



voestalpine Böhler Welding

# Moderne Duplex kwaliteiten en lassen

Johan Cobben

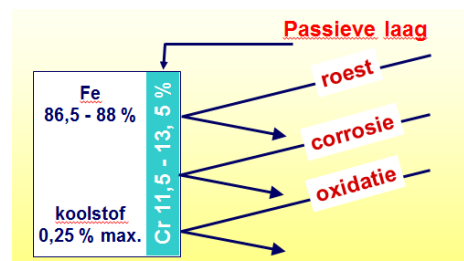
voestalpine Böhler Welding  
www.voestalpine.com/welding

**voestalpine**  
ONE STEP AHEAD.

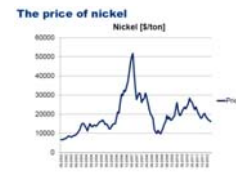
RVS is legering van basis ijzer (Fe) +

### *De belangrijkste legeringselementen*

- C : tot 0,25% (sterkte + , corrosie -)
- Cr : 13 - 30% (corrosie +, oxydehuid)
- Ni : 0 - 25% (taaiheid +)
- Mo : 0 - 6% (corrosie +)



## RVS is legering van basis ijzer (Fe) +

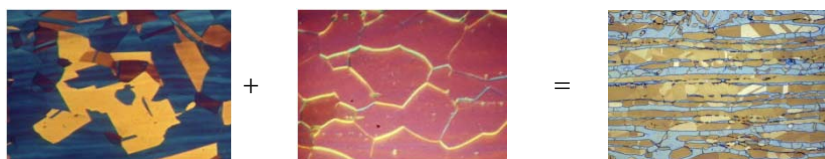


### Extra toevoegingen

- Mn : 0 -6% (mech.eig.+ , onderdrukt warmsteuren en **vervanger van nikkel**)
- N : tot ca. 0,4% (vloei-grens +, kruipsterkte +, corrosie+)
- Ti/Nb : 8 x %C (stabilisatie C, sterkte +)
- Cu : 0 - 3% (corrosie +)
- Si : 0 - 3% (HT bestendigheid +)
- W : < 1% (ondersteuning sterkte en corrosie)
- Al : 0 - 2% (oxydatie +)
- Sporelementen van Se, S, Co en Ce

3

## RVS indeling op basis van microstructuren



Austeniet (304L)  
*niet magnetisch*

Ferriet (409)  
*wel magnetisch*

Duplex (1.4462)  
*austeniet en ferriet (50-50)*

Duplex combineert de eigenschappen van  
austeniet en ferriet

4

## Welke eigenschappen?

1. Hoge sterkte
2. Goede corrosiebestendigheid (scheurvormende stresscorrosie)
3. Gunstige prijs / prestatie verhouding



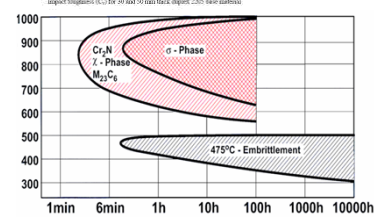
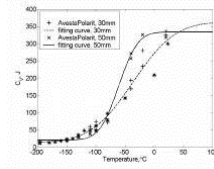
- 1. Spanningen
- 2. Cl-houdend
- 3.  $T > 60^\circ \text{C}$

### MAAR:

1. Beperkte inzetbaarheid bedrijfstemperaturen
2. Gevoelig voor sigmafase (FeCr)
3. Gevoelig voor 475°C brosheid

↓

*Als gevolg van verkeerde lastechniek cq PWHT!!*



5

## History kort

### Jaren 1930

- Type 26 Cr – 5 Ni voor hitte bestendige toepassing
- Type 26 Cr – 5 Ni – 1 Mo voor corrosie toepassingen
- Lassen problematisch door scheurvorming (carbiden en hoog ferriet)

Autoclave for gunpowder.  
Duplex 453S, built 1933.



6

## History kort

### Jaren 70 “2-de generatie”

- Sterke verbetering in productieproces (reductie C + N toevoegen)
- N ter bevordering austeniet en verbetering corrosiebestendigheid
- Duplex 22(Cr)05(Ni) cq. 1.4462 is geboren

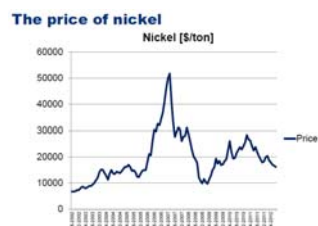


7

## History kort

### Jaren > 2000 tot nu “3-de generatie”

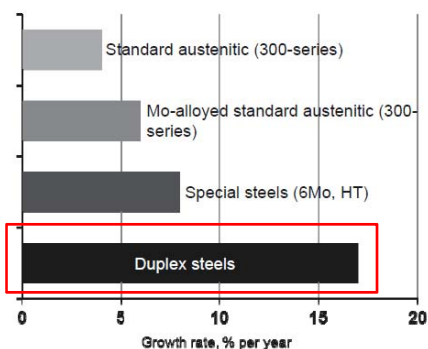
- HD Hyper Duplex (SAF 2707 HD / 3207 HD)
- Super Duplex kwaliteiten typen 25(Cr)07(Ni)
- Verhoogd Cr, Mo, N en soms Cu en W
- Lean Duplex kwaliteiten 21(Cr)01(Ni) cq. 24(Cr)04(Ni)
- Verlagen van het “dure” nikkel en vervangen met goedkoper Mn en N



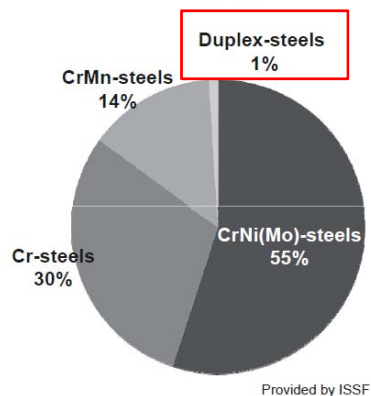
8

### Markt ontwikkeling

Growth by type 2010



Production by type 2010



9

### Overzicht diverse kwaliteiten

EN	ASTM/UNS	Cr	Ni	Mo	N	Others	PRE!
1.4162	S32101	21.5	1.5	0.3	0.22	5Mn	26
1.4362	S32304	23	4.8	0.3	0.10	-	26
1.4662	S82441	24	3.6	1.6	0.27	3Mn	33
1.4462	S32205	22	5	3.1	0.17	-	35
1.4501	S32760	25	7	3.8	0.25	W, Cu	42
1.4410	S32750	25	7	4	0.27	Cu	43
1.4307	304L	18.1	8.1	-	-	-	18
1.4404	316L	17.2	10.1	2.1	-	-	24
1.4432	316L	16.9	10.7	2.6	-	-	25
1.4539	904L	20	25	4.3	-	1.5Cu	34
1.4547	S31254	20	19	6.1	0.20	Cu	43
1.4565	S34565	24	17	4.5	0.45	5.5Mn	46

