Cromax® induction-hardened hard-chrome-plated bar

Cromax® IH 482

General information

Induction-hardened Cromax IH 482 is based upon a medium-carbon, micro-alloyed steel which is characterised by high yield and tensile strength in the as-rolled condition, i.e. without the necessity for heat treatment. The 482 base steel is thereby a cost-effective alternative to traditional low-alloy quenched and tempered grades with, for application as piston rods, equivalent properties.

The analysis of the base steel in Cromax IH 482 is well adapted to induction hardening and a high and uniform hardness is achieved throughout the case irrespective of diameter. In consequence, the resistance to even high-energy external impact is excellent.

Typical chemical analysis of steel 482

C%	Si%	Mn%	P%	S%	V%	CEV % (*)
0.39	0.40	1.20	0.020 max	0.020	0.13	0.72 max

** CEV = %C + %Mn/6 + (%Cu + %Ni)/15 + (%Cr + %Mo + %V)/5*

Corresponding international standards

The closest equivalent steel grades in some selected international standards for the base steel in Cromax IH 482 are tabulated below. Note that in some instances, the correspondence is only approximate.

Ovako	EN 10267	DIN (*)	SS (*)	AFNOR (*)	BS 970-1 (*)	ASTM A920/920M	JIS G 4053
482	38MnVS6 1.1303	38MnV6	–	38MV6	280M01 Grade T	Grade 15V41	SMn 438 (+V)

** These standards are discontinued.*

Mechanical properties (§)

Diameter, mm	Yield stress, $R_{p0.2}$, MPa	Ultimate tensile stress, R_m, MPa	Elongation (#), $A_{5.65}$, %	Hardness, HB	Impact toughness (≠), ISO-V, Joule
20–140	580 min.	850–1 000	14 min.	250–300	10–20 @ 20°C

§ Applies to the base steel beneath the induction-hardened layer and to the finished chrome-plated condition.
 # In longitudinal direction.
≠ Typical range from testing in longitudinal direction, values not guaranteed.

Chrome layer

The chrome-layer thickness is more than 20 µm.

Surface roughness

The surface roughness (Ra) is always less than 0.2 µm and normally between 0.05–0.10 µm. Rt (ISO) is always less than 2.0 µm and normally in the range 0.5–1.0 µm.

Hardness of chrome layer
The chrome layer has a minimum hardness of 850 HV0.1. The hardness in the induction hardened zone immediately beneath the chrome layer is min 55 HRC min and normally in the range 59–62 HRC.

The depth of hardening, which is defined as the distance from steel/chrome interface at which the hardness has dropped to 400 HV5, is 1.0–2.3 mm and depends on diameter as tabulated below:

Diameter, mm	Hardening depth, mm
⩽ 28	1.0–1.5
> 28–40	1.3–1.7
> 40	1.7–2.3

Other hardening depths can be supplied upon request.

Straightness
The maximum height of arc over a length of 1 m is 0.2 mm.

Diameter tolerance
Tolerance f7 as defined in ISO 286-2 is standard. Other tolerances can be supplied upon request but the narrowest range is ISO level 7.

Out of roundness
Out of roundness or ovality is at most 50% of the diameter tolerance interval. For example, the diameter of a bar with nominal dimension 40 mm and tolerance f7 lies between 39.950 and 39.975 mm. The tolerance range is therefore 0.025 mm and the maximum out of roundness is 50% of this or 0.0125 mm.

Dimensions available

Diameter, mm	kg/m	Diameter, mm	kg/m	Diameter, mm	kg/m
20	2.47	50	15.41	90	49.94
22	2.98	55	18.65	95	55.64
25	3.85	56	19.33		
28	4.83			100	61.65
		60	22.19	110	74.60
30	5.55	63	24.47	115	81.53
32	6.31	65	26.05	120	88.78
35	7.55			125	96.33
36	7.99	70	30.21		
38	8.90	75	34.68	130	104.19
				140	120.83
40	9.86	80	39.46		
42	10.88	85	44.54		
45	12.48				

Other metric sizes can be supplied upon request but not outside the above range. A limited number of imperial dimensions are also manufactured on a regular basis.

