

This information is based on our present state of knowledge and is intended to provide general notes on our products and their uses. It should not therefore be construed as a warranty of specific properties of the products described or a warranty for fitness for a particular purpose.

Classified according to EU Directive 1999/45/EC
For further information see our "Material Safety Data Sheets".

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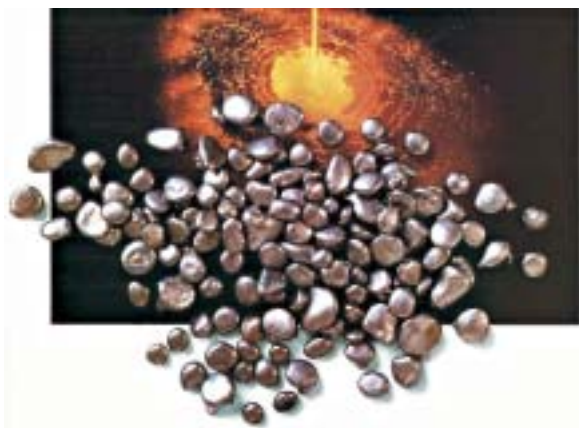
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General

Uddeholm Carmo Granshots is a foundry meltstock for production of cast tools and dies.

The use of Granshots means that no further metallurgy is needed in the foundry. After melting of the granules in a high frequency furnace the molten metal is ready for immediate casting without further processing.

Uddeholm Carmo Granshots is manufactured utilizing Uddeholm Technology's water granulation process. When the molten material has reached the granulation tank it is poured onto a refractory target and distributed as small droplets into a water bath. Thereafter the material is passed through dewatering, drying and surface deoxidation equipment.



Packaging

Granshots is supplied in new steel drums placed on pallets. There are two drum sizes, 112 l and 200 l (~450 kg and 800 kg). Steel grade, charge number and weight are specified on each drum.

Advantages with Granshots

- Reduced handling costs
- Reduced material consumption
- Reduced power consumption
- Exact and certified chemical analysis
- Consistent quality
- No charge for laboratory analyses
- High yield of charge material as well as castings
- Just-in-time supply
- High flexibility

Chemical composition

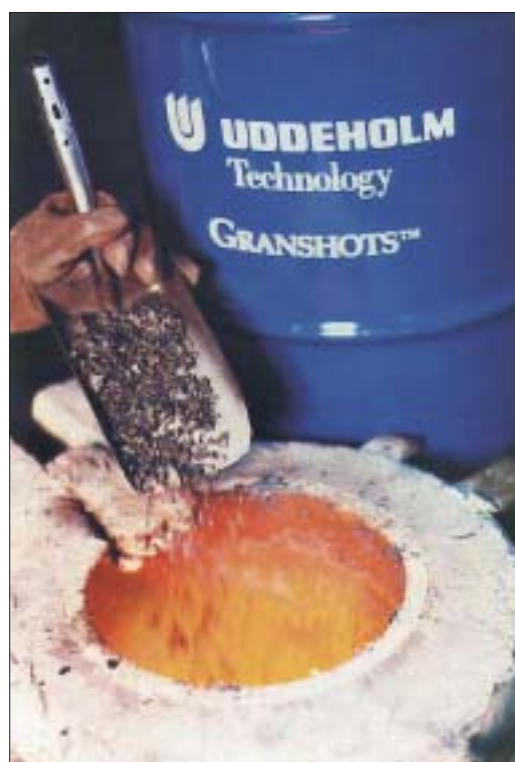
Typical analysis %	C	Si	Mn	Cr	Mo	V
	0,60	0,35	0,80	4,50	0,50	0,25
Delivery condition	Granules with a bulk density of 4 kg/l. Average size of granules 10–15 mm.					

Melting procedure

Granshots material can be charged directly into the furnace. The granules generally melt very quickly. When using a furnace with a lower capacity, the following procedures can be considered:

- Charge the granules into a hot furnace.
- Keep if possible a small part of the pour from the previous heat and charge the granules into.
- If no previous pour can be used it is beneficial to use some return scrap of larger size together with the granules.
- Make sure that there is no build up of a bridge/lid of solid material on the surface.
- Always keep a liquid "eye" open into which the granules is charged.

Melting of metal with a high melting point should be done with necessary care to avoid any risk of burns. Always make sure that the material is completely dry before it is charged into the furnace.



Applications

The chemical composition of Uddeholm Carmo Granshots corresponds to a cold work tool steel which has been developed together with the automotive industry. The chemical composition has been balanced to give an universal tool steel grade for car body dies. The steel can be used in flame-/induction hardened or through hardened condition for blanking and forming of both car body parts (thin sheet) or structural parts (thicker sheet).

It is possible to get a tool surface hardness of 58 ± 2 HRC by flame-/induction hardening without water cooling.

