FACULTY OF MECHANICAL
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Corrosion resistance of steel used for spent nuclear fuel storage

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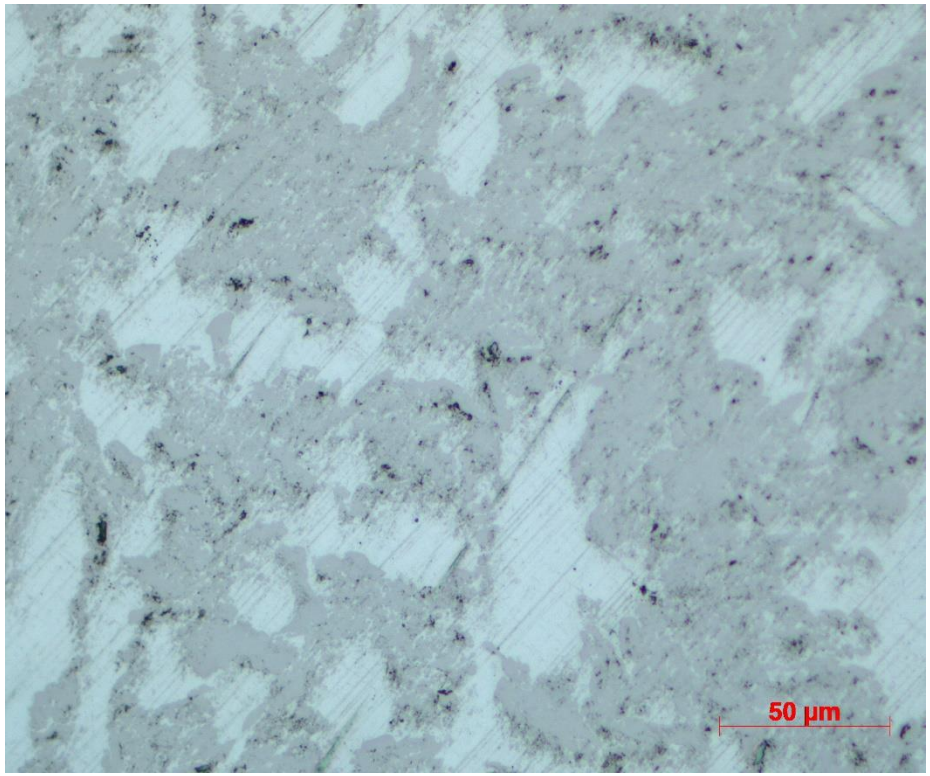
Boron alloyed steel

- Isotope B_{10} has the property to capture neutrons produced by nuclear reactions
- Natural boron contains about 19.9 at% or 18.45 wt % of B_{10} isotope, the remaining being B_{11} isotope
- Ferroboron (FeB) is a ferroalloy consisting of iron and boron. The metal usually contains 17.5% to 20% boron and is used to produce specialist steels

