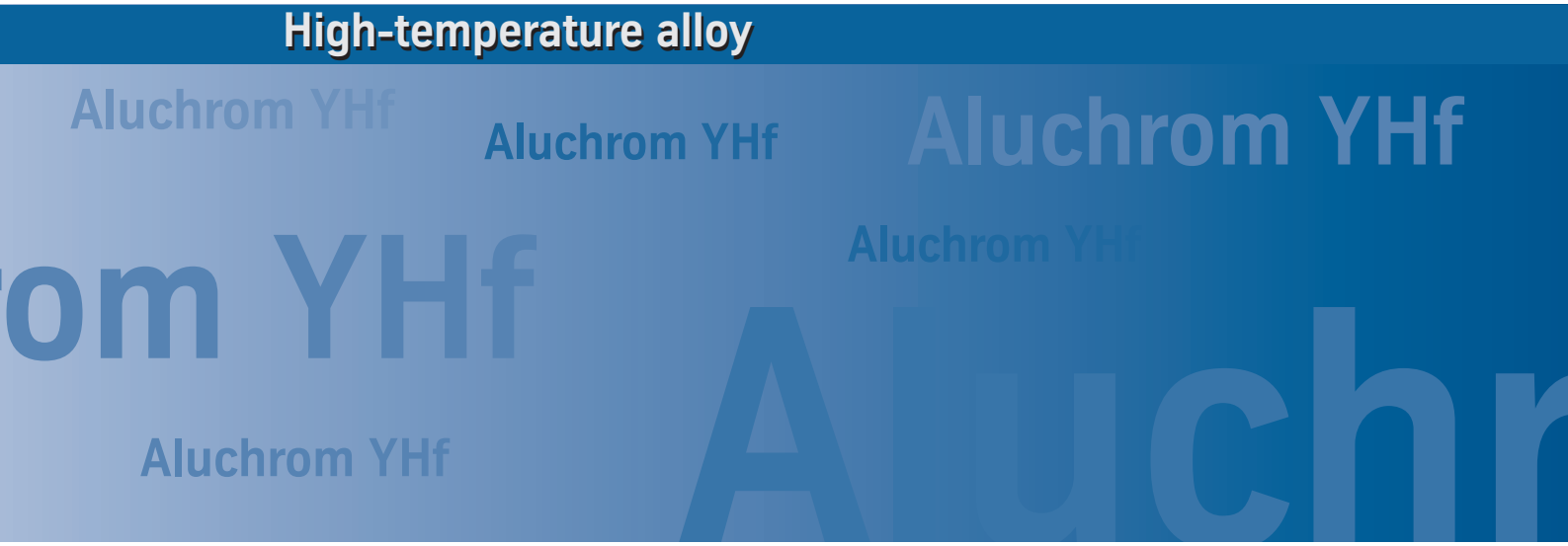
Aluchrom YHf

Material Data Sheet No. 4049
March 2008 Edition

High-temperature alloy



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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.

Aluchrom YHf is characterized by:

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

Designations and standards*

Country National standards	Material designation	Specification		
		Chemical composition	Strip	Wire
D DIN	**(W.-Nr. 1.4767)** (X8CrAl20-5)	(17470)		(17470)
*Designations & standards in brackets signify that ThyssenKrupp VDM's data does not conform in all respects.				

Table 1 – Designations and standards.

Chemical composition

	Ni	Cr	Fe	C	Mn	Si	Al	Zr	Y	Hf	N
min.	–	19.0	bal.	–	–	–	5.5	–	–	–	–
max.	0.30	22.0		0.05	0.50	0.50	6.5	0.07	0.10	0.10	0.01

Table 2 – Chemical composition (wt.-%).

Physical properties

Density	7.16 g/cm^3	0.258 lb/in.^{3}
Melting temperature	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	μΩ · cm	Ω · circ mil / ft	W / m · K	Btu · in. / ft^2 · 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		0.2 % Yield strength, $R_{p0.2}$		Tensile strength, R_m		Elongation, A_5
°C	°F	MPa	ksi	MPa	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 – Minimum short-time properties in the soft annealed condition.

Aluchrom YHf

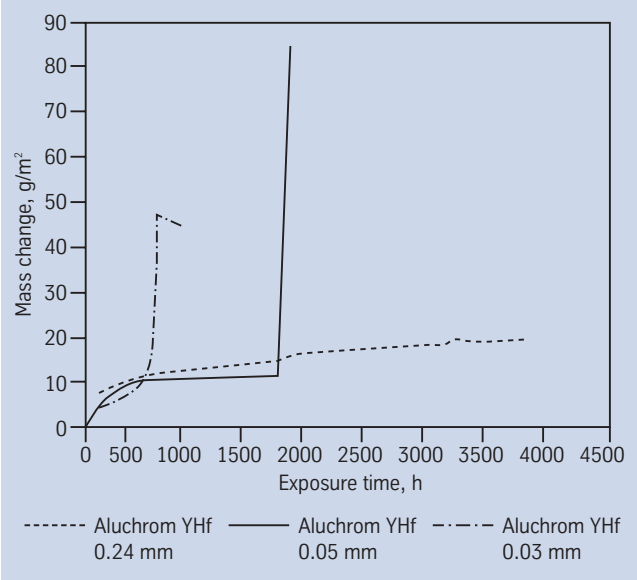

Fig. 1 – High temperature oxidation resistance of Aluchrom YHf strip in various thicknesses at 1100 °C (2012 °F) using 100 h cycles.