Bar lengths

Stock standard length for bar diameters 25 mm and upwards is 6.1 m with a length tolerance -0/+100 mm. Lengths shorter or longer than standard can be manufactured upon request. However, the maximum length capability is 7.6 m.

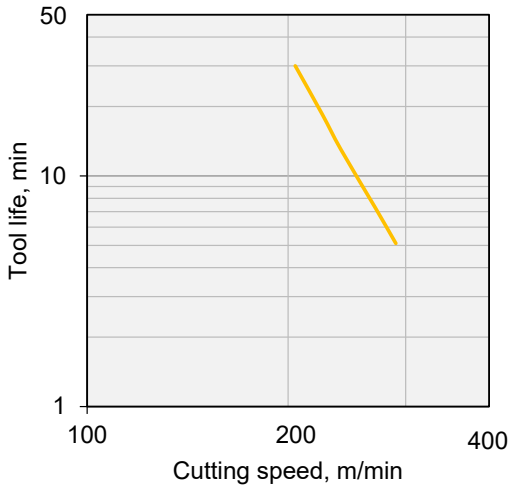
Bar lengths for diameters smaller than 25 mm are as follows:
20 mm: 5.0 m,
22 mm: 5.5 m,
with length tolerance -0/+100 mm in both cases.

The necessity for electrical contact during plating means that tolerances and chrome-layer properties cannot be guaranteed over a length of 100 - 150 mm at each end of the bar. When working with full-length bars, this so-called "un-chromed portion" must be discarded or alternatively incorporated into a machined section in the finished product.

Appreciable cutting capacity is available for supply of cut-to-length pieces with length tolerance -0/+2 mm irrespective of diameter.

Machining

A Taylor diagram for turning of the base steel in Cromax IH 482 is shown below.



Test details:
Tool: coated carbide Sandvik SNMG 120408 PM–4015
Feed: 0.4 mm/rev.
Cut depth: 2 mm
Cutting fluid: Peralube 0125 5%
Wear criterion: 0.4 mm flank wear

V_{15}-value = 234 m/min

The following table indicates specific machining recommendations for turning and threading of Cromax IH 482 once the induction-hardened layer has been removed (see below).

Operation	Rough turning	Fine turning	Threading
Tool (coated)	ISO P15–P30	ISO P10–P15 or cermet	ISO P20–P30
Depth of cut, mm	2–5	0.2–2	6-8 passes for pitch 2 mm
Feed, mm/rev.	0.3–0.6	0.05–0.3	–
Speed, m/min	180–230	230–280	120–150
Cutting fluid?	Yes	Carbide: yes Cermet: no	Yes

Removal of the induction-hardened layer by turning

Best results are obtained with mixed ceramic inserts. However, low-speed turning with a coated cemented carbide insert having high wear resistance is perfectly feasible. Recommended data for both options are tabulated below.

Tool	Speed, m/min	Feed, mm/rev.	Cut depth, mm
Mixed ceramic, dry machining	120–140	0.08	2–3
Cemented carbide with cutting fluid	40–45	0.2	2–3

For further information, please ask for Ovako Cromax Technical Report on "Machinability testing of induction-hardened piston-rod material".

Welding

Cromax IH 482 can be fusion welded using any of the conventional methods. However, the carbon equivalent of the base steel is quite high, 0.72% max, and preheating to 200–300°C (depending on heat input) is strongly recommended for all dimensions. The upper limit should, however, not be exceeded because of risk for impairment of corrosion resistance. MAG-welding (SMAW) is to be preferred with an appropriate active shielding gas such as M21 (approx. 80% argon, 20% carbon dioxide).

Some suitable consumables for various fusion-welding processes are tabulated below:

Welding process	EN ISO (*)	ESAB	Elga	Böhler Welding
MMA	18275-A; E55 4 MnMo B 3 2 H5	OK 74.78	P 65MR	Fox EV 63
MAG	14341-A; G 50 4 M21 4Mo	OK Aristorod 13.08	Elgamatic 135	Union MV 70 Union NiMoCr
MCAW	17632-A; T 50 2 Z M M21 2 H10	OK Tubrod 14.02	Megafil 740 B	Union TG 55 Ni

* *EN ISO classifications given apply to ESAB products. Some of the products listed from other consumable suppliers are not exactly equivalent but will also give welds with satisfactory mechanical properties.*

For applications where such is deemed necessary, Cromax IH 482 can be friction welded with good results.

