Alleima

Alleima® 353 MA
Tube and pipe, seamless
Datasheet

Alleima® 353 MA is an austenitic chromium-nickel steel alloyed with nitrogen and rare earth metals. The grade is characterized by:

- High creep strength
- Very good resistance to isothermal and cyclic oxidation
- Very good resistance to combustion gases
- Very good resistance to carburization
- Good resistance to nitriding gases
- Good structural stability at high temperatures
- Good weldability
- Maximum operating temperature is approx. 1175°C (2150°F)

Trademark information: 353 MA is a trademark owned by Outokumpu OY.

Standards

- UNS: S35315
- EN Number: 1.4854

Product standards

- ASTM A312
- EN 10297-2

Chemical composition (nominal)

Chemical composition (nominal) %

C	Si	Mn	P	S	Cr	Ni	N	Ce*
0.07	1.6	1.5	≤0.040	≤0.015	25	35	0.16	0.05

* The quantity of other rare earth metals should be added to cerium, because the addition takes the form of misch metal containing about 50 % Ce.

Applications

The excellent oxidation and carburization resistance of Alleima® 353 MA in constantly carburizing gas, makes it particularly suitable grade for high-temperature petrochemical furnaces. The high nitriding resistance is very

Datasheet last updated 5/9/2025 6:38:12 AM (supersedes all previous editions)

beneficial for service in high temperature cracked ammonia gas. Typical applications are:

- Ethylene furnace, radiant cracking tubes
- EDC furnace tubes
- Tubes in wast heat recovery systems in the metallurgical industry, e.g. recuperators
- Tubes in heat treatment furnaces, e.g. muffle tubes, radiant tubes, thermocouple protection tubes, burner components, furnace rollers
- Recuperator tubes in chemical waste and sewage sludge incineration

Trademark information: 353 MA is a trademark owned by Outokumpu OY.

Corrosion resistance

Oxidation

Owing to the high silicon content and the addition of rare earth metals (REM), Alleima® 353 MA has very high resistance to oxidation. The REM addition also contributes to improved scale adhesion during temperature cycling. Figure 1, which shows the measured weight increase after 45 h cyclic oxidation at different temperatures, illustrates how Alleima® 353 MA compares with some other high temperature grades. Weight increase after longer exposure at 1150°C (2100°F) is shown in Figure 2. The weight increase shown in Figure 1 and Figure 2 includes the weight of any spalled oxide.

Figure 1. Weight increase for Alleima 353 MA and other grades after 45h oxidation.

Figure 2. Weight increase versus time during oxidation at 1150°C

Carburizing and nitrogen pick-up

Corrosion attack by carburization or nitrogen pick-up usually follows a parabolic rate law: $x^2=k_p * t+C$, where x is the attack, expressed as penetration depth or weight increase, k_p a rate constant, t exposure time and C a constant accounting for the initial attack (which follows a different rate law).

Due to its ability to form a dense chromium oxide and its high nickel content, Alleima® 353 MA also has good resistance to carburization and nitrogen pick-up.

Figure 3 shows the measured rate constants for carburization tests of various alloys at different temperatures. Cyclically carburizing-oxidizing conditions are often more detrimental, but, as Figure 4 shows, Alleima® 353 MA is able to resist these conditions better than other alloys.

In nitrogen pick-up tests, Figure 5, Alleima® 353 MA showed similar resistance to Alloy 601.

Figure 3. Rate constant for total carburization; a_c=1; PO_2~0.

Figure 4. Rate constant for total carburization and carburizationoxidation. Carburization: 950°C(1740°F); a_c=1; PO_2~0. Oxidation: 1050°C(1920°F); a_c~0; PO_2=0.21atm.

Figure 5. Rate constant for nitrogen pick-up in cracked ammonia.

Sulphur attack

Alloys with high nickel content are generally sensitive to attack by sulphur at higher temperatures. However, under oxidizing conditions a protective oxide will be able to form, contributing to an improved resistance to sulphur

Datasheet last updated 5/9/2025 6:38:12 AM (supersedes all previous editions)

attack. This is illustrated in Figure 6, which shows the rate constant for different alloys in different sulphidizing-oxidizing conditions. Again, the dense oxide formed on Alleima® 353 MA is shown to be advantageous.

