Manaurite® XA14

MANOIR INDUSTRIES

MANAURITE® XAI4: 4% ALUMINIUM TO INCREASE FURNACE PERFORMANCE

Manaurite® XAI4 is a nickel-based alloy developed to face coke formation and carburization issues encountered within steam-crackers for ethylene production. Its oxidation and mechanical properties are a result of its specific chemical composition.

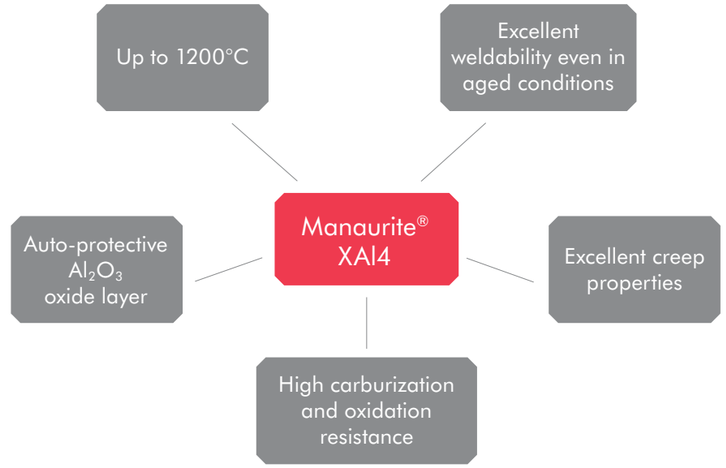
With its 4% aluminum content, Manaurite® XAI4 develops a uniform, auto-protective and self-healing oxide layer with very high thermal stability suitable for steam crackers service conditions.

Aluminum oxide being much more stable than chromium oxide, alumina forming alloys exhibit much better oxidation and carburization resistance than their chromia forming equivalent. The enhancement of high temperature oxidation resistance contributes to improve carburization and coking resistance.

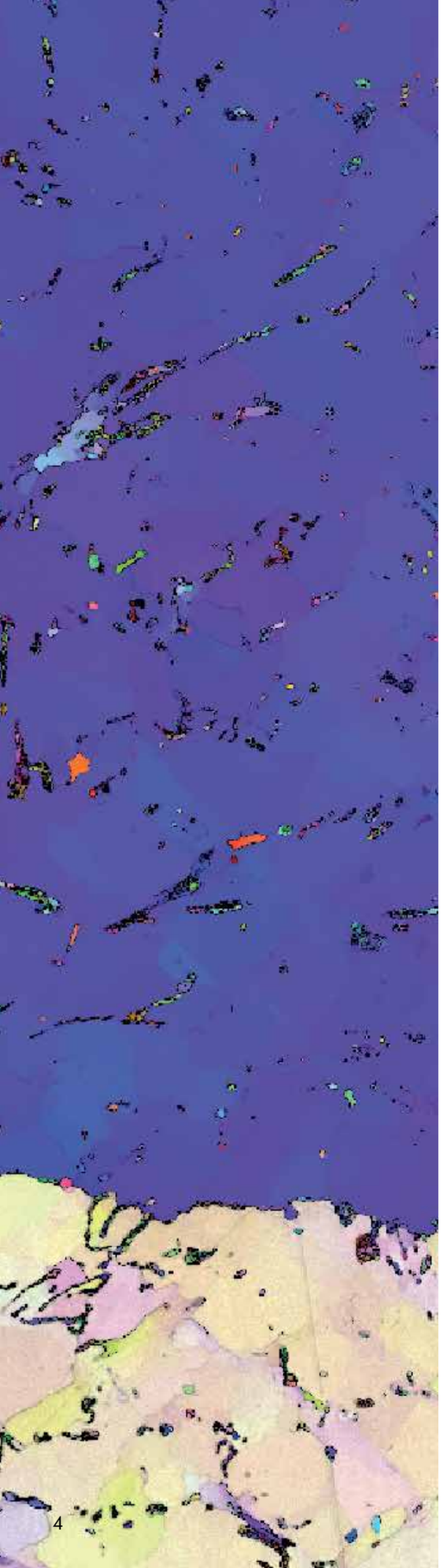
The mechanical properties of this micro-alloyed grade, including creep resistance, have been carefully optimized through balance of chemical composition and overpass the level of standard 35/45 Manaurite® XTM heat-resistant alloy.