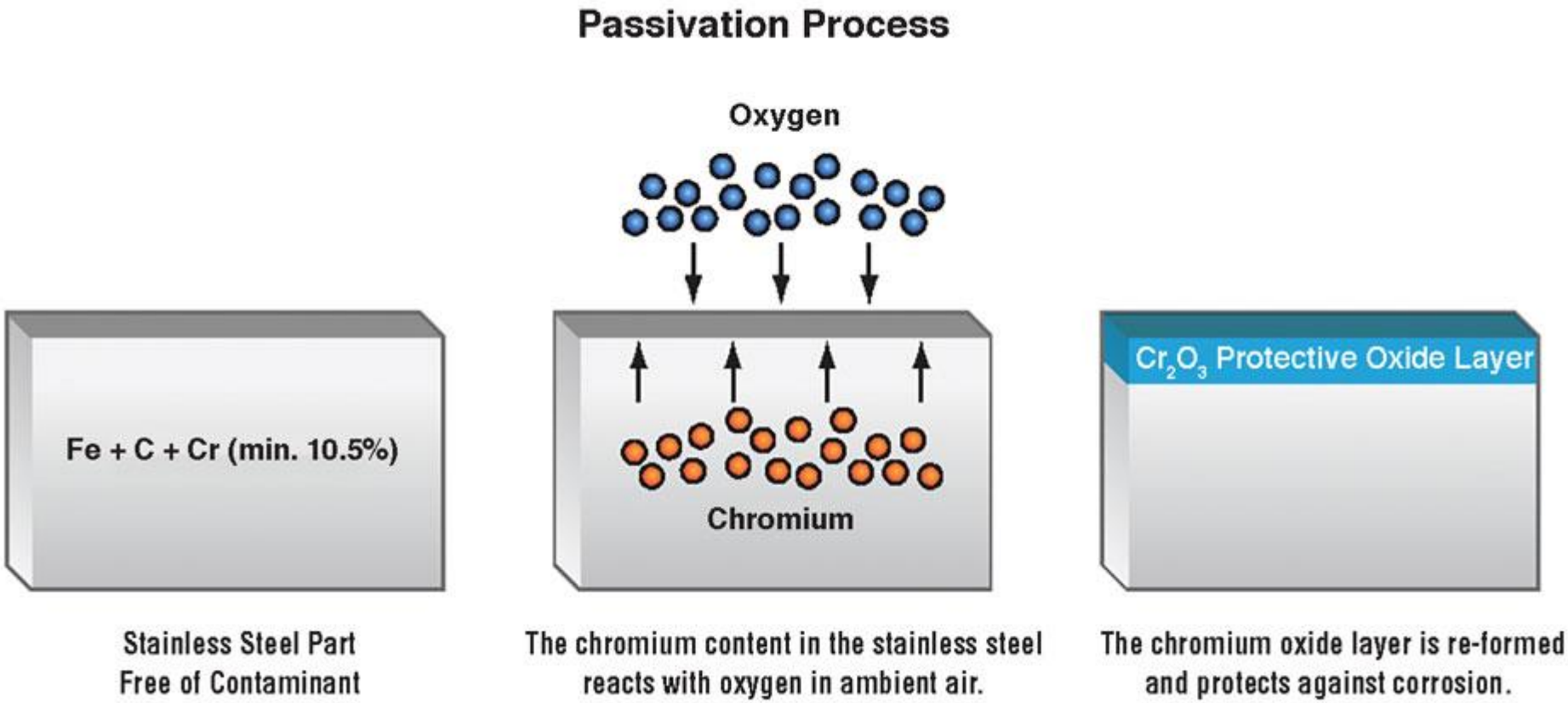


Material used for spent fuels storage racks

ATABOR Chemical composition (wt %)									
C	Mn	Si	P	S	Cr	Ni	B	Co	N
0.022	1.48	0.51	0.018	0.001	19.45	12.55	1.03	0.03	0.024

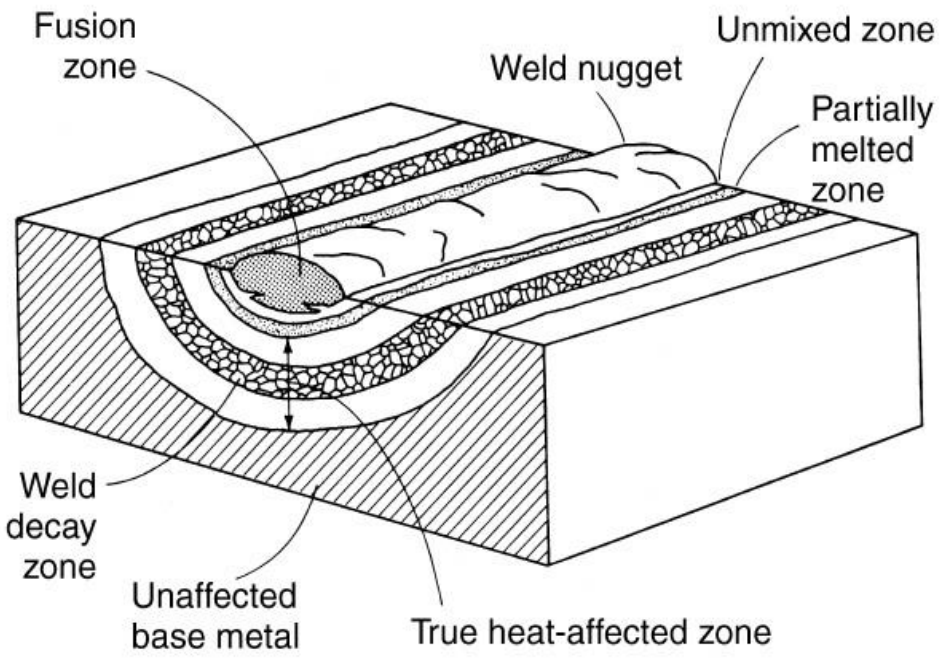
AISI 304 B chemical composition (wt %)							
C	Mn	Si	Cr	Ni	B	Co	N
0.013	0.8	0.3	18.5	12.5	1.1	0.03	0.024