↓  
austenieten

10

## Superduplex

Nominal composition of some commonly used superduplex stainless steels

UNS No.	Common Name	Nominal Composition (wt %)						
		Fe	Cr	Mo	Ni	N	Cu	W
S32760	Zeron 100	Bal	25	3.5	7	0.25	0.7	0.7
S32750	SAF2507	Bal	25	3.8	7	0.27	-	-
S32550	UR 52N +	Bal	25	3.8	6	0.26	1.5	-
S39274	DP3W	Bal	25	3	7	0.26	-	2

11

## Pitting Resistance Equivalent (PRE)

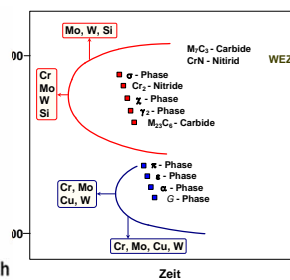
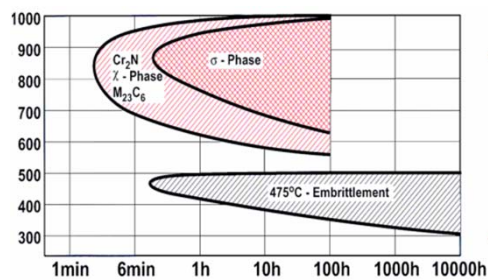
Wolfram verbeterd weerstand tegen put/spleet corrosie

Koper verbeterd de prestaties in een reducerende medium.

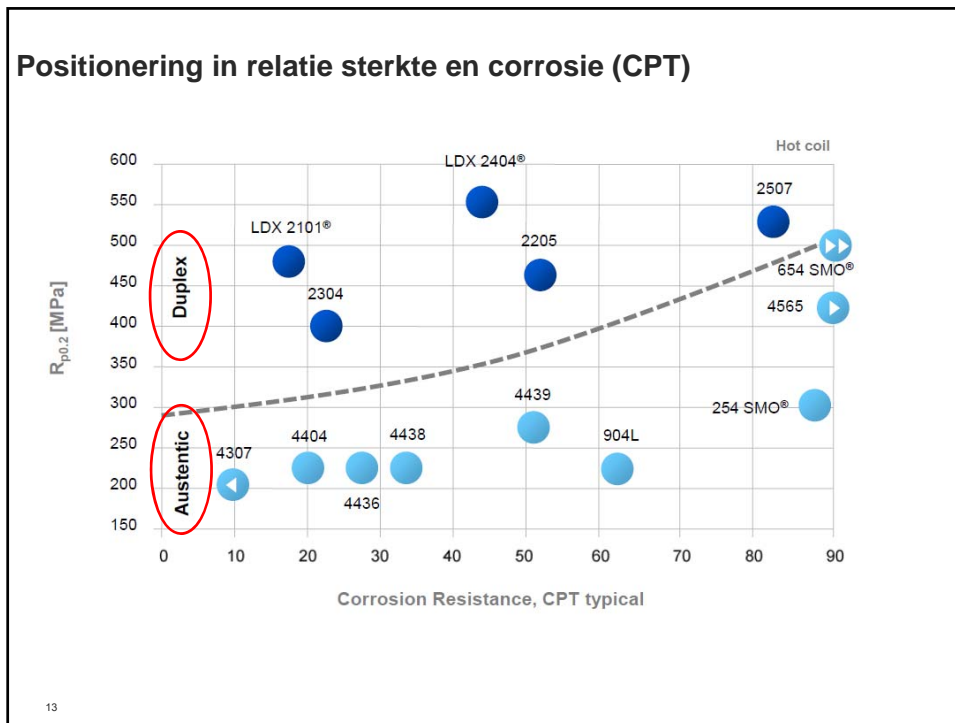
$$PREN = \% Cr + 3.3 \times \% Mo + 16 \times \% N$$

$$PREW = \% Cr + 3.3 (\% Mo + 0.5 \times \% W) + 16 \times \% N$$

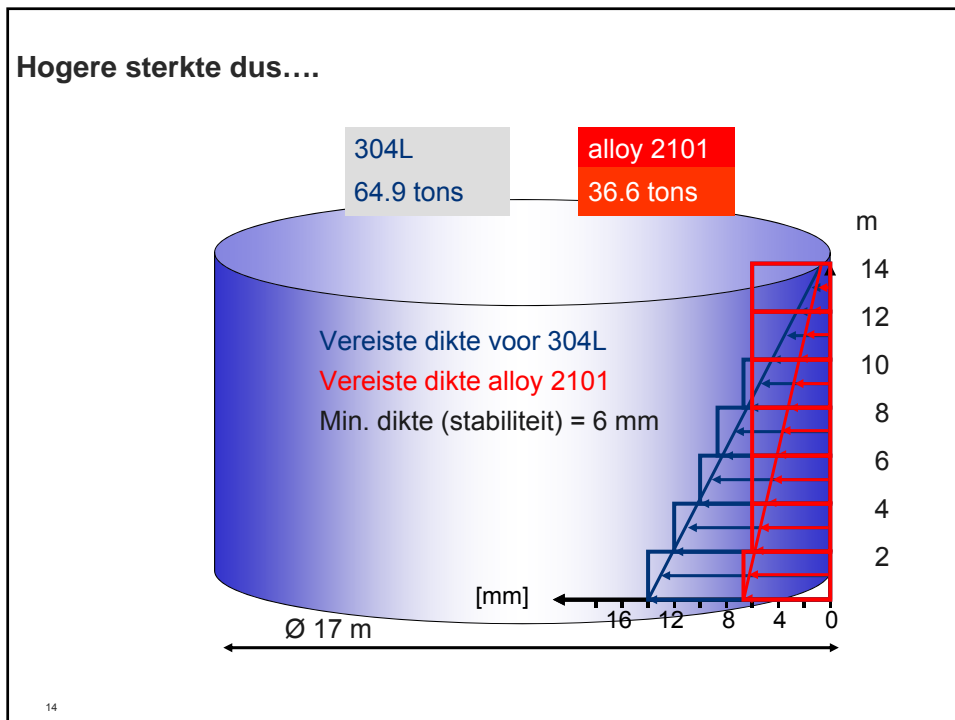
**Let op:**



12

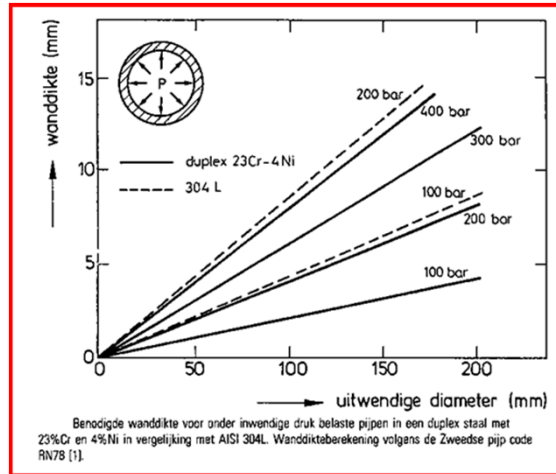


13



14

Hogere sterkte dus....