Figure 6. Rate constant for sulphidation-oxidation.

Bending

Due to its higher strength compared with conventional stainless steels, higher deformation forces are required for cold bending of Alleima® 353 MA.

Annealing after cold bending is not normally necessary, but this decision should be made taking account of the degree of bending and the service conditions.

Forms of supply

Seamless tube and pipe in Alleima® 353 MA is supplied in dimensions up to 200 mm (7.9 in.) outside diameter in the solution-annealed and white pickled condition, or solution annealed by a bright-annealing process.

Other forms of supply

- Bar steel

Heat treatment

Tubes are delivered in the heat treated condition. If another heat treatment is needed after further processing, the following is recommended:

Stress relieving

1000–1100°C (1830–2010°F), 10–15 minutes, cooling in air.

Solution annealing

1100–1200°C (2010–2190°F), 5–20 minutes, rapid cooling in air or water.

Mechanical properties

Metric units, at 20°C

Proof strength		Tensile strength	Elongation		Hardness
$R_{p0.2}$	$R_{p1.0}$	R_m	A[a)]	$A_{2"}$	Vickers
MPa	MPa	MPa	%	%	
≥300	≥340	≥650	≥40	≥35	≈160

1 MPa = 1 N/mm^2
a) A is based on an original gauge length of 5.65 $\sqrt{S_0}$.

Imperial units, at 68°F

Proof strength		Tensile strength	Elongation		Hardness
Rp0.2	Rp1.0	Rm	Aa)	A2"	Vickers

Datasheet last updated 5/9/2025 6:38:12 AM (supersedes all previous editions)

ksi	ksi	ksi	%	%	
≥44	≥49	≥94	≥40	≥35	≈160

a) A is based on an original gauge length of 5.65 √S0.

At high temperatures

Metric units

Temperature	Proof strength		Tensile strength
	$R_{p0.2}$	$R_{p1.0}$	R_m
°C	MPa	MPa	MPa
100	≥228	≥261	≥536
200	≥195	≥223	≥498
300	≥166	≥190	≥470
400	≥152	≥173	≥444
500	≥143	≥163	≥437
600	≥138	≥159	≥422

Imperial units

Temperature	Proof strength		Tensile strength
	$R_{p0.2}$	$R_{p1.0}$	R_m
°F	ksi	ksi	ksi
200	≥33	≥38	≥78
400	≥28	≥32	≥71
600	≥23	≥27	≥68
800	≥21	≥24	≥63
1000	≥20	≥23	≥62
1100	≥20	≥23	≥61

$R_{p0.2}$ and $R_{p1.0}$ correspond to 0.2 % offset and 1.0% offset yield strength, respectively.

Creep strength (average values)

Metric units

Temperature, °C	Creep strength 1%	Creep rupture strength

	10 000 h	100 000 h	10 000 h	100 000 h
	MPa	MPa	MPa	MPa
550	149	86	206	129
600	88	52	127	80
650	54	33	82	52
700	35	21	56	36
750	22	14	39	25
800	15	9.7	28	18
850	10.5	6.9	20	14
900	8	5.1	15	10
950	6	3.9	11	6.7
1000	4.5	3.0	8	4.8
1050	3.5	2.3	6	3.5
1100	2.7	1.8	4.5	2.9

Imperial units

Temperature, °F	Creep strength 1%		Creep rupture strength	
	10 000 h	100 000 h	10 000 h	100 000 h
	ksi	ksi	ksi	ksi
1100	16.5	9.5	23.2	14.7
1200	8.0	4.9	12.0	7.5
1300	4.8	3.0	7.8	5.1
1400	3.0	1.9	5.4	3.4
1500	1.9	1.3	3.6	2.5
1600	1.4	0.9	2.6	1.7
1700	1.0	0.6	1.9	1.2
1800	0.7	0.5	1.3	0.8
1900	0.5	0.4	0.9	0.5
2000	0.4	0.3	0.7	0.4

