Aluchrom YHf

Material Data Sheet No. 8003
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Ferritic chromium steel

A company of Krupp Thyssen Stainless

Krupp VDM

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Aluchrom YHf

Aluchrom YHf is an aluminium-containing ferritic chromium steel alloyed with yttrium and hafnium. Due to the high contents of aluminium and chromium in combination with yttrium and hafnium the alloy possesses good high temperature stability.

Characteristic features of Aluchrom are:

- good oxidation resistance under isothermal and cyclic conditions
- good high-temperature strength

Approval for pressure vessels with service temperatures up to 1650 °F (899 °C) according to ASME code case 2359 and up to 1150 °C (2102 °F) according to VdTÜV Werkstoffblatt (material data sheet) 540 has been granted.

Designations and standards*

Country National standards	Material designation	Specification Chemical composition	Strip thickness
D	(W.-Nr. 1.4767) (CrAl 20 5)	Table 2	0.02 – 1.0 mm
DIN		(17470)	

*Designations & standards in brackets signify that Krupp VDM's data does not conform in all respects.

Table 1 – Designations and standards

Chemical composition

	Ni	Cr	Fe	C	Mn	Si	Al	Zr	P	Hf	N
min	–	19.0	bal.	–	–	–	5.5	–	–	–	–
max	0.30	21.0		0.05	0.50	0.50	6.0*	0.07	0.1	0.1	0.01

*Higher aluminium contents for special applications are available subject to special enquiry

Table 2 – Chemical composition (wt.-%)

Physical properties

Density	7.16 g/cm³	0.258 lb/in.³
Melting point	approx. 1500 °C	approx. 2730 °F

Temperature (T)		Electrical resistivity		Thermal conductivity		Specific heat		Coefficient of thermal expansion between room temperature and T	
°C	°F	μ Ω cm	Ω circ mil / ft	W / m K	Btu in. / ft² h °F	J / kg K	Btu / lb °F	10^{-6} / K	10^{-6} / °F
30	86	140	842	9.8	68.0	490	0.117		
100	212	140	842	10.9	75.6			12.2	6.7
200	392	141	848	12.4	86.0			12.4	6.9
300	572	141	848	13.9	96.4			12.6	7.0
400	752	141	848	15.5	107.5	640	0.152	12.9	7.1
500	932	142	854	16.9	117.2			13.3	7.4
600	1112	144	866	18.2	126.2			13.6	7.5
700	1292	145	872	19.7	136.6			13.8	7.6
800	1472	145	872	21.1	146.3			14.3	7.9
900	1652	146	878	22.5	156.0			14.8	8.2
1000	1832					670	0.159		

Table 3 – Typical physical properties at room and elevated temperatures.

Mechanical properties

The following properties are applicable to Aluchrom YHf in the soft annealed condition.

Temperature, T		Yield strength, $R_{p0.2}$		Tensile strength, R_m		Elongation, A_5
°C	°F	N/mm²	ksi	N/mm²	ksi	%
20	68	510	74.0	650	94.3	15
600	1112	185	26.8	190	27.6	75
800	1472	55	8.0	60	8.7	80
1000	1832	25	3.6	30	4.4	25

Table 4 – Typical short-time properties of Aluchrom YHf in the soft annealed condition.

Aluchrom YHf

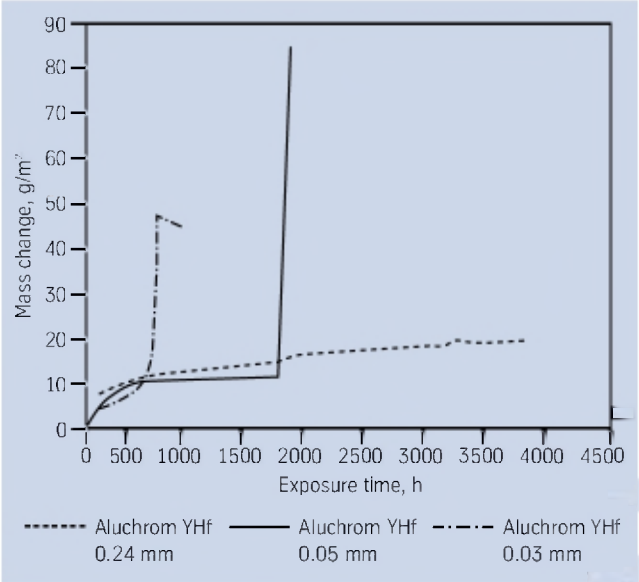

Fig. 1 – High temperature oxidation resistance of Aluchrome YHf strip in various thicknesses at 1100 °C (2012 °F) using 100 h cycles.

