GENERAL INFORMATION

Cold-drawn wire from alloy Fechroma®23 is intended for elements of resistance and heaters. This alloy perfectly combines high electrical resistance and the low temperature coefficient of electric resistance (TCER), a high stain responsiveness, good ductility and excellent heat resistance.

Alloy has a very high maximal working temperature (up to 1350°C) and it is 2-4 times more durable in comparison with nichrome at operation at high temperatures (1000-1350°C) in commonly occurring oxidizing, sulfur-containing and other environments. Alloy possesses stable TCER that allows to keep fixated heating systems temperature.

The newest manufacturing techniques of fechral Fechroma®23 provide uniform structure, uniformity of protective oxidic layer and high adhesion of this layer to a surface. In a combination with decrease of carbon level <0,03%, the high wire ductility, lack of tendency to intercrystalline high-temperature corrosion, high creep strength and also resistance against oxidation, sulfidization and carburizing at increased temperatures are guaranteed. High resistance to oxidation and corrosion in the most widespread industrial oxidizing, sulfur-containing, etc. hostile environment, is caused by the nature of chemically inert, dense superficial protective layer on a basis Al_2O_3.

Classification	
DIN	1.4765 (CrAl 25 5)
UNS	K 92500

* closest specification

Chemical composition, %			
Cr	**Fe**	**Al**	**C**
22.0-24.0	rest	5.5-6.0	≤0.10
Mn	**Si**	**Ni**	**S**
≤0.50	≤0.50	0.30	≤0.015

Mechanical properties at 20°C

Diameter, mm	Elongation,% not less	Tensile strength, MPa
0,12 – 0,5	10	
0,5 – 1,00	10	637-784
1,0 – 12,0	12	

Short-term mechanical properties of strip Fechroma®23 with thickness up to 2 mm after soft annealing

Temperature (T)		Yield strength, $\sigma_{0,2}$	Yield strength, $\sigma_{0,1}$	Tensile strength, $\sigma_в$	Elongation, δ_{50}
°C	°F	N/mm²	N/mm²	N/mm²	%
20	68	485-550	510-610	660-760	16-23

PHYSICAL PROPERTIES

Temperature, °C	Resistance μΩm	Exten. 10^{-6}/K
20	1,37	-
200	1,38	11,0
400	1,39	12,0
500	1,41	-
600	1,42	13,0
800	1,44	14,0
1000	1,45	15,0
1200	1,45	-

CREEP CHARACTERISTICS

Temperature, °C	Creep resistance, 10^{-6}/K
600	40
800	15
1000	6
1200	1

PROCESSING PROPERTIES

Melting point	1500°C
Density	7,1 g/cm³
Heat conductivity	46,1 W/m·K
Elastic modulus	210 KN/mm²
Maximal work temperature	1270°C
Operating time	3500 hours

DELIVERY CONDITION

Fechroma®23 is delivered in shapes of wire and strip

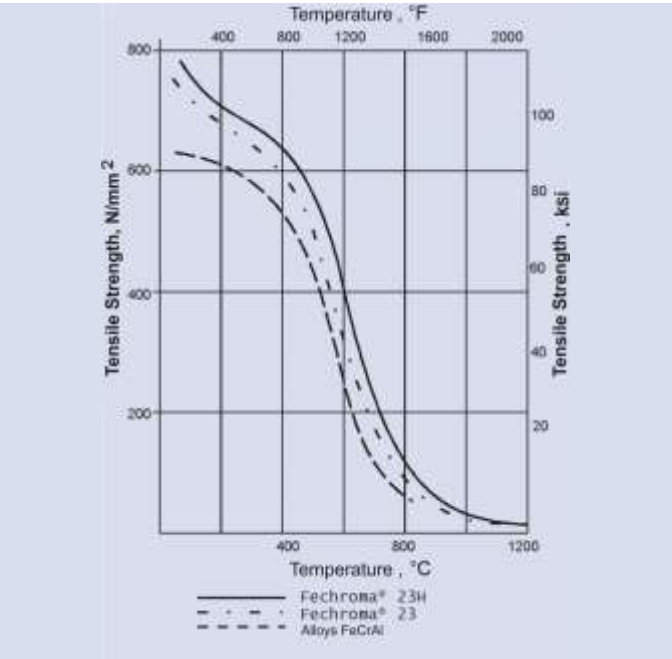
Cold-rolled wire from alloy of grade Fechroma®23 produce in soft heat-treated (HT) conditions with diameters 0,1-10 mm according standard DIN17470. Diameter tolerance of wire is ±0,1 mm, and wire ovality is within half of diameter tolerance limit.

