Exhaust Gas Cleaning Systems
Corrosion and how to deal with it

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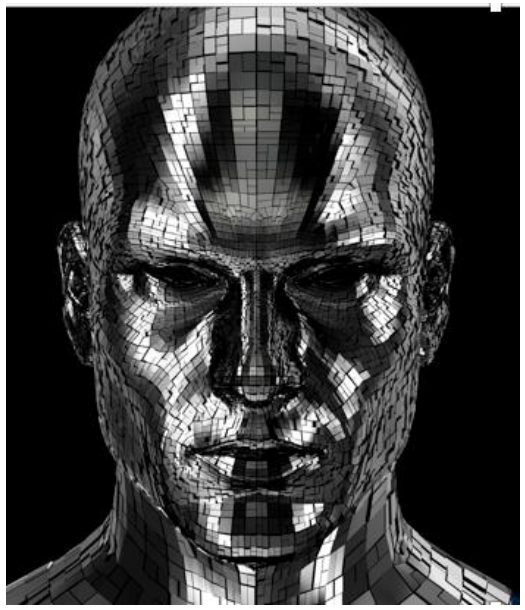
CONTENT OF PRESENTATION

- Introduction of Sverdrup Steel AS
- Preventing corrosion issues
- Material selection
- Challenges in scrubber production
- Quality verification



Sverdrup Steel AS

Sverdrup Steel is a global supplier of high performance stainless steels and nickel alloys.

- Head office in Stavanger, Norway
- Head count 55
- Turn over approx. 85 MEURO in 2018
- Export to approx. 60 countries
- Stock points in
  - Norway (2)
  - Germany
  - Sweden
  - UK
  - Korea

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Scrubber industrial challenges
Initial precautions against corrosion

- Scrubber Designers/ Producers
  - Have a favorable design that avoids tight crevices, stagnant conditions and formation of deposits.

- Choosing appropriate manufacturing partner
  - Steel fabricator with good material track record (e.g. qualified to ISO 17782) with experience in manufacturing of high alloy stainless products.

- Materials handling, rolling, cutting, welding, pickling..
  - Not mixed with carbon steel
  - Rolling machine with stainless rolls or at least protected, no cutting of carbon steels nearby
  - Welding procedures in place
  - Be able to pickle in correct conditions (very important)
  - No footsteps on plates, no grease

- Monitor and verify quality during fabrication.

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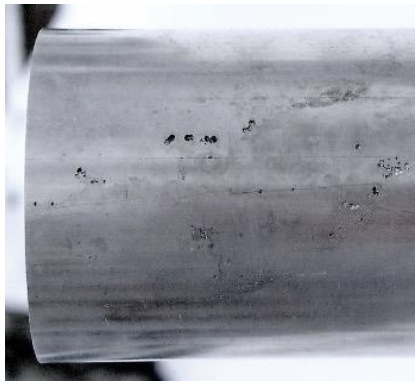
Preventing corrosion issues

- Understanding of operational conditions, mild to severe conditions
  - Temperature : 40 – 80℃ / 250 - 350 ℃
  - pH of sea water = 7.5 – 8.4,
  - Chloride content : ≥ 20.000 ppm
  - Low pH (2–4) during some of the operation
  - Addition of NaOH

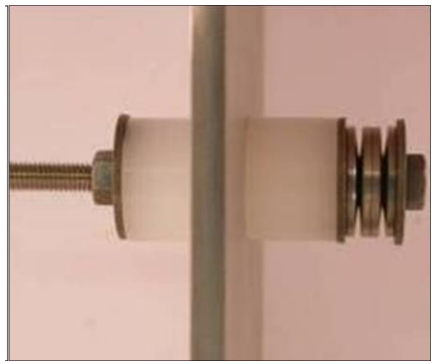
- Pitting and crevice corrosion may occur due to high chloride contents in scrubbing water