Specific applications

- Radiant coils for cracking furnaces
- High severity furnaces



Manaurite® XAI4 is the latest grade developed by Manoir Industries R&D. Since first Manoir patent based on aluminum addition to face severe environment (1978), grade development and optimization have been continuous. Accumulated knowledge and experience have strongly contributed to improve oxidation and carburization properties of Manaurite® XAI4.



CHEMICAL COMPOSITION

Element	Minimum (wt %)	Maximum (wt %)
C	0.4	0.5
Al	3.5	4.5
Ni	43	48
Cr	23	27
Ti	-	0.3
Nb	-	2
W	-	2

PHYSICAL PROPERTIES

Property	Value
Density	7.5 g/cm^3
Melting point	1410 °C

Temperature (°C)	Thermal conductivity (W/m°C)	Thermal expansion coefficient (10^{-6}/K)*	Elasticity modulus (GPa)
20	10.5	-	168
800	24	17.6	121
900	25.3	18.1	112
1000	26.7	18.6	101
1100	28.1	18.8	94

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

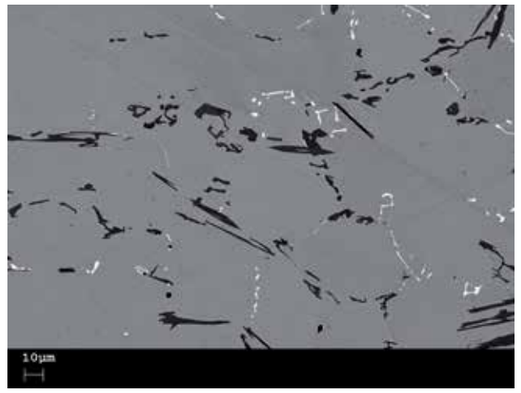
TENSILE PROPERTIES

	Temperature (°C)	Y.S. (MPa)	U.T.S. (MPa)	E (%)
As-cast (minimum values)	20	300	500	6*

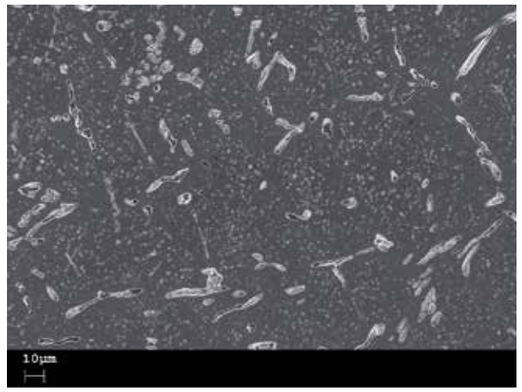
*4% for Statically Cast Fittings.

	Temperature (°C)	Y.S. (MPa)	U.T.S. (MPa)	E (%)
As-cast (minimum values)	20	353	588	7.1
	850	124	192	50
	950	89	106	61
	1050	55	67	61
	1150	32	40	72