Strip*

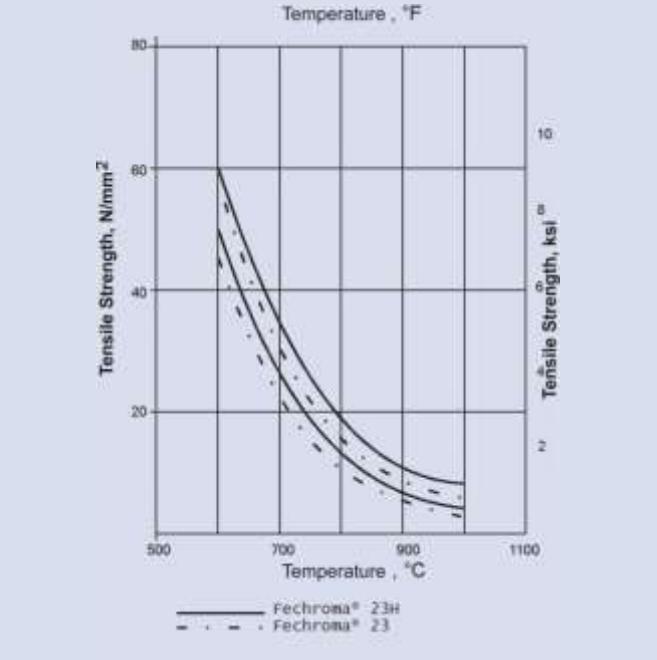
Delivery condition:

Cold-rolled oxidized with bright annealing or oxidized.

Thickness, mm	Width, mm	Coils with inner Ø, mm				
0,04 ≤ 0,10	30-120	100	300			
>0,10 ≤ 0,20	4-200		300	400		
>0,20 ≤ 0,25	4-400		300	400		
>0,25 ≤ 0,60	5-635		300	400		
>0,60 ≤ 1,0	8-635			400	500	
>1,0 ≤ 2,0	15-635			400	500	600



Pic.1 – Comparison of typical tensile strengths depending on temperature.

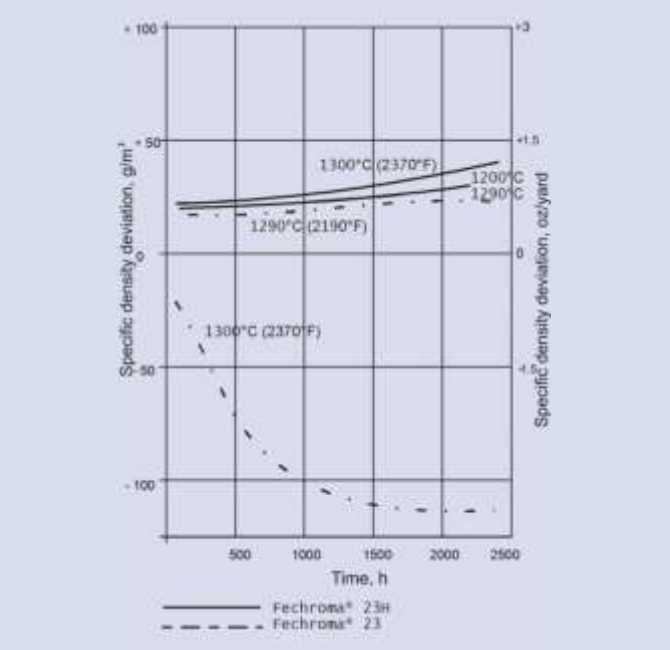


Pic.2 – Comparison of typical indicators of creep-rupture strength (10^3 and 10^4 hour)

