Duplex steel in the nuclear industry

Or, The lack of duplex steel in nuclear power and possible applications

DUWELTOOL, 2020-02-20, Hannes Löfgren

Material requirements

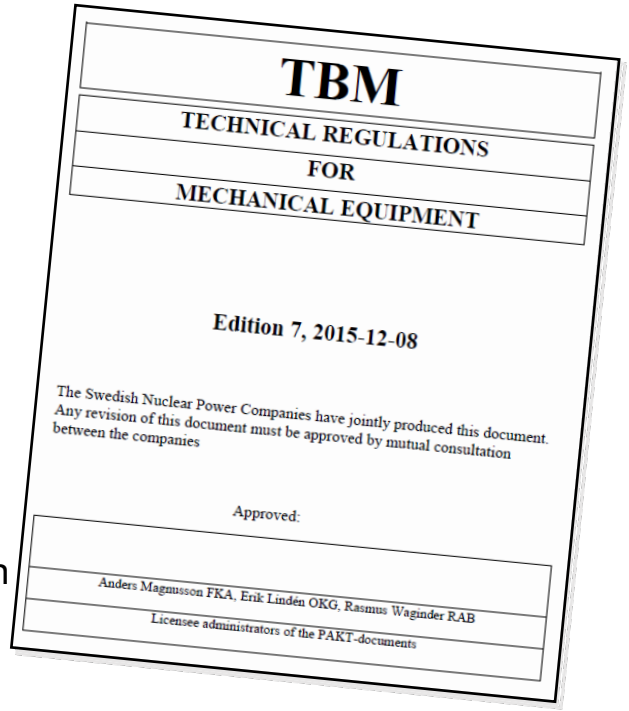
3.1 Material

Well-proven and documented material shall always be selected.

3.1.7 Ferritic and ferritic-austenitic (duplex) stainless steel

These steel types may only be used at permission from the licensee and where specified in TBM.

- A large conservatism regarding materials and manufacturing
- The same materials and methods used in the construction of 70s
- Design changes require a great deal of research and examination



TBM

TECHNICAL REGULATIONS

FOR

MECHANICAL EQUIPMENT

Edition 7, 2015-12-08

The Swedish Nuclear Power Companies have jointly produced this document. Any revision of this document must be approved by mutual consultation between the companies

Approved:

Anders Magnusson FKA, Erik Lindén OKG, Rasmus Waginder RAB

Licensee administrators of the PAKT-documents

Areas for duplex steel in nuclear industry

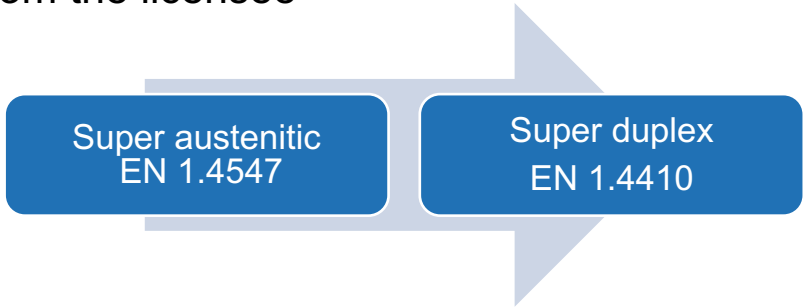
- Salt water systems – Cooling systems based on seawater
- Intermediate drainage system – Low pressure hot systems, resulting in a concentration of chlorides
- Stagnant water – Such as fire water systems
- Waste systems – Evaporation and embedding systems (bitumen)
- Pipe support in corrosive environments
- Other load-bearing structures

Materials for salt water systems

Based on TBM 3.1.11 (3.1.15)

- Titanium alloys
- Rubber lined carbon steels
- High alloy stainless steel with PRE > 37
  Austenitic stainless steels – Mo ≥ 6%
  Ferrite austenitic (duplex) stainless steels – Mo ≥ 3%
- Plastic pipe can be used in quality class 3, 4 and 4A
  upon acceptance from the licensee

PRE = Cr+3,3xMo+16xN
(Pitting Resistance Equivalent)



Materials for intermediate drainage
Based on TBM 3.1.12

For intermediate drainage piping shall one of the following or equivalent material be used:

- EN 1.4563 / UNS S08028 super austenitic (Alloy 28) PREN: 39
- EN 1.4424 / UNS S31500 duplex (3RE60) PREN: 28
- EN 1.4462 / UNS S32205 duplex (2205) PREN: 35
- EN 1.4539 / UNS N08904 super austenitic (904L) PREN:34

Common and interesting materials

Steel name	Number	Steel type	Grade	$R_{p0,2}$	PREN	C_{max}	Si	Mn	P_{max}	S_{max}	N	Cr	Cu	Mo	Ni
X5CrNi18-10	1.4301	austenitic	304	195	19	0,070	≤ 1,00	≤ 2,00	0,040	0,015	≤ 0,10	17,5 - 19,5	-	-	8,0 - 10,5
X5CrNiMo17-12-2	1.4401	austenitic	316	205	24	0,070	≤ 1,00	≤ 2,00	0,040	0,015	≤ 0,10	16,5 - 18,5	-	2,0 - 2,5	10,0 - 13,0
X2CrNiMo17-12-2	1.4404	austenitic	316L	190	23	0,030	≤ 1,00	≤ 2,00	0,040	0,015	≤ 0,10	16,5 - 18,5	-	2,0 - 2,5	10,0 - 13,0
X2CrNiMo18-14-3	1.4435	austenitic	316L	190	26	0,030	≤ 1,00	≤ 2,00	0,040	0,015	≤ 0,10	17,0 - 19,0	-	2,5 - 3,0	12,5 - 15,0
X1CrNiMoCuN20-18-7	1.4547	super austenitic	254 SMO	300	44	0,020	≤ 0,7	≤ 1,00	0,030	0,010	0,18 - 0,25	19,5 - 20,5	0,5 - 1,0	6,0 - 7,0	17,5 - 18,5
X1NiCrMoCu25-20-5	1.4539	super austenitic	904L	230	34	0,020	≤ 0,7	≤ 1,00	0,030	0,010	≤ 0,15	19,0 - 21,0	1,2 - 2,0	4,0 - 5,0	24,0 - 26,0
X1NiCrMoCu31-27-4	1.4563	super austenitic	Alloy 28	215	39	0,020	≤ 0,7	≤ 1,00	0,030	0,010	≤ 0,10	26,0 - 28,0	0,70 - 1,50	3,0 - 4,0	30,0 - 32,0
X2CrMnNiN21-5-1	1.4162	lean duplex	2101	435	26	0,040	≤ 1,00	4,0 - 6,0	0,035	0,005	0,20 - 0,25	21,0 - 22,0	0,10 - 0,80	0,10 - 0,80	1,35 - 1,90
X2CrNiMoN22-5-3	1.4462	duplex	2205	450	35	0,030	≤ 1,00	≤ 2,00	0,035	0,015	0,10 - 0,22	21,0 - 23,0	-	2,5 - 3,5	4,5 - 6,5
X2CrNiMoSi18-5-3	1.4424	duplex	3RE60	480	28	0,030	1,4 - 2,0	1,2 - 2,0	0,035	0,015	0,05 - 0,10	18,0 - 19,0	-	2,5 - 3,0	4,5 - 5,2
X2CrNiMoN25-7-4	1.4410	super duplex	2507	550	43	0,030	≤ 1,00	≤ 2,00	0,035	0,015	0,20 - 0,35	24,0 - 26,0	-	3,0 - 4,5	6,0 - 8,0