MANAURITE® DRA: AL-TECHNOLOGY TO GUARANTY CREEP PERFORMANCE

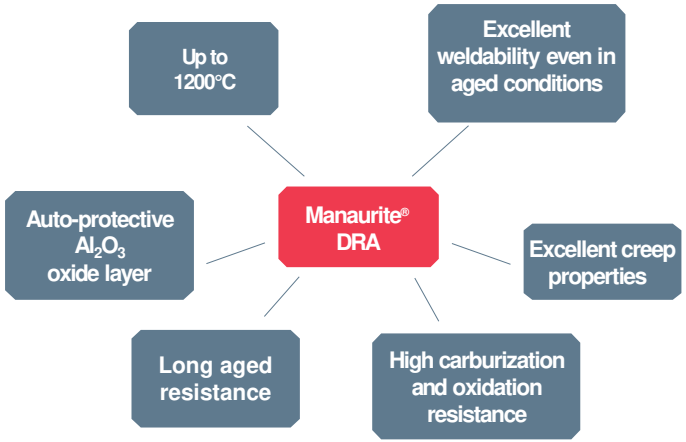
Manaurite® DRA is a nickel-based alloy developed for very high T processes, becoming, so far, the most creep resistant Manaurite® at temperatures exceeding 1100°C.

With its more 50% of nickel content the Manaurite® DRA grade develop a high creep resistance which allow a use at much higher temperature for a much longer time.

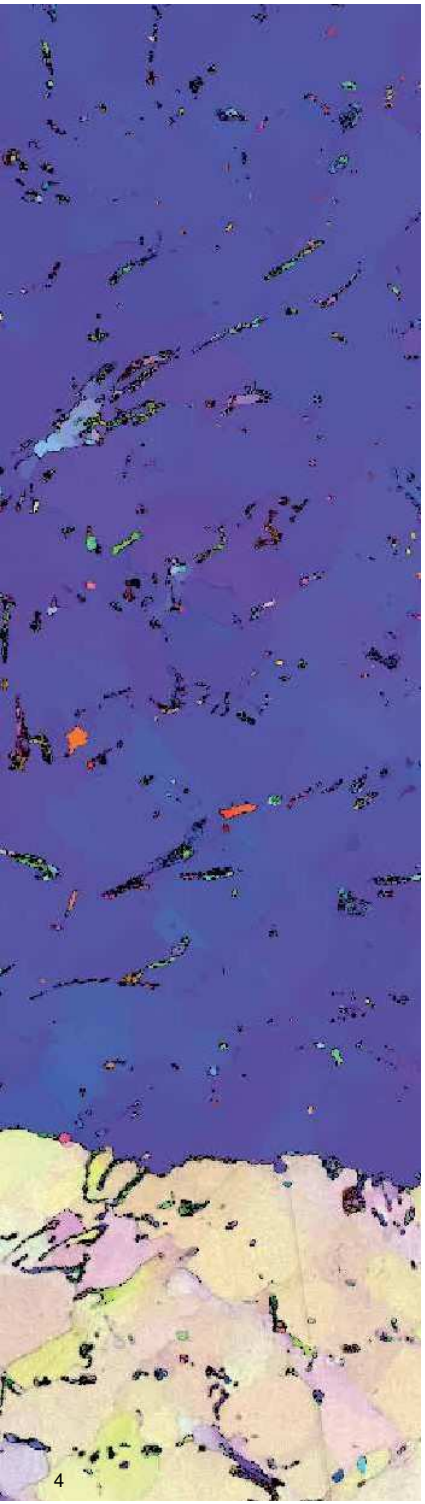
In addition of its heat-resistance, the Manaurite® DRA grade so as the Manaurite® XAl4 grade, develops an auto-protective oxide layer with high-temperature stability thanks to is aluminium content.

Specific applications

- DRI furnaces
- Heat-treatment furnaces



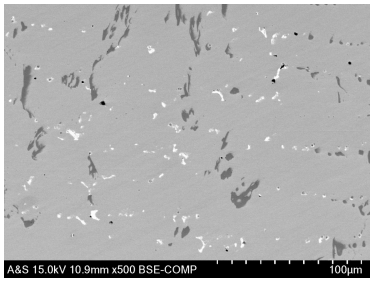
Manaurite® DRA is the latest grade developed by Manoir France's R&D team. Accumulated knowledge and experience have strongly contributed to improve creep resistance properties coupled with oxidation and carburization resistance properties of Manaurite® DRA



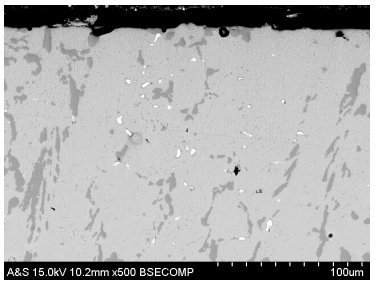
CHEMICAL COMPOSITION

Element	Minimum (wt %)	Maximum (wt %)
C	0.4	0.5
Mn	-	0.7
Si	-	0.7
Ni	50	56
Cr	26	29
Al	2.8	3.8
Ti, Nb, V	-	++

MICROSTRUCTURE



As cast structure of Manaurite® DRA.
Grey particles correspond to chromium carbides and white particles correspond to niobium rejected carbides.