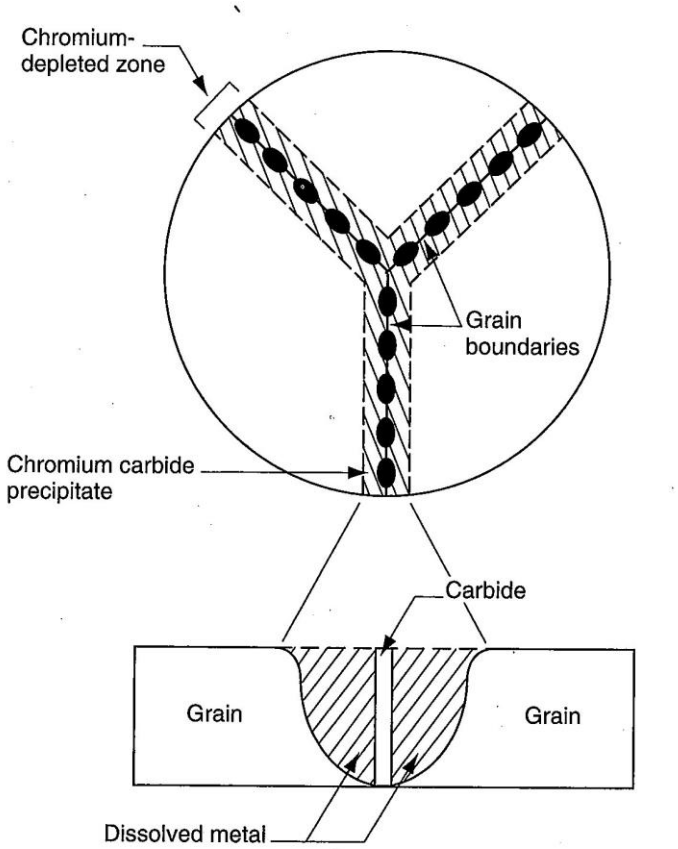
Corrosion protection mechanism



Welding

- Heat affected zone

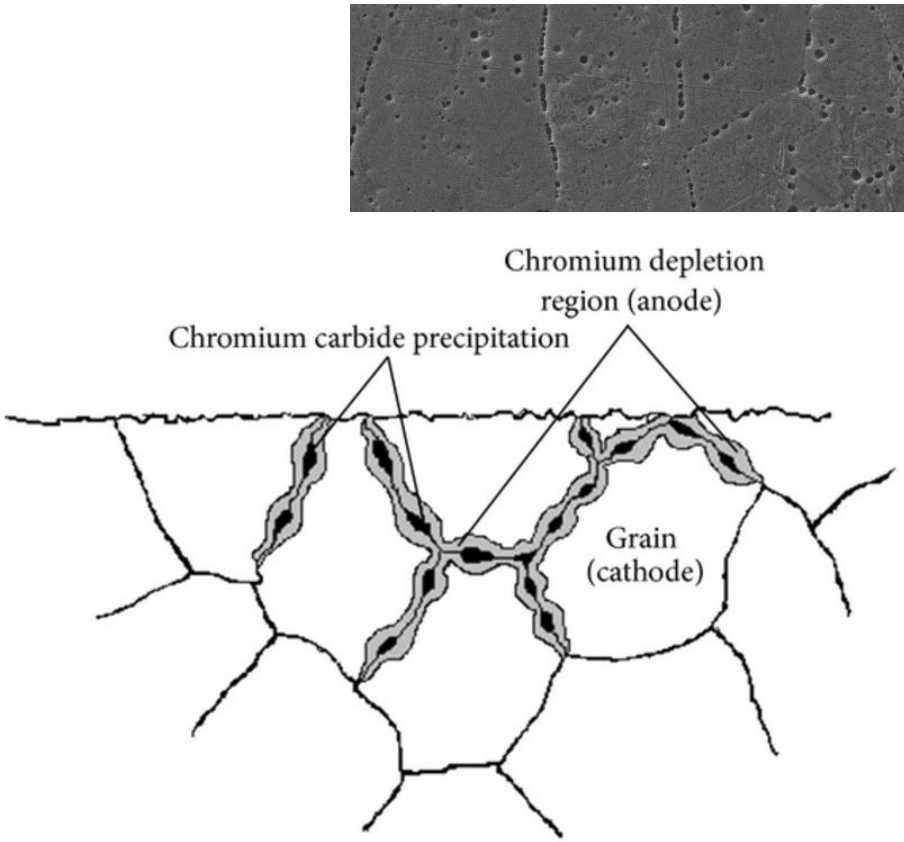