15

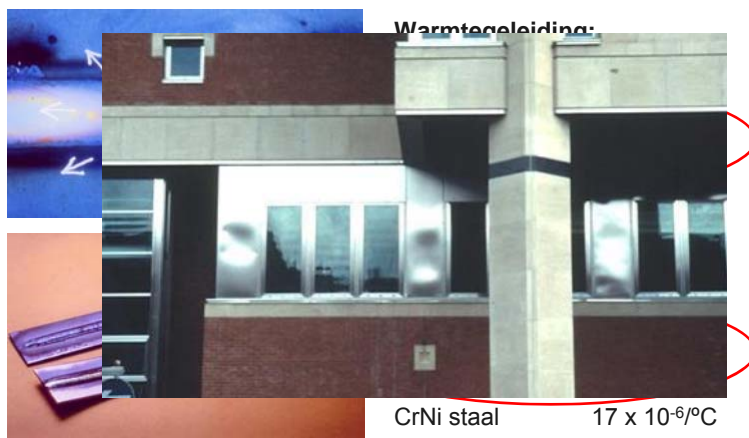
# lassen



16

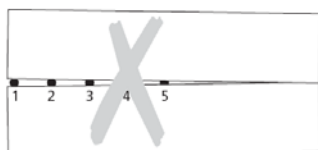
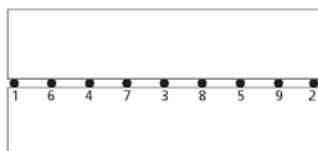


### Fysische eigenschappen - vergelijk



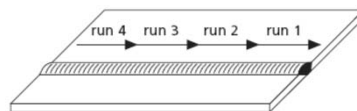
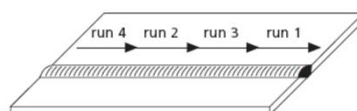
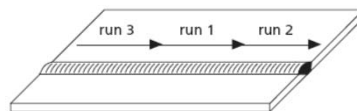
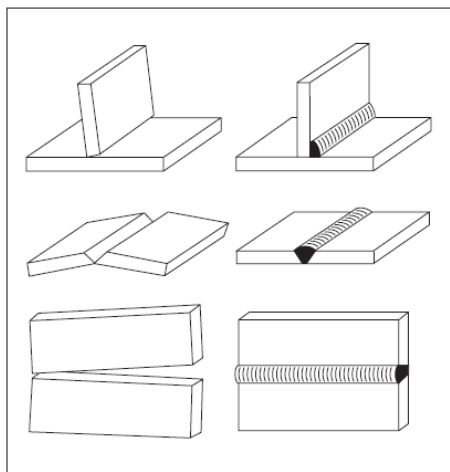
17

### Hechten

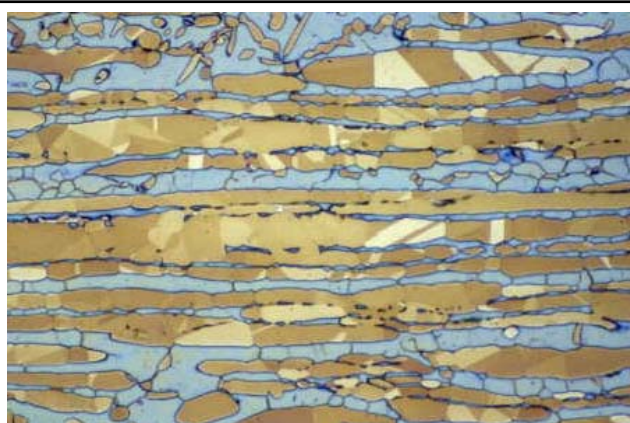


18

Let dus op vervormingen



19



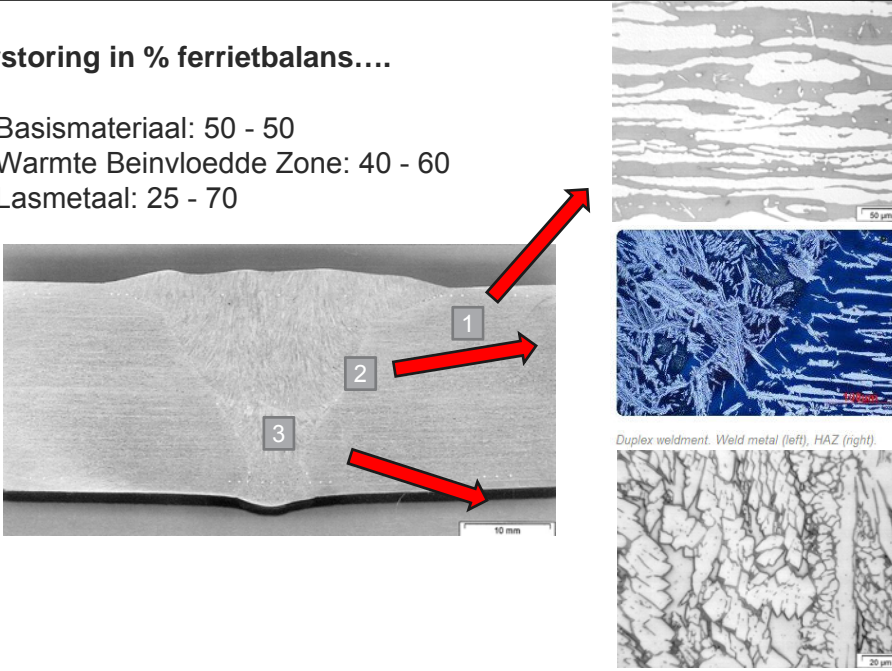
Duplex (1.4462)

*austeniet en ferriet (50-50)*

20

**Verstoring in % ferrietbalans....**

1. Basismateriaal: 50 - 50
2. Warmte Beïnvloede Zone: 40 - 60
3. Lasmetaal: 25 - 70



The figure consists of three micrographs. The largest one on the left shows a cross-section of a weldment with three regions labeled 1, 2, and 3. Red arrows point from these labels to three smaller micrographs on the right. The top-right micrograph shows a fine, uniform ferrite distribution. The middle-right micrograph shows a more complex, interconnected ferrite network. The bottom-right micrograph shows a very coarse, blocky ferrite structure. A scale bar of 10 mm is visible at the bottom of the main micrograph, and 50 μm and 20 μm scale bars are visible in the smaller micrographs.