Aged structure of Manaurite® DRA alloy.
A nanometric, very stable Al_2O_3 layer is created, protecting the microstructure from aggressif environments
Fine grey particles correspond to secondary chromium carbides precipitated in the gamma matrix.

TENSILE PROPERTIES

	Temperature (°C)	Y.S (MPa)	U.T.S (MPa)	E (%)
As-cast (minimum values)	20	400	600	5

*3% for Statically Cast Fittings

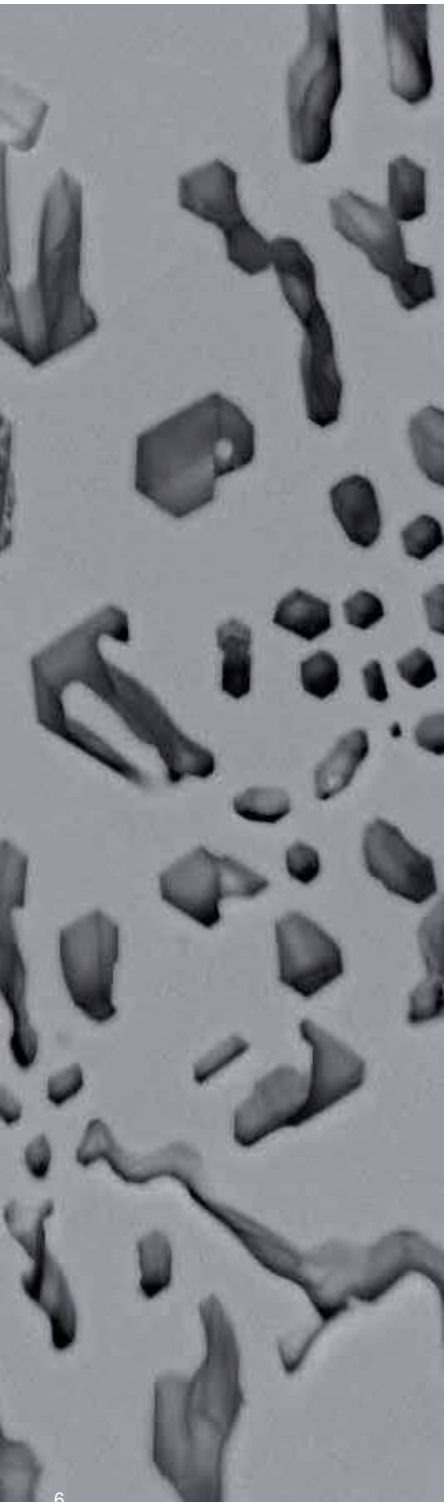
	Temperature (°C)	Y.S (MPa)	U.T.S (MPa)	E (%)
As-cast (typical values)	20	450	650	7.5
	850	168	220	49
	950	98	118	65
	1050	54	67	89
	1150	34	43	76
	1200	25	28	37

PHYSICAL PROPERTIES

Property	Value
Melting point	1350 °C

Temperature (°C)	Thermal conductivity (W/m °C)	Specific Heat (J / g·K)	Thermal expansion coefficient (10^{-6}/K)	Density (g/cm³)	Elasticity modulus (Gpa)	Electrical resistivity (µΩ·cm)
20	10.2	0.46	-	7.70	173	1.40
800	22.2	0.62	17.3	7.51	133	1.51
900	23.7	0.65	18.2	7.45	126	1.50
1000	25.9	0.67	18.5	7.40	119	1.50
1100	28.3	0.70	18.9	7.35	111	1.52
1200	31.0	0.75	19.3	7.30	-	-

*mean coefficient of thermal expansion between 20°C and indicated temperature



Creep properties

10 000 h creep rupture stress data

Temperature (°C)	σ_{min} (MPa)	σ_{avg} (MPa)
900	27.1	29.6
950	22.9	25.0
1000	18.1	19.8
1050	13.5	14.7
1100	9.4	10.3
1150	6.2	6.8
1200	3.9	4.2

Data based on LMP extrapolation

100 000 h creep rupture stress data

Temperature (°C)	σ_{min} (MPa)	σ_{avg} (MPa)
900	23.0	25.1
950	18.1	19.7
1000	13.3	14.5
1050	9.1	10.0
1100	5.9	6.4
1150	3.5	3.8
1200	2.0	2. 2