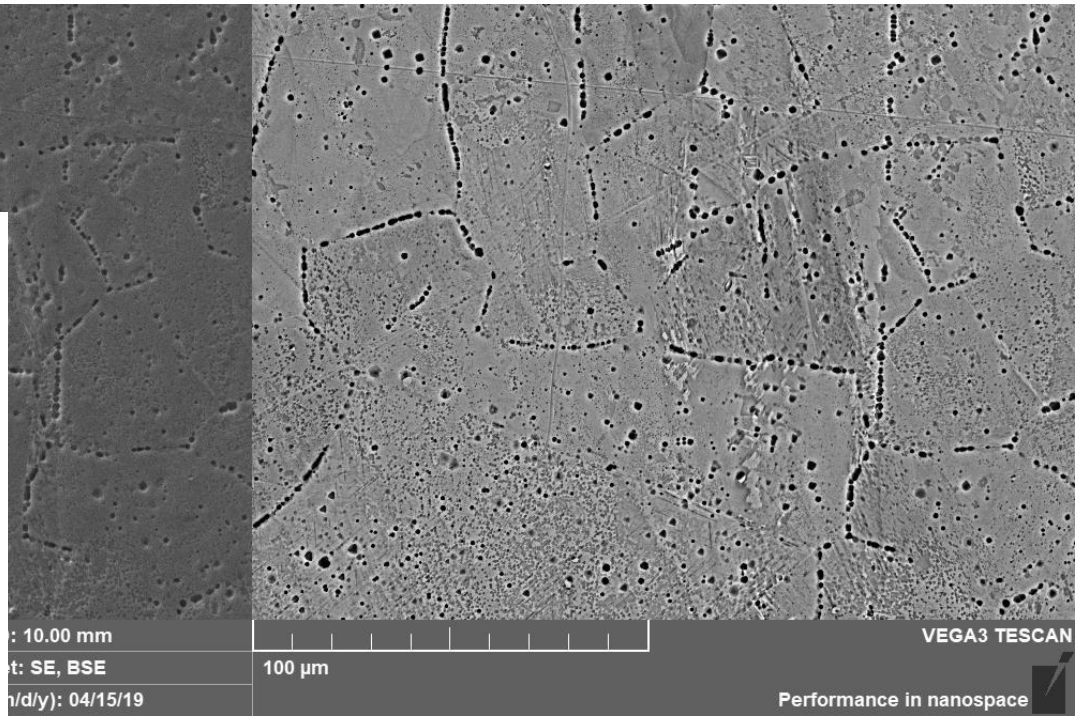


Davis, J. R. *Corrosion of Weldment*; Materials Park: Ohio, 2006.