Duplex weldment. Weld metal (left), HAZ (right)

21

**Problemen indien:**

**Hoog ferriet (> 70 %)**

- Daling in taaiheid
- Verminderde PR corrosiebestendigheid

**Hoog austeniet (> 80 %)**

- Verminderde weerstand tegen SCC
- Daling in sterkte

22

### Oorzaak...

#### Chemische samenstelling

- Samenstelling van het lasmateriaal (*Ni-gehalte 3-4% hoger dan BM*)
- Opmenging met het basismateriaal (lasnaadvoorbewerking/lasparameters)

#### Afkoeltijd (1200→800°C)

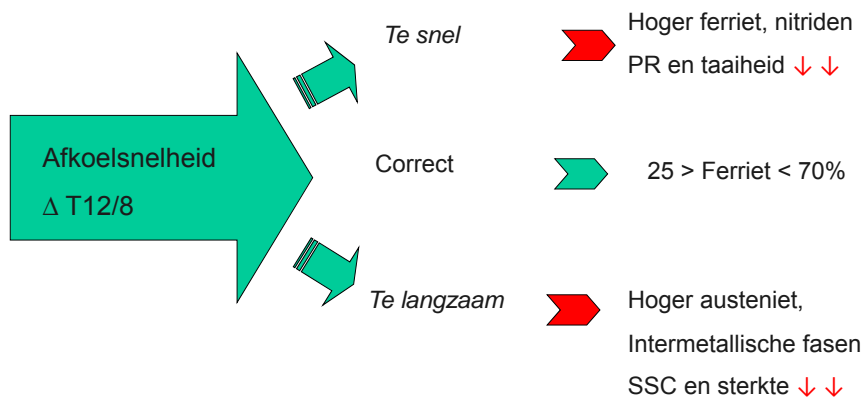
- Heat Input **(lasprocedure)**
- Materiaal dikte **(lasprocedure)**
- Interpass temperatuur **(lasprocedure)**

Avesta Welding				Welding Procedure Specification				WPS No: AWAB-155		
				Issued by: Martin Lindin				Date: 15-5-2008		
				Charge: 10 mm				Size: 111		
Base material: A: 2205 (EN 1.4402)				Thickness: 10 mm				Part: e400-1000 mm		
B: 2205 (EN 1.4402)				10 mm				e400-1000 mm		
Welding position: PA (1G)				Preheat: No °C				Interpass temp. Max. 150° °C		
				PWHT: N.A. °C				Backing: No		
				Joint prep: Milled				Notes: Welding from one side Purging gas: Ar (10-15 l/min) Purging applied for all runs.		
A: 80°				B: 0.5-1.5 mm				C: 1.5-2.5 mm		
Run	Process	Filler material	Dia.	Batch No.	Gas/Flux					
1	GTAW	AVESTA 2205	1.6		Ar +2% N <sub>2</sub> (5-8 l/min)					
2-3	GTAW	AVESTA 2205	2.4							
4-5		2205	3.00		FLUX 805					
Run	Polarity	Current (Amperes)	Voltage (V)	Speed (mm)	Energy (kJ/mm)	Pulsed arg	Wire feed (mm/min)	Note:		
1		60-80	10-12	0.8-1.5	0.6-0.8					
2-3		80-110	10-12	1.5-2.5	0.5-0.6					
4-5		100-200	10-12	5.0	1.4-2.1					

Gebruik de juiste lastoevoegmateriaal en **lasprocedure**

23

### Dus.....



24

### Paar spelregels....

1. Gebruik geschikt basismateriaal en daarbij horend lasmateriaal (hoger Ni)
2. Kies de juiste lasmethode/proces
3. Ferriet doorgaans 25 -70 % ferriet tenzij anders voorgeschreven
4. Kies juiste lasnaadvorm en voorbereiding
  - goede inbranding
  - slakbeheersing bij slakvoerende lasprocessen
  - smeltbadcontrole (bv. positielassen)
5. Hou rekening met afwijkende fysische eigenschappen
6. Schoon en **beitsen/passiveren**
7. Gebruik juiste warmtehuishouding
  - voorwarmen alleen vanaf 25 mm
  - interpass. 100 - 150°C
  - Heat Input 0,5 – 2,5 (1,5 SuperDuplex) KJ/mm



25

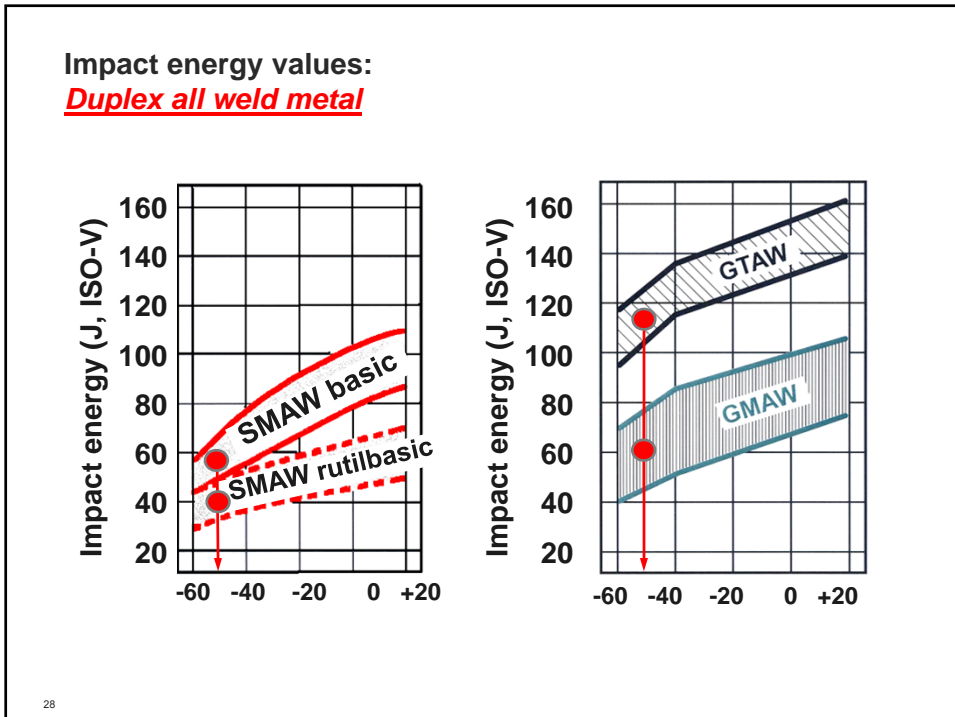
### Eisen taaiheid

<b>Specifications</b>		
<b>DNV</b> (Rules for Ships)	$\geq 27 \text{ J}$	<b>- 20°C</b>
<b>SPIE-CAPAG</b>	$\geq 40 \text{ J}$	<b>- 20°C</b>
<b>NAM/NL</b> (NSS 60)	$\geq 41 \text{ J}$	<b>- 20°C</b>
<b>NORSOK/N</b> M (601)	$\geq 27 \text{ J}$	<b>- 46°C</b>
<b>Shell/UK</b> (ES 124)	<b>41 J</b> (27 J min)	<b>- 50°C</b>

