

2 Background to alloy design

P92 is a development of the now well established alloy P91. The P91, 9%Cr-1%Mo plus microalloying composition, is modified by reducing the molybdenum content to about 0.5% and adding about 1.7% tungsten plus a few parts per million of boron. Controlled microalloying in the form of niobium (columbium), vanadium and nitrogen is retained. This composition modification gives rise to very stable carbides and carbo-nitrides which improve long term creep strength. This steel is designed to operate at temperatures up to 625°C and it is claimed that high temperature rupture strengths are up to 30% greater than for P91. For example at 600°C (1112°F) the 100,000 hour creep rupture strength of P91 base material is about 95MPa (13.8ksi) whereas P92 is about 123MPa (17.8ksi).

Exploitation of P92 is relatively limited and further confidence and experience in the fabrication and use of the alloy still has to be developed. However, a number of installations were completed in the late 1990s and more are under construction or being planned. A selected list of installations which have used P92 is given in Table 1.

P92 was originally developed in Japan in the 1990s as NF616 and was subsequently incorporated into ASTM and the ASME code as Grade 92. Parallel developments in Europe resulted in a grade of steel designated E911*, in which the molybdenum is maintained at about 1% and a further 1% of tungsten is added.

* Note: Contact Metrode for further information and consumables for welding E911

2.1 P92: Specifications and product forms

ASTM/ASME specified composition range is given in Table 2 and the various product forms, required properties and heat treatments are given in Table 3. The commonly used descriptors are given below and for the remainder of this document the material will be referred to as P92.

T92 (ASTM/ASME A213): **92 tube**

P92 (ASTM/ASME A335): **92 pipe**

F92 (ASTM/ASME A182): **92 forging**

Table 2 Specified composition for P92 steels

	C	Mn	Si	S	P	Cr	Ni	Mo	W	Nb	V	N	Al	B
<i>min</i>	0.07	0.30	-	-	-	8.50	-	0.30	1.50	0.04	0.15	0.030	-	0.001
<i>max</i>	0.13	0.60	0.50	0.010	0.020	9.50	0.40	0.60	2.00	0.09	0.25	0.070	0.04	0.006

Table 3 Heat treatment and mechanical property requirements for P92 steels

ASTM/ASME specifications	Alloy	Heat treatment		Tensile strength MPa (ksi)	0.2% proof stress MPa (ksi)	Longitudinal elongation %	Hardness HB
		Normalising temp, °C (°F)	Tempering temp, °C (°F)				
A213-A335	T/P92	≥1040 (1900)	≥730 (1350)	≥620 (90)	≥440 (64)	≥20	≤250
A182	F92	≥1040 (1900)	≥730 (1350)	≥620 (90)	≥440 (64)	≥20	≤269