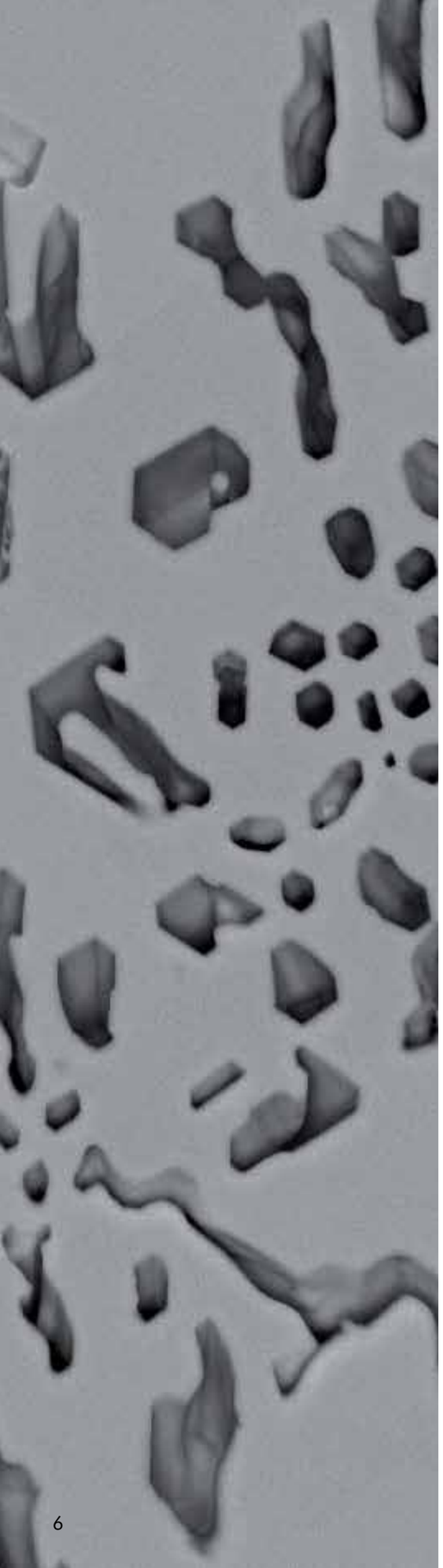
MICROSTRUCTURE



As cast structure of Manaurite® XAl4.
Black particles correspond to chromium carbides and white particles correspond to niobium carbides.



Aged structure of Manaurite® XAl4 (etched sample after creep test). Fine particles correspond to secondary chromium carbides precipitated in the gamma matrix.



CREEP PROPERTIES

10 000 h creep rupture stress data

Temperature (°C)	σ_{min} (MPa)	σ_{avg} (MPa)
900	30.1	36.5
950	21.3	25.8
1000	14.6	17.6
1050	9.6	11.6
1100	6.2	7.4
1150	3.8	4.6
1200	2.3	2.8

Data based on LMP extrapolation

100 000 h creep rupture stress data

Temperature (°C)	σ_{min} (MPa)	σ_{avg} (MPa)
900	22.1	26.7
950	15.0	18.0
1000	9.7	11.7
1050	6.1	7.4
1100	3.7	4.5
1150	2.2	2.6
1200	1.2	1.5