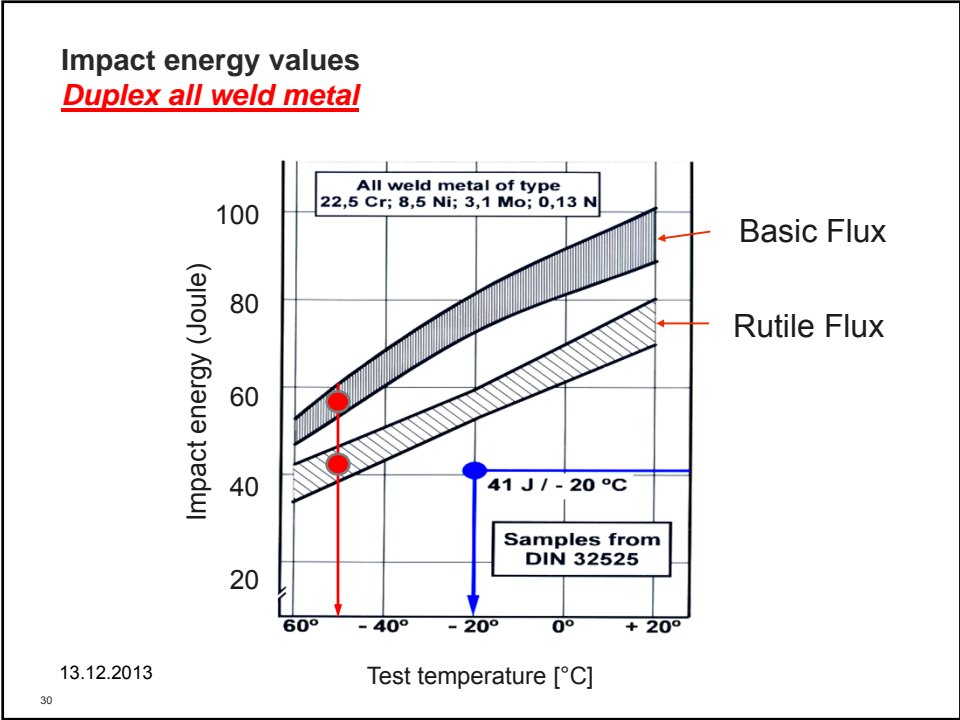
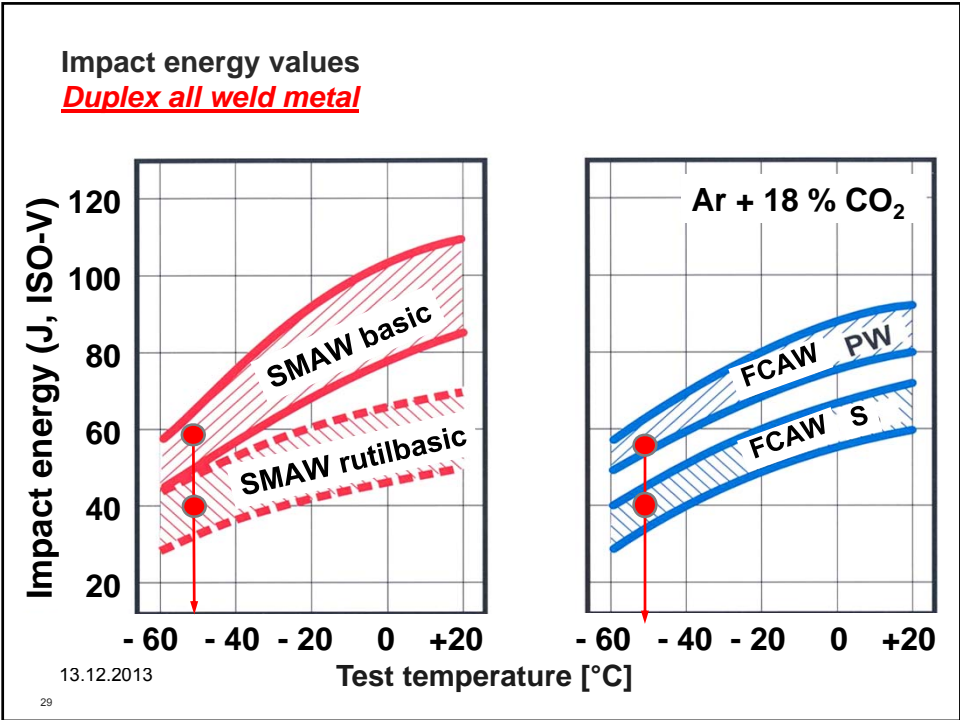
26

<b>Specifications</b>		
<b>DNV</b> (Rules for Ships)	$\geq 27 \text{ J}$	$- 20^{\circ}\text{C}$
<b>SPIE-CAPAG</b>	$\geq 40 \text{ J}$	$- 20^{\circ}\text{C}$
<b>NAM/NL</b> (NSS 60)	$\geq 41 \text{ J}$	$- 20^{\circ}\text{C}$
<b>NORSOK/N</b> M (601)	$\geq 27 \text{ J}$	$- 46^{\circ}\text{C}$
<b>Shell/UK</b> (ES 124)	<b>41 J</b> (27 J min)	$- 50^{\circ}\text{C}$

27

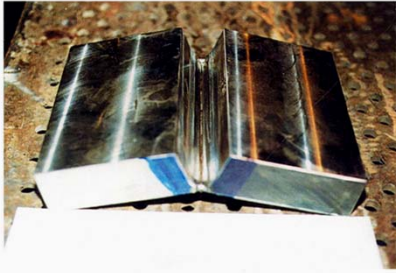


28

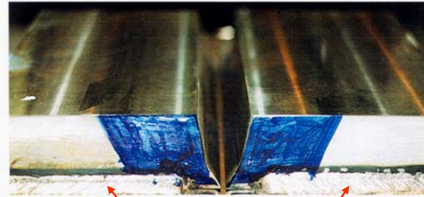


**Shrinkage behaviour during welding of thickwalled V-butt joints**

a) Without clamping - free shrinkage



b) Fixed with fillet welds on a thickwalled plate - hindered shrinkage

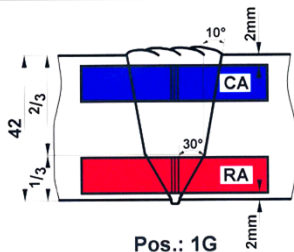


Fixed by welding on stiff underlay

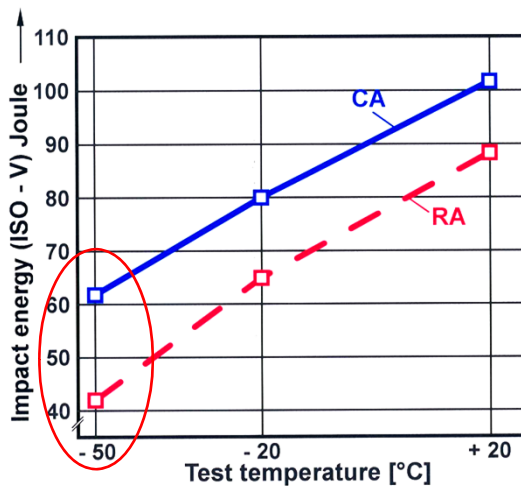
31

**Duplex Stainless Steel UNS S 31803/1.4462  
Impact energy values of thickwalled V-butt joints**

Free shrinkage: no clamping  
SMAW - basic electrode  
(FOX CN 22/9N-B;  
Ø 5,0 / 450 mm)