It is also easy to perform repair welding. Welding electrodes with the same composition as Uddeholm Carmo Granshots and wrought Uddeholm Carmo give a high degree of flexibility and facilitate tool maintenance procedures.

Heat treatment

After casting some type of heat treatment procedure is recommended. Depending of tool size and capacity of available facilities either soft annealing, normalizing or hardening and tempering may be performed.

If flame-/induction hardening of active cutting edges or forming parts is to be carried out, the most appropriate heat treatment procedure is normally prehardening to 250–300 HRC.



Automotive tool parts cast via polystyrene model and Uddeholm Carmo Granshots.

Soft annealing

Protect the steel and heat through to 860°C (1580°F), holding time 2h. Cool in furnace 20°C/h to 770°C (35°F/h to 1420°F), then 10°C/h to 650°C (18°F/h to 1200°F) and subsequently freely in air.

Hardening

For through hardening the following temperatures and times are recommended:

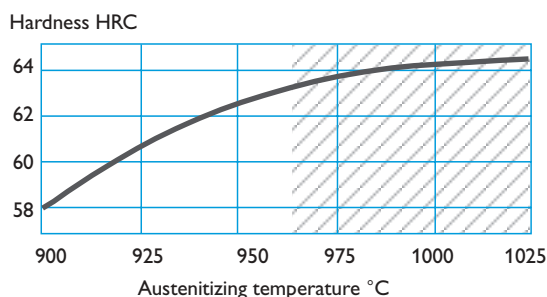
Pre-heating temperature: $600\text{--}700^{\circ}\text{C}$ ($1110\text{--}1290^{\circ}\text{F}$).

Austenitizing temperature: $950\text{--}970^{\circ}\text{C}$ ($1740\text{--}1780^{\circ}\text{F}$), normally 960°C (1760°F).

Holding time: 30–45 minutes.

The tool should be protected against decarburization during hardening.

HARDNESS AS A FUNCTION OF
AUSTENITIZING TEMPERATURE



Risk for grain growth and reduced toughness

Quenching

- High speed gas/circulating atmosphere
- Saltbath $200\text{--}550^{\circ}\text{C}$ ($390\text{--}1020^{\circ}\text{F}$)
- Fluidized bed $200\text{--}550^{\circ}\text{C}$ ($390\text{--}1020^{\circ}\text{F}$)

Note 1: Quenching should not be interrupted until the part has cooled down to $50\text{--}70^{\circ}\text{C}$ ($120\text{--}160^{\circ}\text{F}$).

Note 2: Temper immediately after quenching.

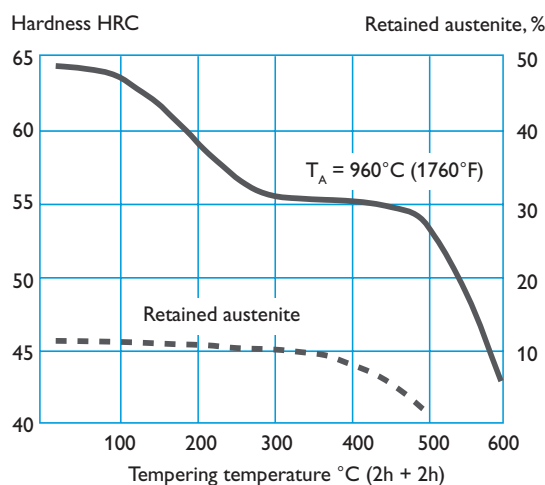
Note 3: Quenching in oil is not recommended.

Tempering

The tempering temperature for the required hardness may be determined by means of the tempering graph. Temper twice. Lowest tempering temperature 200°C (390°F). Holding time at temperature minimum 2 hours.

Surface hardness after tempering

TEMPERING GRAPH



Prehardening

The prehardening treatment consist of three steps:

1. Austenitizing according to the hardening procedure.
2. Quenching with a cooling speed around $15^{\circ}\text{C} (60^{\circ}\text{F})$ or more down to $50\text{--}70^{\circ}\text{C} (120\text{--}160^{\circ}\text{F})$.
3. Tempering two times at $685^{\circ}\text{C} (1265^{\circ}\text{F})$, hardness level ~ 270 HB.

Normalizing

If the size of the tool makes it impossible to perform a proper hardening sequence or if the risk for hardening cracks is very high normalizing is an alternative treatment in order to refine the as-cast microstructure.

The normalizing treatment consist of three steps:

1. Austenitizing according to the hardening procedure, see above.
2. Quenching with a cooling speed around $300^{\circ}\text{C/h} (570^{\circ}\text{F/h})$ down to $50\text{--}70^{\circ}\text{C} (120\text{--}160^{\circ}\text{F})$.
3. Tempering in the temperature range $650\text{--}700^{\circ}\text{C} (1200\text{--}1290^{\circ}\text{F})$ in order to fine tune the hardness.