Corrosion resistance

The chromium layer on Ovako's Cromax products is characterised by a controlled micro-crack distribution with high crack density. This combined with adapted finishing processes provides for a superior level of corrosion resistance. Specifications for corrosion resistance of hard-chrome-plated products are usually based upon salt-spray testing following procedures given in ISO 9227 or equivalent standards (see below), combined with evaluation as stipulated in ISO 10289.

ISO 9227	DIN 50021	ASTM	JIS Z 2371	Salt-spray type
NSS	SS	B 117	NSS	Neutral
AASS	ESS	B 287	AASS	Acetic acid
CASS	CASS	B 368	CASS	Copper-accelerated acetic acid

The relevance of accelerated salt-spray testing for appraisal of the corrosion performance of piston rods in the field is a matter for conjecture. However, the above procedures are accepted and useful for quality control of chrome-plated products. The correlation between results obtained with the various salt-spray types is not always clear but our experience is that a given degree of corrosive attack is achieved about twice as fast in an AASS-test in comparison with testing in NSS.

Every batch of Cromax IH 482 is tested with 48-hours exposure in acetic-acid salt spray. The standard acceptance requirement is rating 9 or better. The corresponding exposure in neutral salt spray is 96 hours but the prolonged test time normally precludes control of each and every batch. Upon request, other corrosion-resistance requirements involving testing in AASS or in NSS can be met.

Cromax C and NiKrom®
For applications where piston rods are exposed to aggressive environments and/or remain extended for long periods of time, Ovako offers coatings with a corrosion performance which is superior even to the already high level offered by standard Cromax IH 482.

Cromax C is a product with a thicker layer of chrome which is plated in two steps. The coating normally comprises two chrome layers with thickness 20 + 20 µm and the acceptance level for corrosion resistance is rating 9 or better after 100 hours exposure in AASS. Apart from these features, Cromax IH 482 with C-execution has the same characteristics and properties as for standard Cromax IH 482 with a single layer of chrome.

In NiKrom execution, a standard chrome layer with minimum thickness 20 µm is combined with an underlying layer of nickel with minimum thickness 30 µm (NiKrom 500) or 10 µm (NiKrom 150). The nickel layer, which is comparatively soft and thereby defect-free, provides for outstanding performance when piston rods are exposed to aggressive environments. In AASS-testing, the acceptance criteria for NiKrom 500 and 150 are no attack (rating 10) after exposure for respectively 500 hours or 150 hours. In spite of the extended exposure times, every manufactured batch is tested to confirm its conformance to the stipulated high levels of corrosion resistance. The product NiKrom® is presented in more detail in a separate data sheet.

In NiKrom execution, a standard chrome layer with minimum thickness 20 µm is combined with an underlying layer of nickel with minimum thickness 30 µm (NiKrom 500) or 10 µm (NiKrom 150). The nickel layer, which is comparatively soft and thereby defect-free, provides for outstanding performance when piston rods are exposed to aggressive environments. In AASS-testing, the acceptance criteria for NiKrom 500 and 150 are no attack (rating 10) after exposure for respectively 500 hours or 150 hours. In spite of the extended exposure times, every manufactured batch is tested to confirm its conformance to the stipulated high levels of corrosion resistance. The product NiKrom® is presented in more detail in a separate data sheet.

Packaging
Suitable packaging is essential to conserve the fine finish of Cromax products and to prevent damage during transport and handling. Standard packing is in tough, durable plastic sleeves but the bars can if required be supplied packed in cardboard tubes. Additional packing protection, in wooden boxes or pallets for example, is dependent on the mode of transport and final destination of the order.

Cromax IH 482 is packed in yellow plastic sleeves which are marked with information permitting complete traceability (product name, dimension, heat number, manufacturing batch number etc) at regular intervals along the length of the bar.

Contact us
E-mail: info.cromax@ovako.com
Tel: +46 (0)8 622 1300
www.ovako.com/en/contact/