Interpass temp.: 120 - max. 180°C  
Heat input: 8,8 - 10,6 kJ/cm



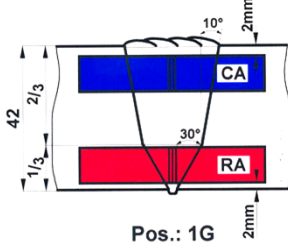
32



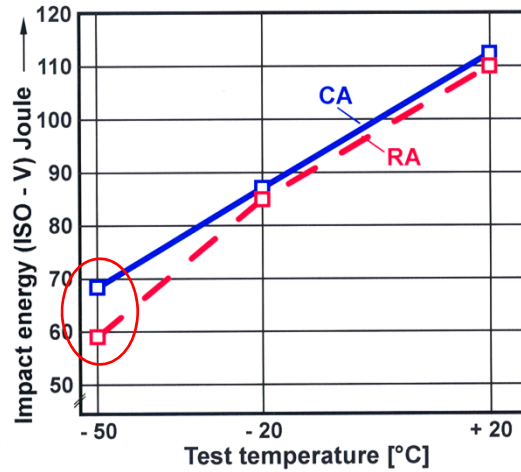
## Duplex Stainless Steel UNS S 31803/1.4462

### Impact energy values of thickwalled V-butt joints

No shrinkage: fixed joint  
SMAW - basic electrode  
(FOX CN22/9N-B;  
Ø 5,0 / 450 mm)



Interpass temp.: 120 - max. 180°C  
Heat input: 8,8 - 10,6 kJ/cm

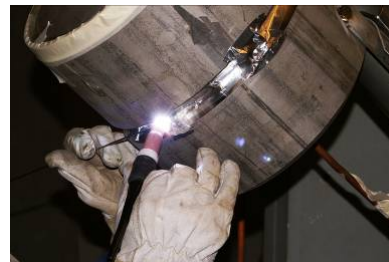


33

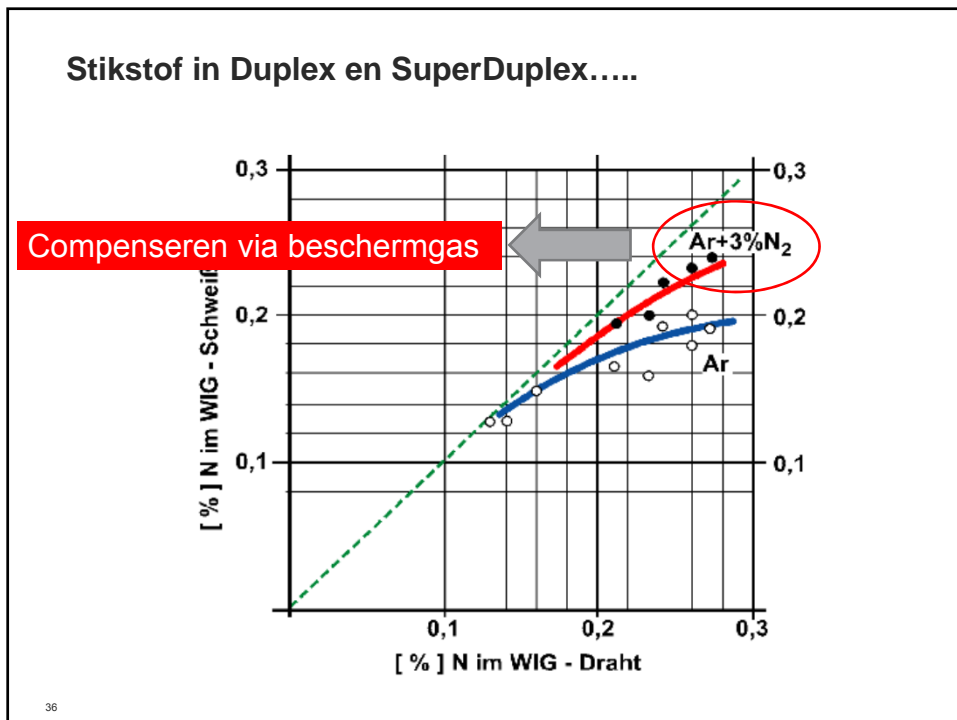
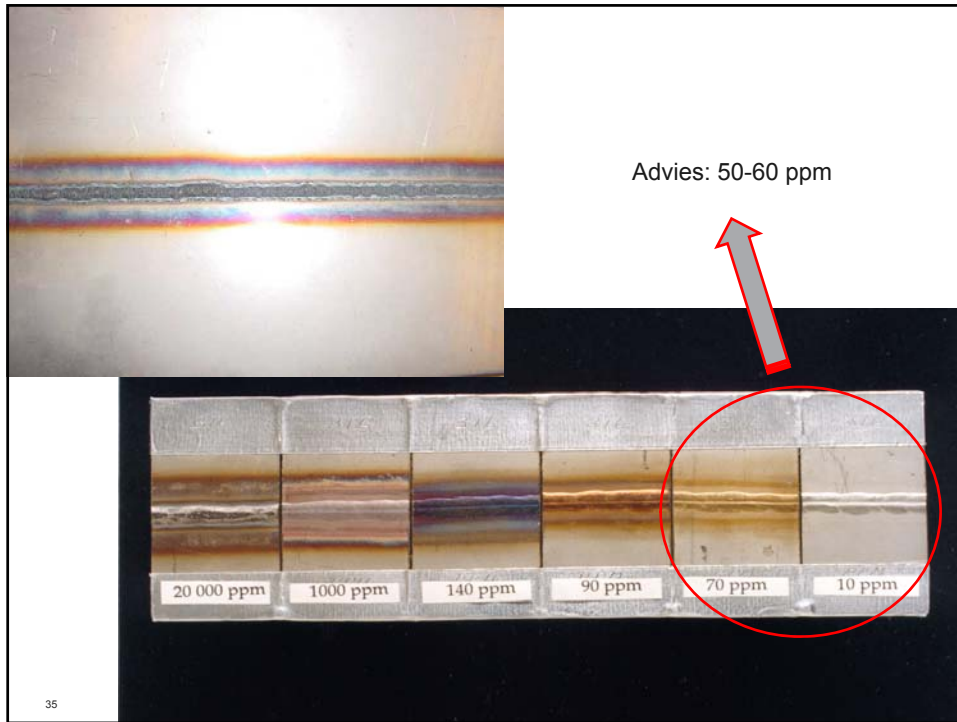
## Meest gebruikte lasprocessen

### GTAW – TIG lassen

1. Hoge kwaliteit
2. Mooi lasuiterlijk
3. Alle posities
4. Lage productiviteit
5. Goede mech. eigenschappen
6. *“Spelen” met stikstof mogelijk (betere corrosiebestendigheid)*
7. Zonder lasdraad lassen? Liever niet...
8. Geschikt voor:
  - *doorlassingen* en dunne plaat
  - leidingwerk
  - gemechaniseerd lassen mogelijk



34



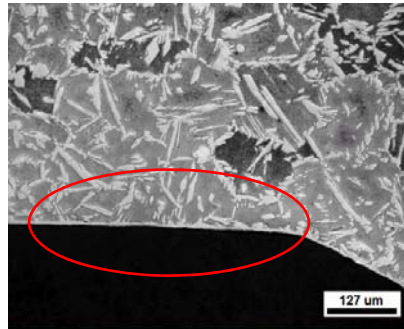
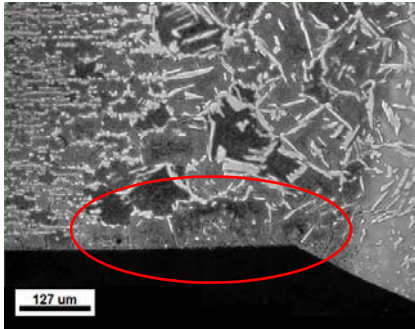
### Stikstof in Duplex en SuperDuplex.....