Proof strength	Tensile strength	Elongation	Hardness Vickers

Datasheet last updated 5/9/2025 6:38:12 AM (supersedes all previous editions)

Rp0.2		Rp1.0		Rm		Aa)	A2"	
MPa	ksi	MPa	ksi	MPa	ksi	%	%	
min.	min.	min.	min.	min.	min.	min.	min.	approx.
300	44	340	49	650	94	40	35	160

1 MPa = 1 N/mm2
a) A is based on an original gauge length of 5.65 √S0.

Physical properties

Density: 7.9 g/cm³, 0.28 lb/in³

Thermal conductivity

Temperature, °C
W/m °C
Temperature, °F
Btu/ft h °F
20
11
68
6.5
100
13
200
7.5
200
15
400
8.5
300
17
600
10
400
18

800
11
500
20
1000
12
600
22
1200
13
700
23
1400
14
800
25
1600
15
900
26
1800
15.5
1000
27
2000
16
1100
29

Specific heat capacity

Temperature, °C

J/kg °C
Temperature, °F
Btu/ft h °F
20
480
68
0.11
100
500
200
0.12
200
530
400
0.13
300
555
600
0.13
400
575
800
0.14
500
590
1000
0.14
600
610
1200
0.15

Datasheet last updated 5/9/2025 6:38:12 AM (supersedes all previous editions)

700
625
1400
0.15
800
640
1600
0.16
900
655
1800
0.16
1000
665
2000
0.16
1100
680

Thermal expansion[1)]

Temperature, °C
Per °C
Temperature, °F
Per °F
20-100
15.5
68-200
8.5
20-200
15.5
68-400

8.5
20-400
16.5
68-800
9
20-600
17
68-1000
9.5
20-700
17
68-1200
9.5
20-800
17.5
68-1400
9.5
20-900
18
68-1600
10
20-1000
18
68-1800
10
20-1100
18.5
68-2000
10.5

1) $(x10^{-6})$

Modulus of elasticity[1)]

Temperature, °C
MPa
Temperature, °F
ksi
20
190
68
27.5
200
180
400
26
400
165
800
23.5
600
155
1000
23
700
150
1200
22
800
140
1400
20.5
900
135
1600

20
1000
130
1800
19
1100
125
2000
18

1) ($x10^3$)

Resistivity

Temperature, °C	μΩm	Temperature, °F	μΩin.
20	1.00	68	39
200	1.07	400	42
400	1.14	800	45
600	1.20	1000	47

700
1.22
1200
48
800
1.25
1400
49
900
1.28
1600
50
1000
1.30
1800
51
1100
1.32
2000
52

Welding

The weldability of Alleima® 353 MA is good. Suitable methods of fusion welding are manual metal-arc welding (MMA/SMAW) and gas-shielded arc welding, with the TIG/GTAW method as first choice.

In common with all fully austenitic stainless steels, Alleima® 353 MA has low thermal conductivity and high thermal expansion. Welding plans should therefore be carefully selected in advance, so that distortions of the welded joint are minimized. If residual stresses are a concern, solution annealing can be performed after welding.

For Alleima® 353 MA, heat-input of <1.0 kJ/mm and interpass temperature of <100°C (210°F) are recommended.

Recommended filler metals

TIG/GTAW or MIG/GMAW welding

ISO 18274 S Ni 6082/AWS A5.14 ERNiCr-3 (e.g. Exaton Ni72HP)

MMA/SMAW welding

ISO 14172 E Ni 6182/AWS A5.11 ENiCrFe-3 (e.g. Exaton Ni71)

Datasheet last updated 5/9/2025 6:38:12 AM (supersedes all previous editions)

Disclaimer:

Recommendations are for guidance only, and the suitability of a material for a specific application can be confirmed only when we know the actual service conditions. Continuous development may necessitate changes in technical data without notice. This datasheet is only valid for Alleima materials.