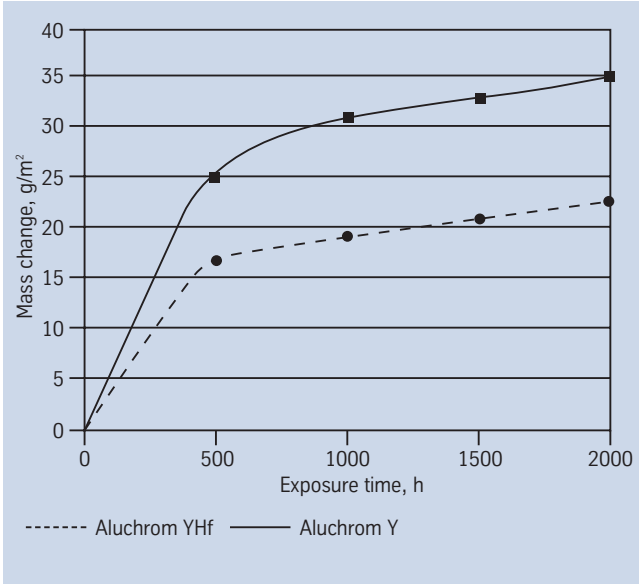

Fig. 2 – Comparison of high temperature oxidation resistance of Aluchrom Y with Aluchrom YHf at 1200 °C (2192 °F) using 100 h cycles.

Metallurgical structure
Aluchrom YHf has a ferritic body-centered-cubic structure.

The alloy is subject to cold brittleness after use at temperatures exceeding 1000 °C (1832 °F). Cold brittleness is also possible after use at temperatures between 400 and 550 °C (752 – 1022 °F).

The alloy is magnetic.

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. This is made possible by a well adhering Al_2O_3-layer.

High temperature oxidation behaviour of Aluchrom YHf is shown in Figures 1 and 2.

Applications
Aluchrom 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
Aluchrom 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.

Aluchrom YHf may become impaired if heated in the presence of contaminants such as sulfur, 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 sulfur as possible. Natural gas should contain less than 0.1 wt.-% sulfur. Fuel oils with a sulfur content not exceeding 0.5 wt.-% are suitable.

Due to their close control of temperature and freedom from contamination, thermal treatments in electric furnaces under vacuum or an inert gas atmosphere are to be preferred. Treatments in an air atmosphere and alternatively in gas-fired furnaces are acceptable though, if contaminants are at low levels so that a neutral or slightly oxidizing furnace atmosphere is attained. A furnace atmosphere fluctuating between oxidizing and reducing must be avoided as well as direct flame impingement on the metal.

Hot working
Aluchrom 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 to achieve optimum properties. For heating up, workpieces should be charged into the furnace at maximum working 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 Aluchrom 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 the material should be charged into the furnace at maximum annealing temperature observing the precautions concerning cleanliness mentioned earlier under **'Heating'**.

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

Before pickling, which may be performed in a nitric/hydrofluoric acid mixture, the surface oxide layer must be broken up by abrasive blasting, by carefully performed grinding or by pretreatment in a fused salt bath. Particular attention must be paid to the pickling time and temperature.

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

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

Welding
Though welding Aluchrom YHf is not recommended it 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.

Cleaning
Cleaning of the base metal in the weld area (both sides) and of the filler metal (e.g. welding rod) should be carried out with ACETONE.

Trichlorethylene (TRI), perchlorethylene (PER), and carbon tetrachloride (TETRA) must not be used as they are detrimental to health.

Welding parameters and influences (heat input)
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.

Interpass temperature should be kept below 120 °C (250 °F).

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.

Consultation with ThyssenKrupp VDM's Welding Laboratory is recommended.

Postweld treatment
(brushing, pickling and thermal treatments)

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 without additional pickling.

Pickling, if required or prescribed, however, would generally be the last operation performed on the weldment. Also refer to the information under **'Descaling and pickling'**.

Neither pre- nor postweld thermal treatments are normally required.

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	4 – 120	100	300	400	
> 0.10 – ≤ 0.20	4 – 200		300	400	
> 0.20 – ≤ 0.25	4 – 400		300	400	
> 0.25 – ≤ 0.60	6 – 700		300	400	
> 0.60 – ≤ 1.0	8 – 700			400	500

inches	inches	inches			
0.0008 – ≤ 0.004	0.16 – 4.75	4	12	16	
> 0.004 – ≤ 0.008	0.16 – 8		12	16	
> 0.008 – ≤ 0.010	0.16 – 16		12	16	
> 0.010 – ≤ 0.024	0.20 – 27.6		12	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 Aluchrom YHf may be obtained from ThyssenKrupp VDM GmbH or can be downloaded from www.thyssenkruppvdm.com:

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.
CORROSION 1998, Paper No. 746,
NACE International, 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, Japan.

March 2008 Edition.

This edition supersedes material data sheet no. 8003, dated November 2001.

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