- Low pH and high temperature make the conditions more aggressive

Pitting corrosion



Crevice corrosion



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Scrubber material selection

Steel Grade	EN	UNS	Cr	Ni	Mo	N	Other	PRE	CPT, °C (ASTM G150)
316L/ 4404	1.4404	S31603	17	10	2			24	20
316L/ 4432	1.4432	S31603	20	10,5	2,5			25	26
904L	**1.4539**	**N08904**	**20**	**24**	**4,3**			**34**	**62**
254SMO	**1.4547**	**S31254**	**20**	**18**	**6,1**	**0,2**	**< 0,5 Cu**	**43**	**86**
AL6XN / Alloy 926	**1.4529**	**N08926**	**20,5**	**24,5**	**6,3**	**0,2**	**0,2 Cu**	**45**	**>90**
4565	1.4565	S34565	24	17	4,5	0,45	5,5 Mn	46	>90
654SMO	1.4552	S32654	24	22	7,3	0,5	3,5 Mn Cu	56	>90
Alloy 31	**1.4562**	**N08031**	**27**	**31**	**6,5**	**0,2**	**1,3 Cu**	**52**	**>90**
22 Cr - 32205	**1.4462**	**S32205**	**22**	**5,5**	**3**	**0,17**		**35**	**51**
25Cr - 32750	**1.4410**	**S32750**	**25**	**7**	**4**	**0,27**	**Cu**	**43**	**83**
25Cr - 32760	1.4501	S32760	25	7	4	0,25	0,75 W Cu	42	83
Alloy 59	**2.4605**	**N06059**	**21**	**59**	**16**			**74**	**>90**
Alloy 625	2.4856	N06625	22	62	8,5		3,5 Nb	52	>90
Alloy C - 276	**2.4819**	**N10276**	**16**	**57**	**16**		**4 W**	**75**	**>90**

PREn=Cr+3,3Mo+16N PREw=Cr+3,3(Mo+0,5W)+16N

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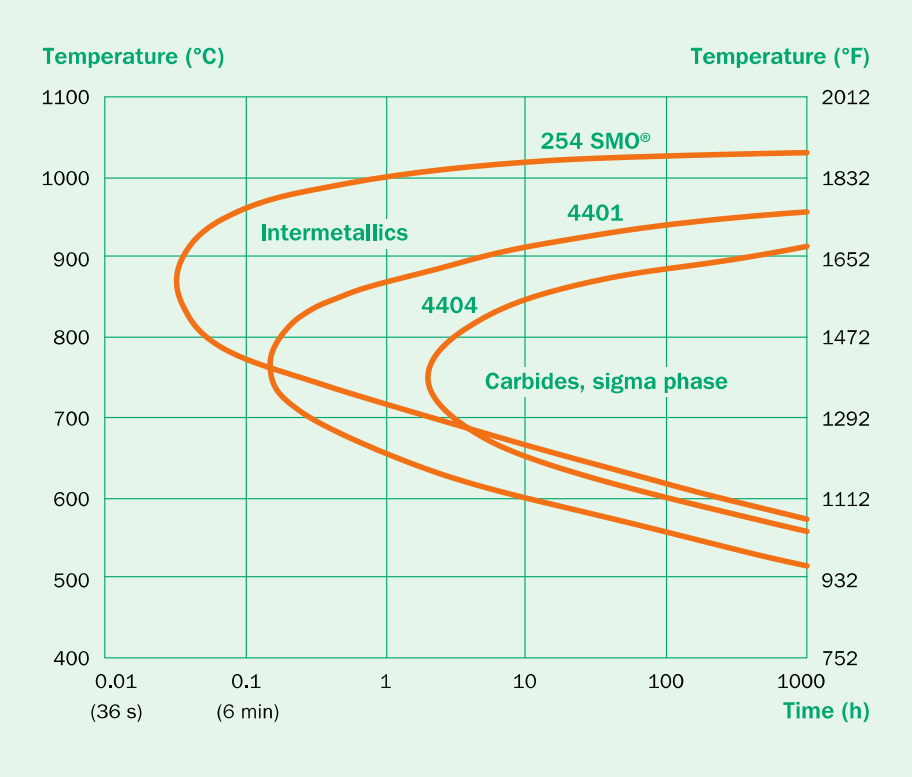
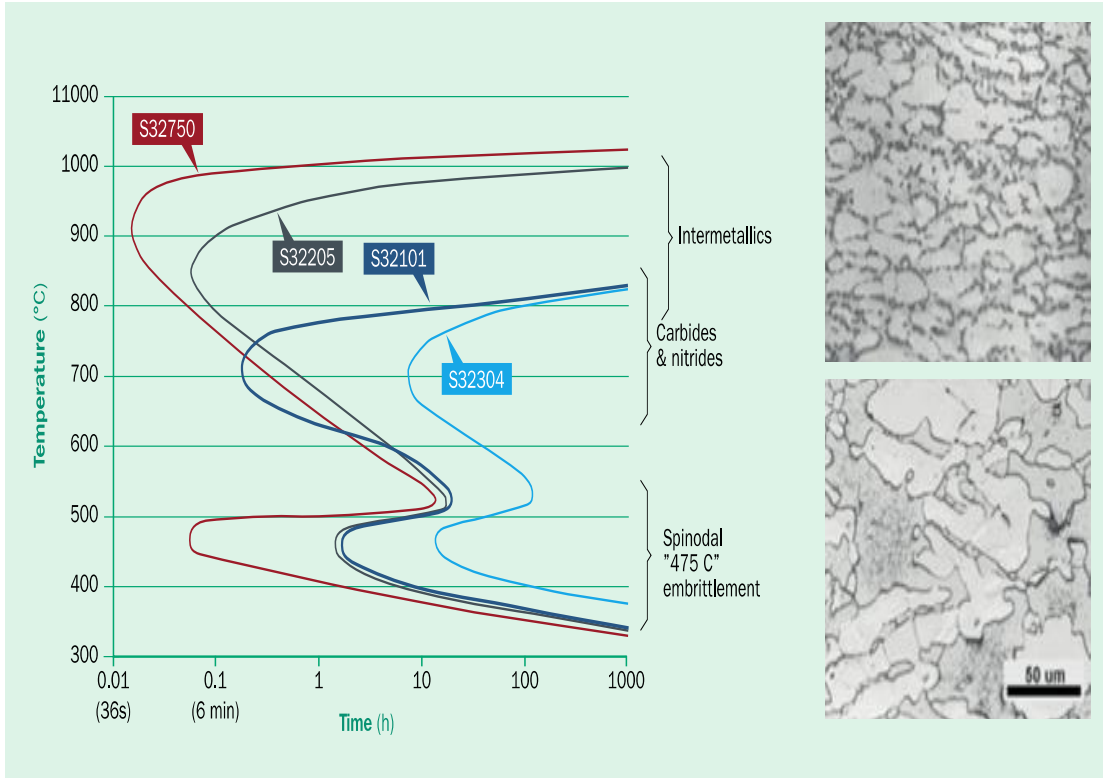
Welding - corrosion issues