Data based on LMP extrapolation

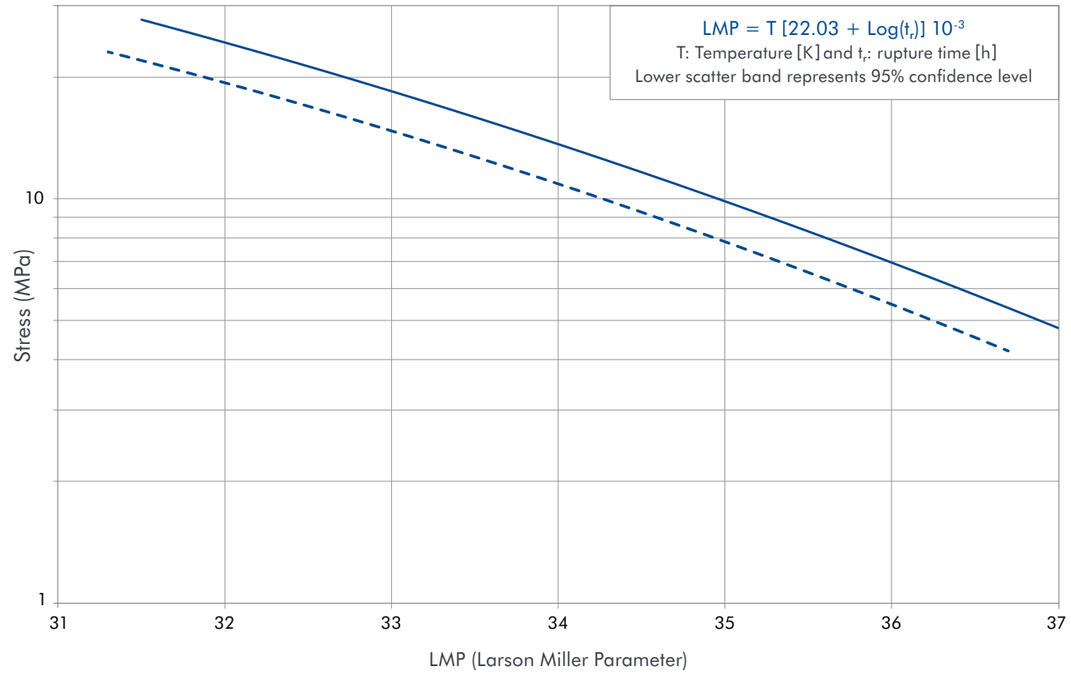
CREEP RATE

Typical creep stress (MPa)

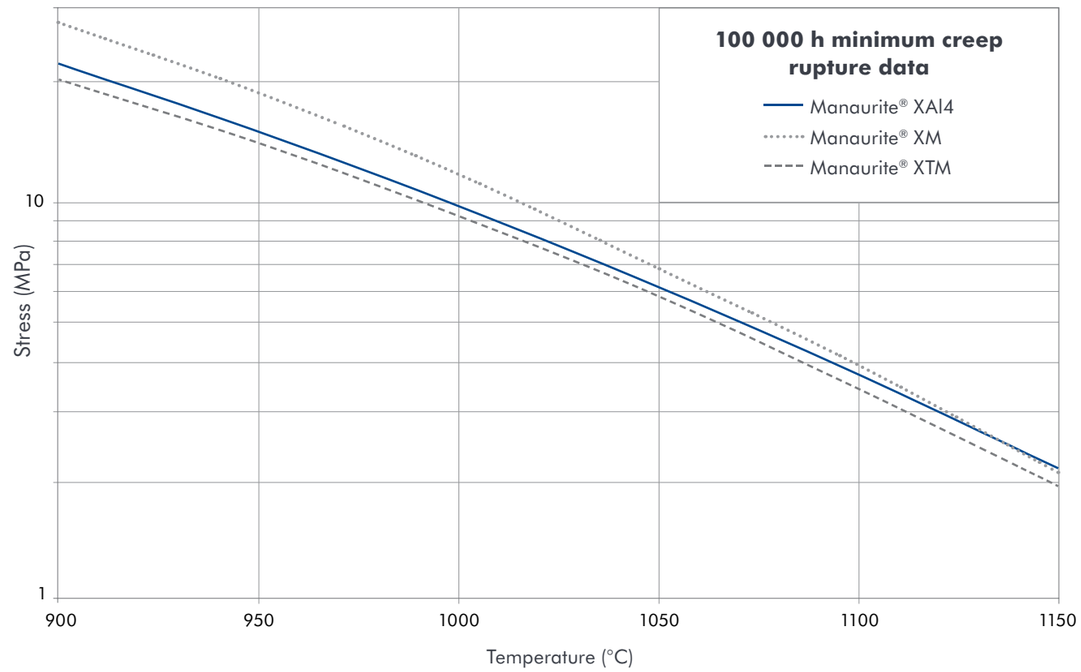
%/hour	1050 °C	1100 °C
0.01	29	16
0.001	19	10.6
0.0001	13.4	7.4
0.00001	9.4	5

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

Manaurite® XAl4 creep rupture stength



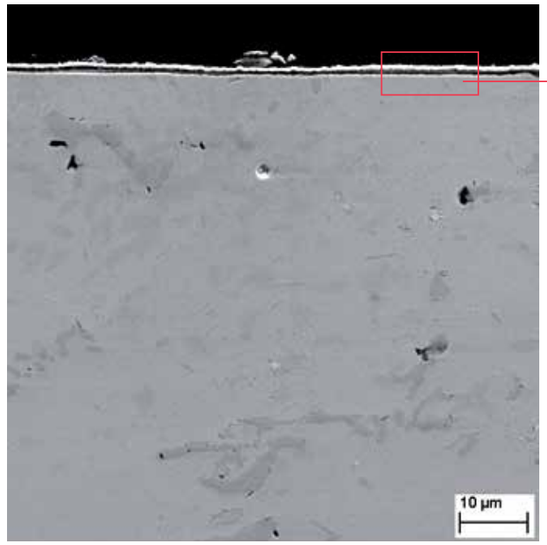
Manaurite® XAl4 vs Manaurite® XM & Manaurite® XTM