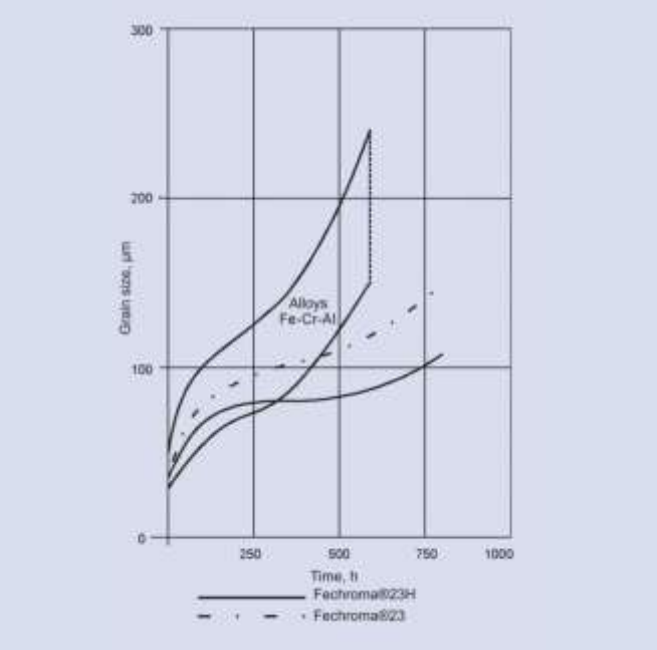
Metallurgical structure
Alloy Fechroma®23 has body-centered cubic lattice

Corrosion resistance
Alloy Fechroma®23 – is heat resisting alloy on iron basis with addition about 5% on the mass of aluminum

Resistance to oxidation allows to apply products from Fechroma®23 at temperatures up to 1300°C. Even under extreme conditions, such as cyclic heating and cooling, quality of Fechroma®23 remains due to an oxide layer of aluminum.



Pic. 3 – Change of specific weight depending on temperature at cyclic testing on air.



Pic. 4 – Growth of grain at Fechroma®23 and Fechroma®15 in comparison with common FeCrAl alloys at 1050°C

TYPICAL APPLICATION

Fechroma®23 alloy application ranges as electric heating elements of the thermal equipment are caused, first of all, by very high admissible operation temperatures as well in commonly occurring industrial sulfur-containing (sulfur vapour, H_2S, SO_2, etc.), oxidizing etc. environments. Foreign fechrals, which is among and fechral grade Fechroma®23, have more high maximal work temperature and are much more durable in comparison with nichrome and ferronichrome in oxidizing, sulfur-containing etc. environments. Besides, fechral possess stabler temperature coefficient of electric resistance that allows to maintain heating temperature more precise.

PROCESSING AND THERMAL PROCESSING

Fechroma® 23 can be easily processed by usual industrial technologies. The processed products have to be cleaned and not contain any impurity both before and during heat treatment.

Sulfur, phosphorus, lead and other metals with a low temperature of melting at heat treatment of Fechroma®23 can cause damages. Marking and thermometric paints and pencils, lubricants, liquids and combustible materials can be a source of similar impurity. Fuel has to contain as little sulfur as possible. Natural gas has to contain no more than 0,1% on the mass of sulfur, and the content of sulfur in liquid fuel has to be not higher than 0,5% on weight.

Carrying out heat treatment in electric furnaces is recommended (in a vacuum or inert gas) since in this case it is possible to provide exact control of parameters of temperature and to guarantee lack of impurity.