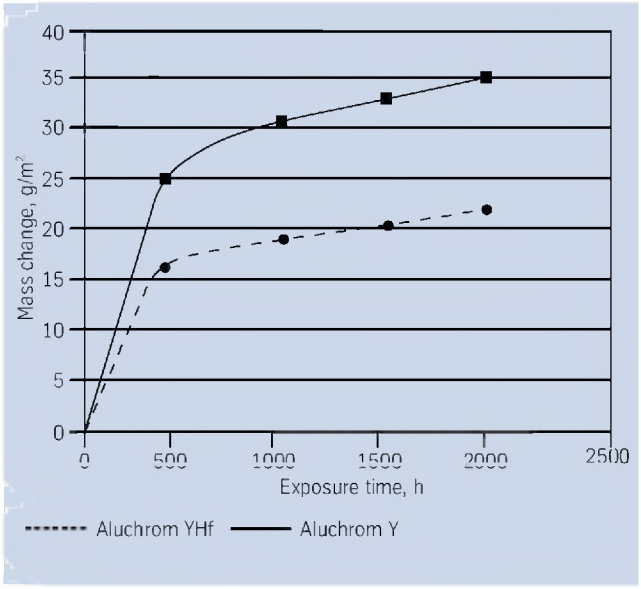

Fig. 2 – Comparison of high temperature oxidation resistance of Aluchrome Y with Aluchrome YHf at 1200 °C (2192 °F) using 100 h cycles.

Metallurgical structure

Aluchrome YHf has a body-centered-cubic structure.

High temperature corrosion resistance

Aluchrom YHf is a ferritic chromium steel with additions of more than 5% aluminium and up to 0.1 % yttrium and hafnium respectively.

The high aluminium content in combination with precisely adjusted additions of yttrium and hafnium permit applications under severe conditions up to 1200 °C. The reason for this is a well adhering Al_2O_3-layer.

Applications

Aluchrome YHf is used mainly as a metallic substrate for automotive catalytic converters in the automotive industry and as heating elements for hot plates.

It has also found application as heating shields in gas burners.

Fabrication and heat treatment

Aluchrome YHf can readily be hot- and cold-worked and machined.

Heating

Workpieces must be clean and free from all kinds of contaminants before and during heat treatment.

The quality of Aluchrome YHf may be impaired if heated in the presence of contaminants such as sulphur, phosphorus, lead and other low-melting-point metals. Sources of such contaminants include marking and temperature-indicating paints and crayons, lubricating grease, fluids, and fuels.

Fuels must be as low in sulphur as possible. Natural gas should contain less than 0.1 wt.-% sulphur. Fuel oils with a sulphur content not exceeding 0.5 wt.-% are suitable.

Though electric furnaces are desirable due to their close control of temperature and freedom from contamination, gas-fired furnaces are acceptable if contaminants are kept at low levels.

The furnace atmosphere should be neutral to slightly oxidizing and must not fluctuate between oxidizing and reducing. Direct flame impingement on the metal must be avoided.

Hot working

Aluchrome YHf should be hot-worked in the temperature range 1050 to 850 °C (1920 to 1560 °F), followed by water quenching or rapid air cooling.

Heat treatment after hot working is recommended in order to achieve optimum properties. For heating up, workpieces should be charged into the furnace at temperature.

Hot bending is preferably carried out at 200 to 300 °C (390 to 570 °F).

Cold working
The material should be in the soft annealed condition. Interstage annealing may be necessary with high degrees of cold forming.