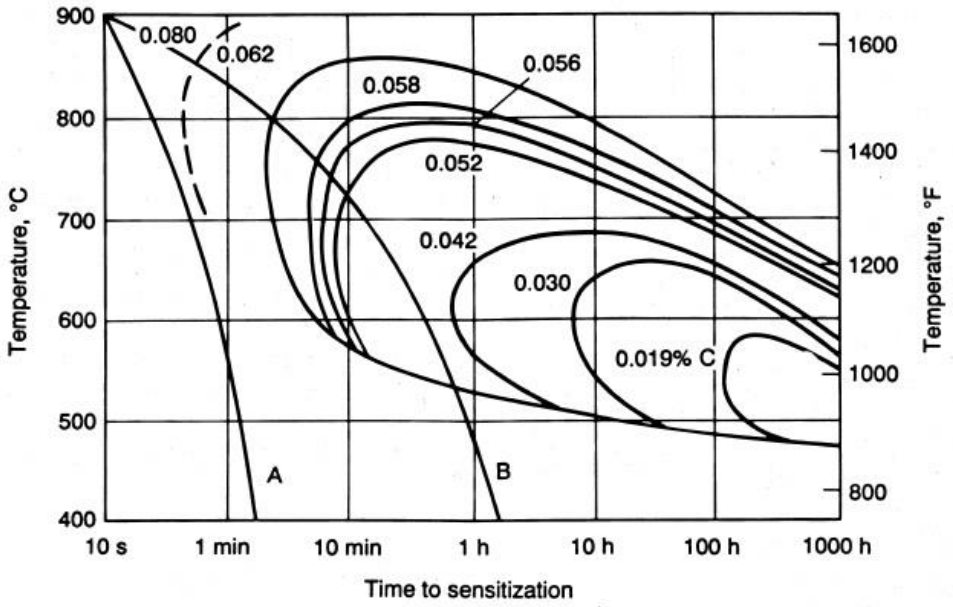
Intergranular corrosion

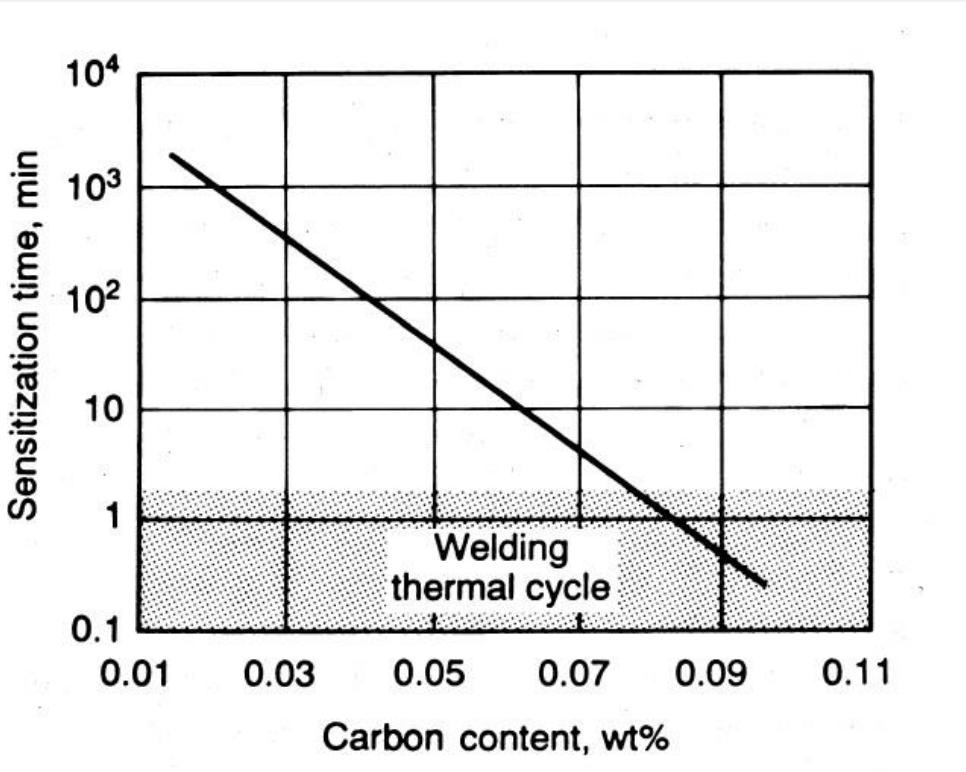
- Precipitation of carbides
- $Cr_{23}C_6$
- Chromium depletion at the grain boundaries or sensitization
- 12 % Cr