Gas furnaces are also acceptable, on condition of the low content of impurity and establishment of the atmosphere of the furnace neutral or slightly oxidizing. It is necessary to avoid fluctuation of furnace atmosphere between oxidizing and recovery and also to avoid direct impact of a flame on metal.

HOT DEFORMATION

Fechroma®23 has to be exposed to hot deformation in the range of temperatures 1050-850°C (1920-1560°F) with further cooling in water or on air, and passing of a temperature interval of 560-400°C (1040-750°F) has to be carried out fast.

Thermal bend is preferable to carry out at a temperature 200-300°C. Top temperature 400-750°C (390-570 °F) should be avoided.

COLD DEFORMATION

At essential deformations intermediate annealings are necessary.

After cold drafting deformation at the level of 30% of a product, it is demanded to repeat soft annealing.

Fechroma® 23 alloy are widely used for production of heating elements of furnaces and devices of extensive heating of hardening shops of the industrial enterprises, food and other productions. In particular, it's intended for stress relieving, annealing, normalization, hardening and other thermal operations, electric chamber and shaft furnaces, bell-type furnaces for annealing of wires and strips, vacuum furnaces and externally-heated tank furnaces, electric rotary, drum, belt etc. furnaces heat up with heating elements made, as a rule, from the fechral alloys.

Industrial chamber furnaces are manufactured on the basis of refractoriness from lightweight fibrous refractory materials that in a complex with heaters from Fechroma® 23 allow, in comparison with furnaces on the basis of brick refractoriness with heaters from nichrome, to reduce warm-up period and also considerably reduce electricity consumption and operational expenses.

HEAT TREATMENT

Thermal treatment is carried out at temperature 760-900°C (1400-1680°F), preferred temperature 800°C (1470 ° F).

Hardening in water is necessary for obtaining optimum properties. At the small sizes of a product it is possible to carry out the accelerated cooling on air.

When carrying out any heat treatment, it is necessary to observe the requirements to purity of a product specified earlier.

SCALE REMOVAL

Heat resisting materials create in use protective oxide layers. Thus need of removal of scale has to be coordinated.

Fechroma®23 scales keep stronger, than at stainless steel. If scale removal is obligatory, then grinding is recommended by a fine-grained tape, with a grinding wheel.

MACHINING

Fechroma®23 has to be exposed to machining in a non-oxide condition.

WELDING

Fechroma®23 it can be welded by SMAW technology.

For material could be welded, it has to be in the annealed condition and cleaned from scale, fat and marking. The zone in radius of 25 mm on both sides of a seam is grinded to metal gloss. In many cases annealing colors can be removed with brushes so far material is in a warm condition. During welding an indispensable condition is high degree of purity.

Both the low supply of heat, and accelerated heat removal is necessary. Intermediate temperature shouldn't exceed 150°C.

Preliminary and subsequent heat treatments aren't carried out.

It is desirable to use auxiliary materials, which corresponds to welding.

Temperature		Specific heat		Heat conductivity		Electrical resistance		Expansion coefficient from 20°C to T		Creep characteristics
°C	°F	J/kg K	Btu/lb °F	W/m·K	$\frac{\text{Btu In.}}{\text{Ft h °F}}$	μΩcm	$\frac{\Omega\text{circ mil}}{\text{ft}}$	10^{-6}/K	10^{-4}/°F	10^{-6}/K
0	32									
20	68	465		46.1		1.35				
93	200									
100	212					1.35		11.5		
200	392					1.36		11.9		
204	400									
300	572					1.37		12.1		
316	600									
400	752					1.38		12.3		
427	800									
500	932					1.40		12.6		
538	1000									
600	1112					1.43		13.0		40
649	1200									
700	1292					1.44		13.5		
760	1400									
800	1472					1.44		13.8		15
871	1600									
900	1653					1.45		14.2		
982	1800									
1000	1832					1.45		14.8		6
1093	2000									
1100	2012	630				1.46		15.5		
1148	2100									
1200	2192					1.46				
1204	2200									
1260	2300									
1300	2372					1.46				
1316	2400									