Oxidized sheet can also be bent and cold worked. The inside bending diameter should be at least three times the sheet thickness.

Heat treatment
Soft annealing of Aluchrome YHf should be carried out at temperatures above 800 °C (1470 °F). For optimum properties the material should be water quenched after annealing. Thin strip can also be cooled by means of forced air.

For any thermal treatment operation the precautions concerning cleanliness mentioned earlier under 'Heating' must be observed.

Descaling
High-temperature alloys develop a protective oxide layer in service. Pre-oxidation in air can produce increased corrosion resistance at high temperatures. Therefore based on the end use the necessity of descaling should be checked.

Oxides of Aluchrome YHf and discoloration adjacent to welds are more adherent than on stainless steels. If descaling is required, grinding with very fine abrasive belts or wheels is recommended. Care should be taken to prevent tarnishing.

Machining
Aluchrome YHf should preferably be machined in the thermally treated condition.

Operating parameters generally employed when machining ferritic chromium steels are also applicable to Aluchrome YHf.

Welding
Aluchrome YHf can be welded by the GTAW process. For welding the material should be in the soft annealed condition and be free from scale, grease and markings. Maximum cleanliness and avoidance of draughts during welding are paramount.

An area approx. 25 mm (1 inch) in width on both sides of the weld seam must be ground metallically clean prior to welding. Cleaning of the base metal in the weld area (both sides) and of the filler metal, if necessary, should be carried out with ACETONE.

Trichlorethylene (TRI), perchlorethylene (PER) and carbon tetrachloride (TETRA) must not be used.

Care should be taken that the work is performed with a deliberately chosen, low heat input and with rapid dissipation of the heat generated during welding. Brushing with a stainless steel wire brush immediately after welding, i.e., while the metal is still hot generally results in removal of heat tint and produces the desired surface condition.
Interpass temperature should be kept below 120 °C (250 °F).

Neither pre- nor postweld thermal treatments are required.

The welding parameters should be monitored as a matter of principle.

The heat input Q may be calculated as follows:

$$Q = \frac{U \times I \times 60}{v \times 1000} \text{ (kJ/cm)}$$

U = arc voltage, volts
I = welding current, amps
v = welding speed, cm/min.

Aluchrom YHf

Availability

Aluchrom YHf is available in the product form strip:

Strip[1]
Conditions:
cold rolled hard;
cold rolled and bright annealed

Thickness[2] mm	Width[2] mm	Coil I.D. mm			
0.02 – ≤ 0.10	30 – 120	100	300		
> 0.10 – ≤ 0.20	4 – 200		300	400	
> 0.20 – ≤ 0.25	4 – 400			400	
> 0.25 – ≤ 0.60	6 – 700			400	
> 0.60 – ≤ 1.0	8 – 700			400	500

inches	inches	inches			
0.0008 – ≤ 0.004	1.18 – 4.75	4	12		
> 0.004 – ≤ 0.008	0.16 – 8		12	16	
> 0.008 – ≤ 0.010	0.16 – 16			16	
> 0.010 – ≤ 0.024	0.20 – 27.6			16	
> 0.024 – ≤ 0.040	0.32 – 27.6			16	20

[1] cut-to-length available in lengths from 500 to 4000 mm (20 to 158 in.)
[2] Other sizes subject to special enquiry

Technical publications

The following publications concerning Aluchrome YHf may be obtained from Krupp VDM GmbH:

J. Kloewer, A. Kolb-Telieps, U. Heubner, M. Brede
Effects of alloying elements and foil dimensions on the life time of thin Fe-Cr-Al foils in catalytic converters.
Nace paper 746, San Diego 1998

J. Kloewer, A. Kolb-Telieps, B. Brede
Effect of aluminium and reactive elements on the oxidation behaviour of thin Fe-Cr-Al foils.
Int. Conference MACC '97, Wuppertal 1997

A. Kolb-Telieps, J. Kloewer, A. Heesemann, F. Faupel
High temperature corrosion resistant Fe-Cr-Al foils.
HTCP Conference 2000, Hokkaido

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