Content of Cr





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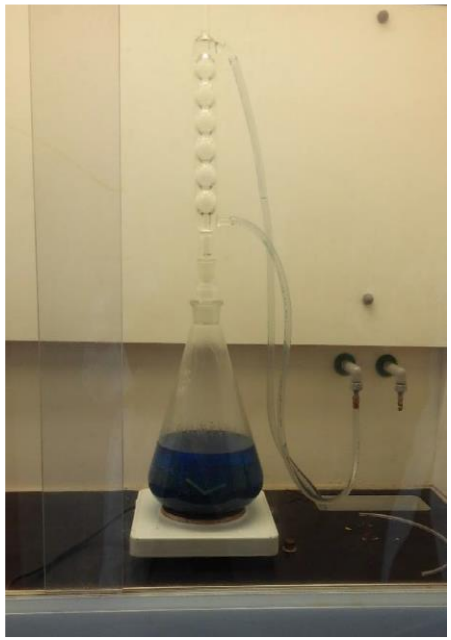
$(Fe,Cr)_2B$

AISI 304 B chemical composition (wt %)							
C	Mn	Si	Cr	Ni	B	Co	N
0.013	0.8	0.3	18.5	12.5	1.1	0.03	0.024

Corrosion tests – intergranular corrosion

TABLE 9.2 Standard Intergranular Corrosion Tests for Stainless Steels

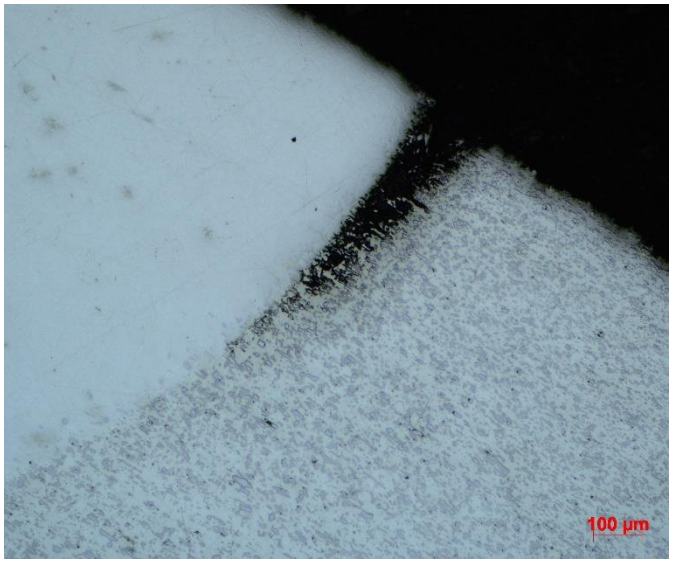
ASTM Standard (Common Name)	Species Environment	Exposure	Evaluation	Attacked
A708-86 (Strauss)	16% H_2SO_4 +6% $CuSO_4$. Boiling.	One 72-hour period.	Macroscopic appearance after bending.	Chromium-depleted area
A262-86 Practice A (Oxalic Etch)	10% $H_2C_2O_4$.	1.5 min. Anodic at one A/cm^2. Ambient temp.	Microscopic type of attack.	Various carbides.
A262-86 Practice B (Streicher)	50% H_2SO_4 +2.5% $Fe_2(SO_4)_3$. Boiling.	One 120 hour period.	Weight loss per unit area.	Chromium-depleted area.
A262-86 Practice C (Huey)	65% HNO_3. Boiling.	Five 48 hour periods. Fresh solution each period.	Average weight loss per unit area.	Chromium-depleted area, σ phase and carbides.
A262-86 Practice D (Warren)	10% HNO_3 +3% HF. 70C	Two 2-hour periods.	Weight loss per unit area.	Chromium-depleted area in Mo bearing steels.
A262-86 Practice E (Copper Accelerated Strauss)	16% H_2SO_4 +6% $CuSO_4$. Boiling. Specimen in contact with copper metal.	One 24-hour period.	Macroscopic appearance after bending.	Chromium-depleted area.



Jones, D. A. *Principles and Prevention of Corrosion*; Pearson: Harlow, 2014.

Corrosion environment

- Corrosion environment is not aggressive
- Racks are usually in 3 % H_3BO_3
- Boric acid is weak acid
- Corrosion rates are less than 1 μm/year



Corrosion protection

- Modification of material
  - Ti, Nb – more affinity to C (still problem with B)
  - Mo
- Heat treatment
- Surface treatment
  - Passivation
  - Nickel, Zinc plating
  - Corrosion inhibitors
- No welding
- Not so hard testing?

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Thank you for your attention

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