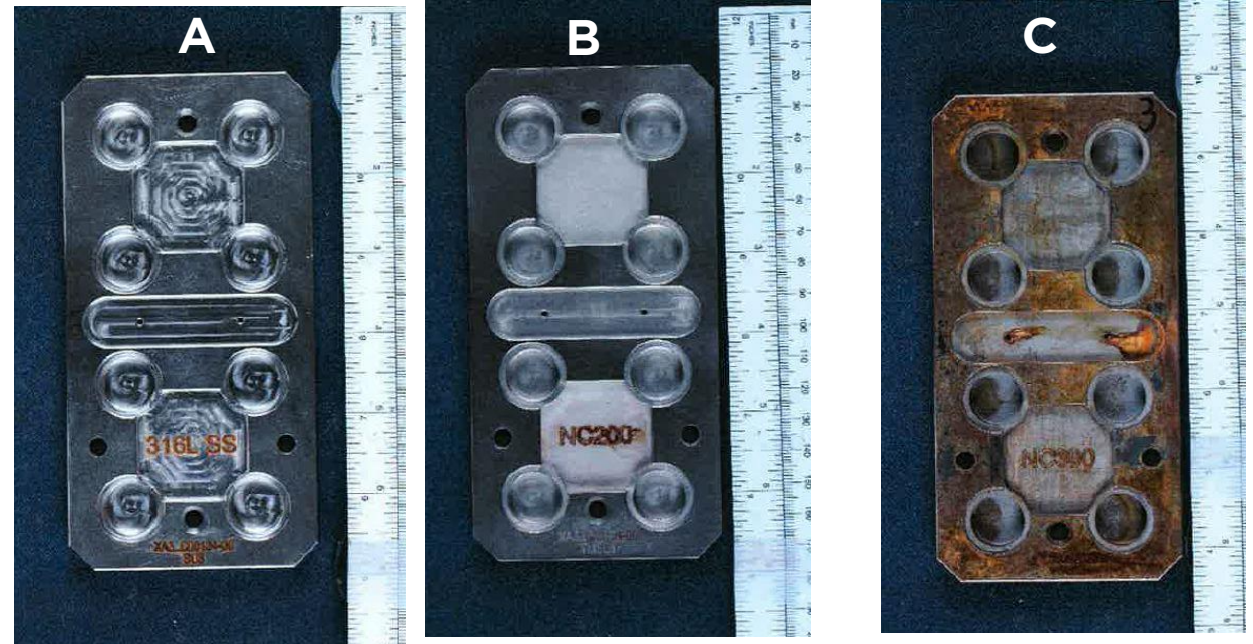
Date: 3/17/2014
 Purchase Order Number: 130544
 Work Order Number: TEC010-03-10-69693-1

| | |
|-----------------------|--|
| Part No.: | 13072.01 (SU8) |
| Description: | 4"W x 6"L x 1/2" Natural 316 Stainless Steel (SU8) |
| Specification: | FOR INFORMATION ONLY |

SALT SPRAY

Requirement: Expose for a total of 168 hours or till the parts show red rust.
Test Method: ASTM B117-11
Quantity Tested: 1
Total Hours: 168
Angle: 15° - 30° from vertical
 Salt spray was performed in a salt spray chamber using a 5% +/- 1% salt solution at 95° +/- 3° Fahrenheit, in accordance with ASTM B117-11.
 The results are as follows: The samples showed visual evidence of red rust on the engraved marked areas at the end of 168 hours of continuous exposure to salt spray corrosion testing.

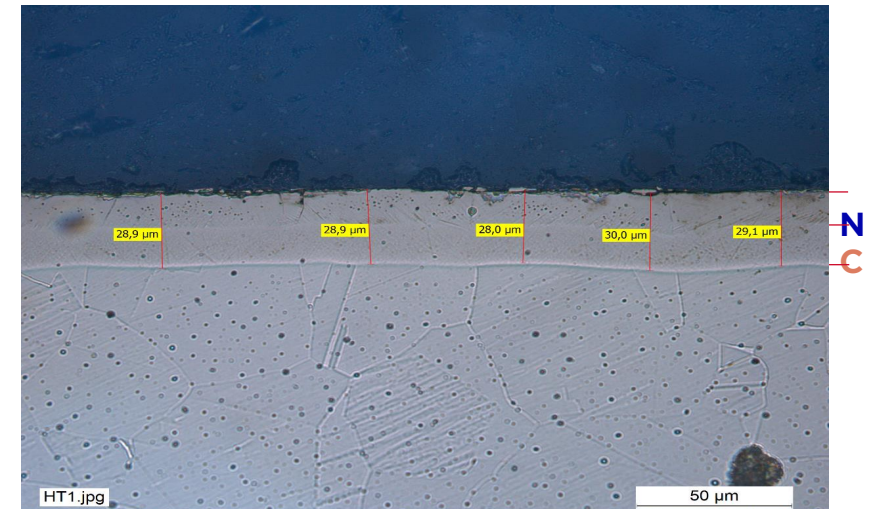
| Sample: | Results: |
|------------------------------------|----------|
| A= Not treated: 316L | no rust |
| B= Stainihard NC: 316L | no rust |
| C= Classic Nitro carburized : 316L | red rust |



Summary

- Stainihard:
 - » Low temperature Gaseous Nitrocarburizing for (Austenetic) Stainless Steels
 - » Layerthickness 15-30 μ m
 - » Surface Hardness 1000-1400HV

 - » Maintain corrosion resistance
 - » Wear resistance and fatigue life increase



Stainihard

Surface Hardening of Stainless Steels

Jeroen Knippenberg

Process Engineer

jeroen.knippenberg@aalberts-st.com