Puur argon als backing gas

- Stikstof verlies
- Hoger ferriet aan oppervlakte

90% N<sub>2</sub> + 10% H<sub>2</sub> als backinggas

- Uniforme balans
- Beschermende austeniet laag

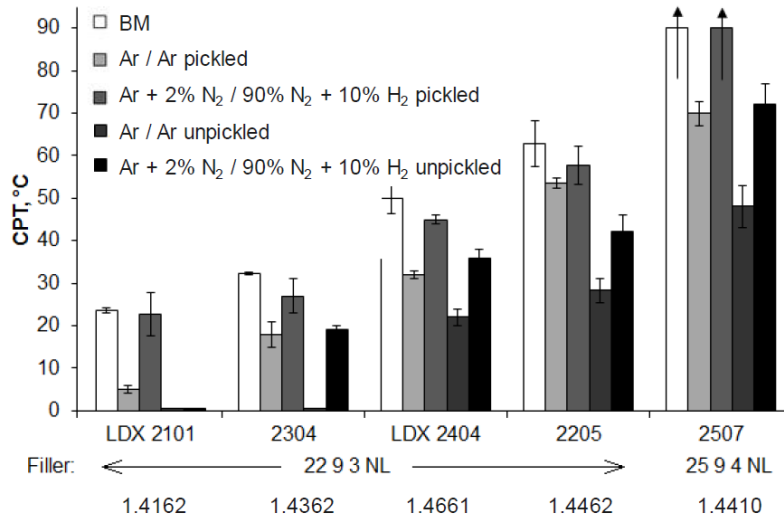


Westin & Serrander (WiW 2012)

37

### Pitting resistance – pickled and as-welded (ASTM G150)

Root side of single-side GTAW samples (1 mm and no gap)



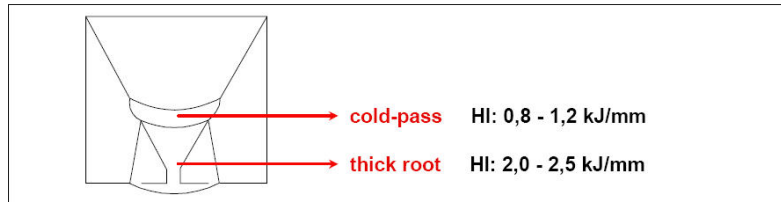
Westin & Serrander (WiW 2012)

FULLFILLING HIGH DEMANDS

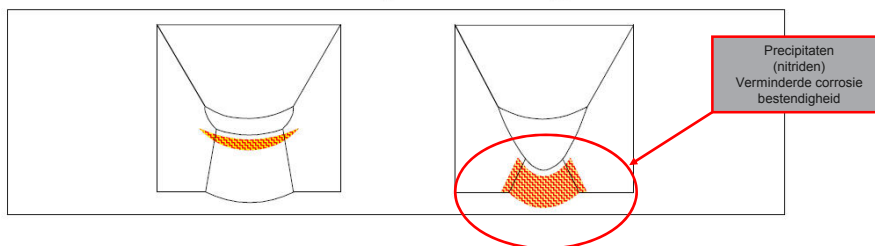
36 | Company | Presentation Title | Date



## Hot & cold pass techniek TIG



## Cold Pass- technique at welding SDSS



39

## Meest gebruikte lasprocessen

### SMAW – Bmbe lassen

1. Flexibel (alle posities)
2. Flexibel (chemische analyse)
3. Flexibel (bekledingstype)
4. Plaatdikte vanaf 2 mm
5. Geschikt voor:
  - produktielassen
  - on site lassen
  - reparatie lassen



40

## Meest gebruikte lasprocessen

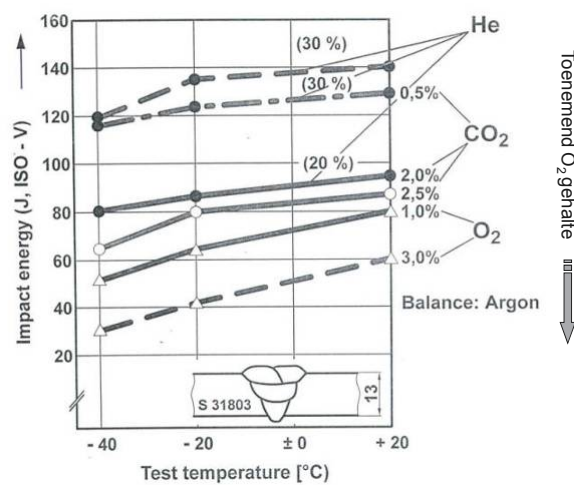
### GMAW – MAG lassen

1. Hoge productiviteit
2. Mooi lasuiterlijk bij gebruik puls-boog ,  
- ook kortsluitbooglassen mogelijk!!
3. Goede mechanische eigenschappen
4. Geschikt voor:
  - gemechaniseerd lassen
  - robot lassen
5. *Let op bij SuperDuplex!!*



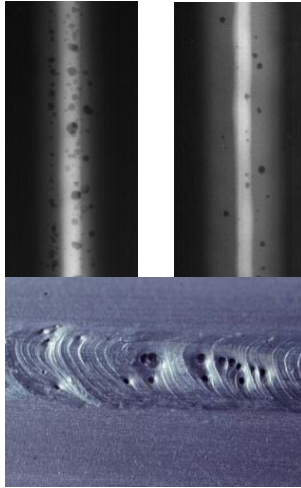
41

## Invloed beschermgas GMAW op taaiheid (2209)



42

### SuperDuplex GMAW lassen



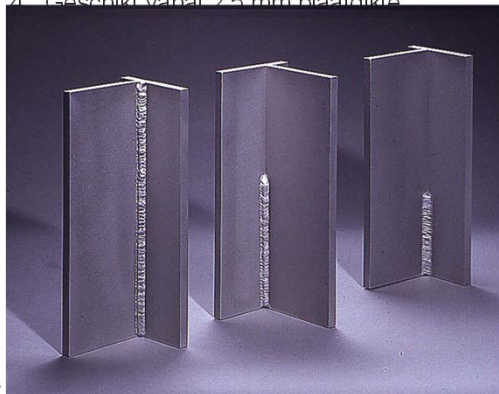
Lassen met puur Argon of.....