- Welding conditions
  - 22Cr / 25Cr duplex, 6Mo, various nickel alloys
    - Correct welding heat input, interpas temperature, gas protection…

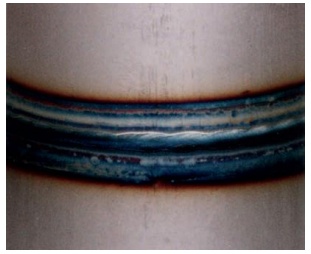




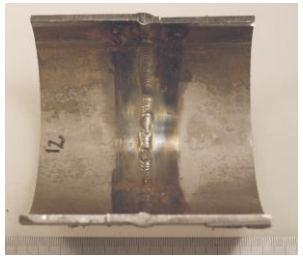
NON OPTIMAL CONDITIONS

Roll contamination

Spatter



Welding oxides



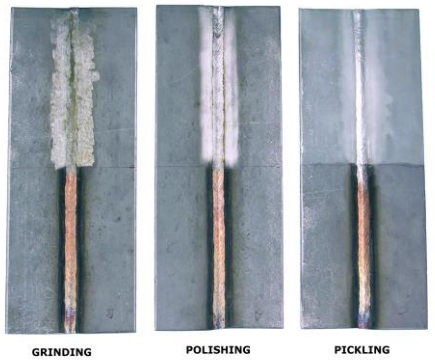
Harsh grinding

Overlap

Pitting

PICKLING SOLUTION?

- High alloyed stainless steels are difficult to pickle correct
  - temperature, humidity, time, product size..
- Solution of Nitric acid (HNO3) and Hydrofluric (HF) acid
  - It removes weld oxides, the underlying chromium-depleted layer and other defects that may cause local corrosion.
- The process is sensitive to strong sunlight/high temperatures and the solution may dry into the surface and be difficult to remove.
- It does not impact the microstructure!!
- Nickel alloys are hard to pickle, the oxide layers should prior to pickling be destroyed by abrasive blasting or fine grinding.



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Quality verification

- Pre production: WPS/ WPQR, with adequate mechanical, corrosion, microstructure, bend test and hardness survey.
- Production: Weld parameters and especially heat input records (V, A and travel speed) during fabrication shall be maintained as per WPQR and recorded. Explain the need for control with the welders.
- Quality Control system of fabricator shall be reviewed by metallurgist/ welding engineer. Audits shall be held during fabrication.
- Separate carbon steel and stainless steel in the workshop to avoid contamination of the stainless steel
- Ferrite verification of duplex production welds with Ferritescope.
- Apply consumable and welding/ backing gas control and and execute PMI, also for root pass.

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Thank You For Your Attention

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