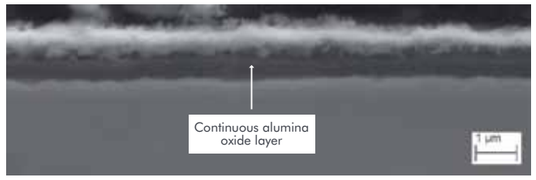


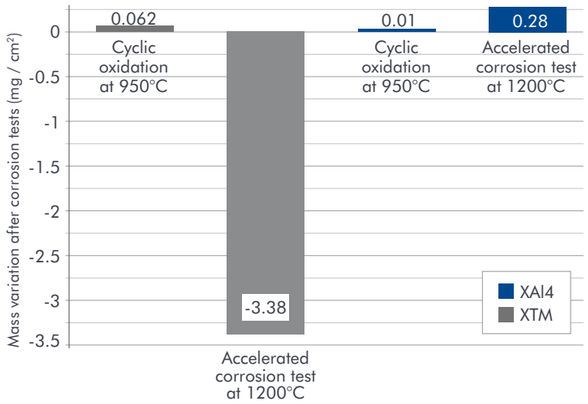
OXIDATION

In oxidizing conditions, Manaurite® XAl4 develops a thin uniform protective Al_2O_3 layer (clearly visible on the SEM cross section). Alumina being much more stable than chromia, it offers two main benefits: it shows a lower oxidation rate and no spallation nor volatilization. This can be seen through cyclic oxidation at 950°C during which Manaurite® XAl4 performs better than Manaurite® XTM in terms of weight gain.

Long term oxidation (simulated by a high temperature corrosion test at 1200°C) leads to spallation in the case of Manaurite® XTM whereas Manaurite® XAl4 only slightly gains mass, demonstrating its excellent resistance to spallation and volatilization.



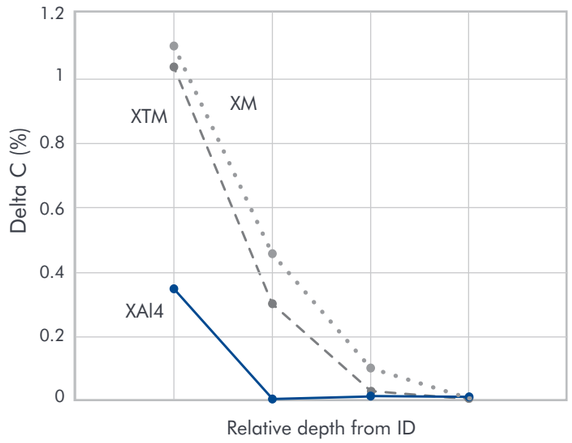




CARBURIZATION

Manaurite® XAl4, with its improved oxidation resistance, provides higher carburization resistance than Manaurite® XTM and Manaurite® XM and better creep resistance than Manaurite® XTM. Its high maximal temperature operation limit combined to a high carburization and coking resistance leads to numerous process benefits (e.g. run length increase).

Carburization peak after cementation test at 1150°C



WELDABILITY

Manaurite® XAI4 is welded with a specific filler material. Postweld heat treatment or preheating is not necessary.
Aged materials can also be welded. Further information will be supplied upon request.

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Future is our raw material.

As a metal processing specialist, Manoir Industries develops alloys and operates processes for the manufacture of high-performance components. Known and recognised for several decades, its know-how is complemented by its expertise in casting, forging, boilermaking, welding and assembly. Manoir's solid technical expertise continues to drive its sustainable leading position, offering innovative services to its customers worldwide as a true partner.

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