*Zie volgende sheet*

43



4. Geschikt vanaf 2.5 mm plaatdikte



44

### Overzicht gebruikte beschermgassen

Methode	Kwaliteiten	Beschermgas
MIG	LDX 2101, 2304, 2205	1. Ar+30%He+1-3%CO <sub>2</sub> 2. Ar+1-2%O <sub>2</sub> or Ar+2-3%CO <sub>2</sub>
	2507/P100	1. Ar+30%He+1-3%CO <sub>2</sub> 2. Ar 3. Ar+30%He+1-2%N <sub>2</sub> +1-2%CO <sub>2</sub>
TIG	LDX 2101, 2304, 2205, 2507/P100	1. Ar+10-30%He+2%N <sub>2</sub> 2. Ar
FCAW	LDX 2101, 2304, 2205	1. Ar+16-25%CO <sub>2</sub> 2. 100%CO <sub>2</sub>
Plasma	LDX 2101, 2304, 2205, 2507/P100	1. Ar* 2. Ar+20-30%He+1-2N <sub>2</sub> *
Laser	LDX 2101, 2304, 2205, 2507/P100	1. Ar

45

### Meest gebruikte lasprocessen

#### SAW – OP lassen

1. Zeer hoge productiviteit
2. Mooi lasuiterlijk (juiste DPC!!)
3. Alleen PA positie
4. Vanaf 10 mm plaatdikte, hoge H.I.
5. Geschikt voor:
  - prefab
  - plaat/pijp mits voldoende lengte/diameter



46

## Lassen aan staal

1.4462/UNS S31803 met	Keuze LTM	Opmerking
Grade A  S 355 J2G3 (1.0570)	1.: 309 MoL	23Cr 12Ni 3Mo
	2.: 309L	23Cr 12Ni
	3.: 2209	22Cr 9Ni 3Mo N*

\* Groot gevaar op martensietvorming bij hoge opmenging

47

## Beitsen en passiveren

**Avesta**  
Finishing Chemicals



**Pickling Paste**  
Our pickling pastes and gels are specially intended for brush pickling of weld seams and smaller surfaces. They offer a perfect paste consistency that gives good adhesion to difficult surfaces and reduces the risk of splashing. [Read more >>](#)



**Pickling Spray**  
Our pickling spray can be used on most stainless steel grades, and is suitable for pickling larger surfaces. They have a thixotropic consistency, which makes it stick to the surface and hence facilitates the application even in difficult positions. [Read more >>](#)



**Pickling Bath**  
The bath fluid is recommended for immersion pickling of small objects and for pickling surfaces that are time-consuming to brush or spray pickle. It can also be used for circulation cleaning of pipe systems. [Read more >>](#)



**Cleaning**  
Superficial rust, grease and lime deposits can occasionally appear on any stainless steel surface. Cleaning with our cleaning agents eliminates these spots with ease, restoring the surface and returning your stainless steel to its original finish. [Read more >>](#)



**Passivation**  
Our passivating agents improve the pickling result and diminish the risk of discoloured surfaces, after pickling. The passivation layer on stainless steel surfaces is restored at the same time. [Read more >>](#)



**Others**  
Auxiliary products for safe handling and detection of Molybdenum. [Read more >>](#)



**euro inox**  
The European  
Stainless Steel  
Development Association

48



**BÖHLER CN 22/9N-FD**

**mixer for pharmaceutical industry**



49

**BÖHLER CN 22/9 PW-FD + Th 2209 + Mth 431**

**Shipbuilding Duplex inner tank**

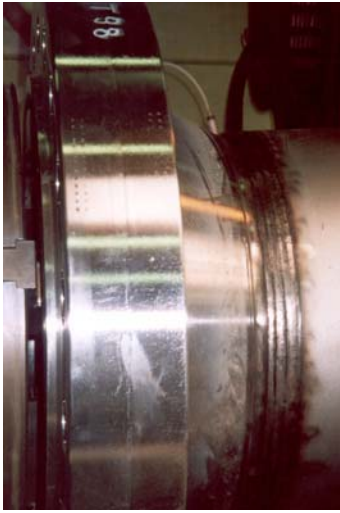


50



**BÖHLER CN 22/9N -IG + CN 22/9 N-FD**

pipeline oil&gas



**BÖHLER CN 22/9N -IG + CN 22/9 PW-FD  
+ Th 2209 & Mth 431 . Pressure vessels.**



53

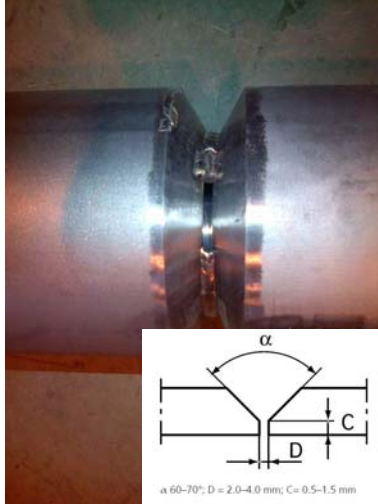
**Storage tanks – m.n. “lean” Duplex LDX 2101**

Caustic liquor, petroleum products, wine, water, etc.



54

### Leidingwerk SuperDuplex (kwalificatie)



55

**Welding Duplex Stainless Steels  
is not difficult just  
different**

**VRAGEN??**






*Bedankt voor uw aandacht*

*[johan.cobben@voestalpine.com](mailto:johan.cobben@voestalpine.com)*



voestalpine Böhler Welding  
www.voestalpine.com/welding

**voestalpine**  
ONE STEP AHEAD.



**Sandvik 27.9.5.L (Welding wire)**


**Datasheet updated 2013-11-27 10:42:32** (supersedes all previous editions)

Sandvik 27.9.5.L is a filler material for welding of hyper-duplex (ferritic-austenitic) stainless steels of UNS S32707 and 33207 type (e.g. Sandvik SAF 2707 HD and SAF 3207 HD). Sandvik 27.9.5.L is available as wire and rods.

**Standards**

- EN number Z 27 9 5 N L

FULFILLING HIGH DEMANDS



58 | Company | Presentation Title | Date

First a definition: Ferrite Number, an arbitrary standardized value designating the ferrite content of an austenitic stainless steel weld metal. It should be used in place of percent ferrite or volume percent ferrite on a direct replacement basis.

FN has been adopted as a relative measure for quantifying ferritic content using standardized magnetic techniques. The FN approach was developed in order to reduce the large variation in ferrite levels determined on a given specimen when measured using different techniques in different laboratories. FN approximate the "volume percent ferrite" at levels below 8 FN; above this level deviation occurs.

A number of instruments are commercially available for determining the ferrite content of welds, including the Magnagage, Severn gage, and ferrite scope.

So, now you can conclude that the ferrite number is not calculated with any formula or something, but measured or determined using some special instruments and methods.