Data based on LMP extrapolation

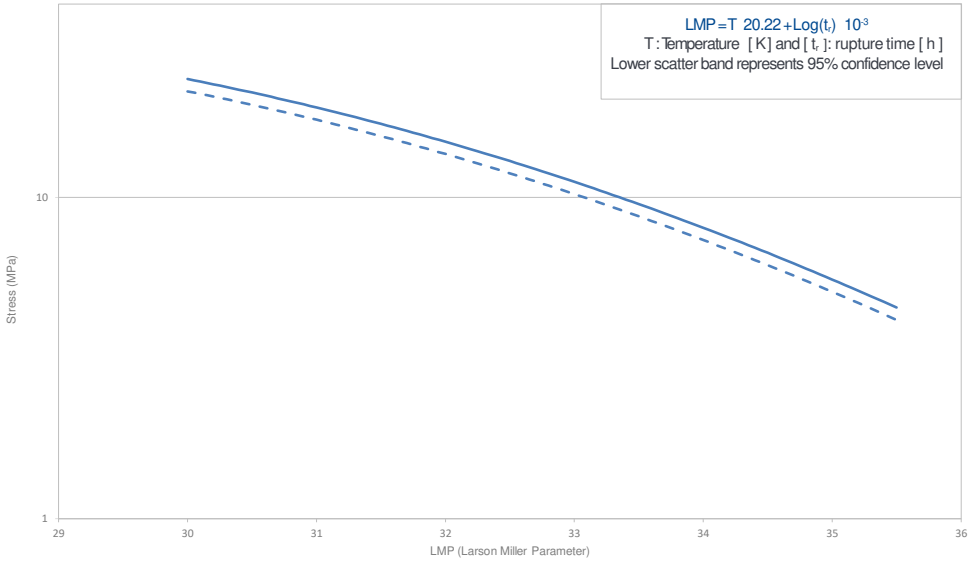
Creep rate

Typical creep stress (MPa)

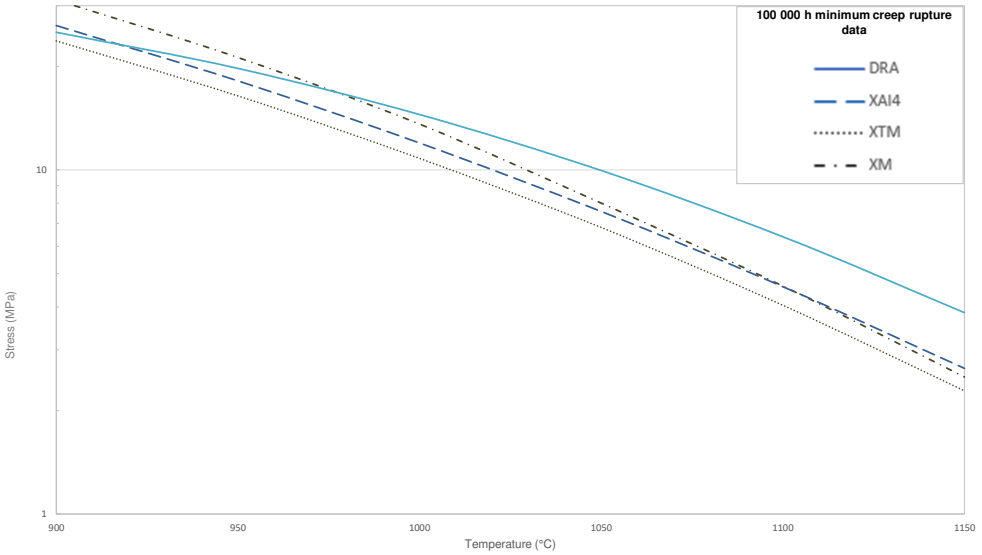
%/hour	1100 °C	1150 °C	1200°C
0.01	29	16	
0.001	18	10.6	
0.0001	13.4	7.4	
0.00001	9.4	5	

Creep data may be updated as new test results are available.

Manaurite® DRA creep rupture stength

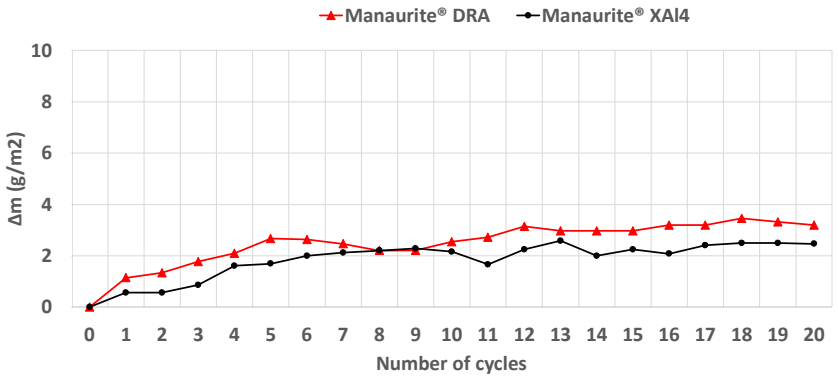


Manaurite® DRA vs Manaurite® XAI4 vs Manaurite® XM & Manaurite® XTM



Oxidation

In oxidizing conditions, Manaurite® DRA develops a thin uniform protective Al_2O_3 layer. Aluminium being stable at high temperatures, it offers two mains benefit: it shows a lower oxidation rate and no spallation nor volatilization.
This can be see through cyclic oxidation at 1150°C during which Manaurite® DRA performs as much as Manaurite® XAl4 our previous grade with high Al content.



Carburization

DRA, with its improved oxidation resistance, provides higher carburization resistance and better creep resistance. Its high maximal temperature operation limit combined to a good carburization and coking resistance leads to numerous process benefits (e.g. run length increase).