Machining recommendations

For machining of cast Uddeholm Carmo in the pre-hardened condition, (HB <300 HB), use the recommendations given in the data sheet of wrought Uddeholm Carmo. In case of soft annealed condition use recommendations given in the data sheet of wrought Uddeholm Calmax.

At machining of the surface skin reduce the cutting speed $\sim 20\%$ in relation to given recommendations.

Welding recommendations

General

When cold work steels are welded, there is always a risk of cracking in the weld metal and/or in the heat affected zone (HAZ). However, cracking can be avoided by using a proper welding technique and the right consumables. Wrought material is always easier to weld than castings because it has a higher toughness. In general, the following is valid:

- Always keep the arc length as short as possible. The coated electrode should be angled at 90° to the joint sides to avoid undercut. In addition, the electrode should be held at an angle of $75\text{--}80^{\circ}$ to the direction of forward travel.
- Larger repair welds must be made at elevated temperature. The temperature of the workpiece should be held as constant as possible during welding. The best way to keep the tool at constant temperature during welding is to use an insulated box with thermostatically regulated electrical heating elements inside the walls.
- The first two layers should always be welded with the same heat input and with a small diameter electrode (max 3,25 Ø electrode for MMA or max 120A for TIG welding).
- First of all, the parent metal is clad in using an appropriate number of runs. All other runs should then be made up on top of pre-existing weld metal except in those cases where soft metal electrodes of the type 29/9 are used. When a soft weld metal is used, a

space of 3 mm must be left below the finished surface so that the hard facing electrode can be used to give the right surface hardness on the welded tool.

- For large weld repairs, the parent metal should be coated with a soft weld metal of the 29/9 type (i.e. 29% Cr, 9% Ni electrodes AWS ER 312 or AWS E312), which gives a tougher weld metal with lower hardness.
- The choice of electrode for welding depends on the hardness required in the weld metal (see table below).
- In order to obtain the required hardness (as given in the table below), the weld should be built up with at least 3 layers plus an additional layer which is ground off after welding has been completed. When welding tool steels, the last layer should always be ground off.
- It should be noted that differences between expected and achieved hardness in the weld metal normally depend on how the grinding of the last layer has been carried out. Grinding should always be carried out before the temperature in the tool sinks too much. If the grinding is too rough so that the weld becomes red hot, micro-cracks will appear in the weld metal.
- The following heat treatment cycle is recommended for large weld repairs:
 1. Pre-heat the tool to 200–250°C (390–480°F). Keep that temperature during the whole welding operation.
 2. Let the tool cool slowly after welding to 70°C (160°F).
 3. Temper the tool at a temperature 20°C (70°F) below previously used preheating temperature.



Joint preparation

The importance of careful joint preparation cannot be over-emphasized. Cracks should be ground out so that the joint bottom is rounded and the sides of the joint slope at an angle of at least 30° to the vertical. The width of the joint bottom should be at least 1 mm greater than the electrode diameter (including the coating) which is used.

Further recommendations on welding of tool steels can be found in the Uddeholm brochure “Welding of Tool Steel”.

TIG WELDING CONSUMABLES FOR WROUGHT CARMO

Condition of material	Consumables	Hardness as welded	Hardness after re-hardening	Preheating ¹⁾ temperature
Hardened	UTPA 651	240 HB	Austenitic	200–250°C (390–480°F)
Pre-hardened	CastoTig 680 ²⁾	230 HB	Austenitic	
	UTPA 73G2	53–56 HRC	57 HRC	
	UTPA 67S	55–58 HRC	52 HRC	
	UTPA 696	60–64 HRC		
	CALMAX/ CARMO TIG-WELD ³⁾	58–61 HRC	58–61 HRC	

MMA (SMAW) CONSUMABLES FOR WROUGHT CARMO

Condition of material	Consumables	Hardness as welded	Hardness after re-hardening	Preheating ¹⁾ temperature
Hardened	Avesta P7 ⁴⁾	ca 270 HB	Austenitic	200–250°C (390–480°F)
Pre-hardened	Castolin 680S ⁴⁾	ca 220 HB	Austenitic	
	UTP 65D	ca 250 HB	Austenitic	
	UTP 67S	55–58 HRC	52 HRC	
	UTP 73G2	55–58 HRC		
	CALMAX/ CARMO WELD ³⁾	58–61 HRC	58–61 HRC	

Remarks:

¹⁾ The tool should cool slowly after welding

²⁾ TIG rods of the type AWS ER 312

³⁾ Calmax/Carmo TIG-Weld/Weld consumables corresponds to the chemical composition of Uddeholm Carmo/Calmax, i.e. similar heat treatment responses

⁴⁾ MMA-Consumables of the type AWS E 312

Further information is given in the steel treatment brochure “Welding of Tool Steel” from Uddeholm Tooling.

Automotive tool part cast via polystyrene model and Uddeholm Carmo Granshots, weight 750 kg.

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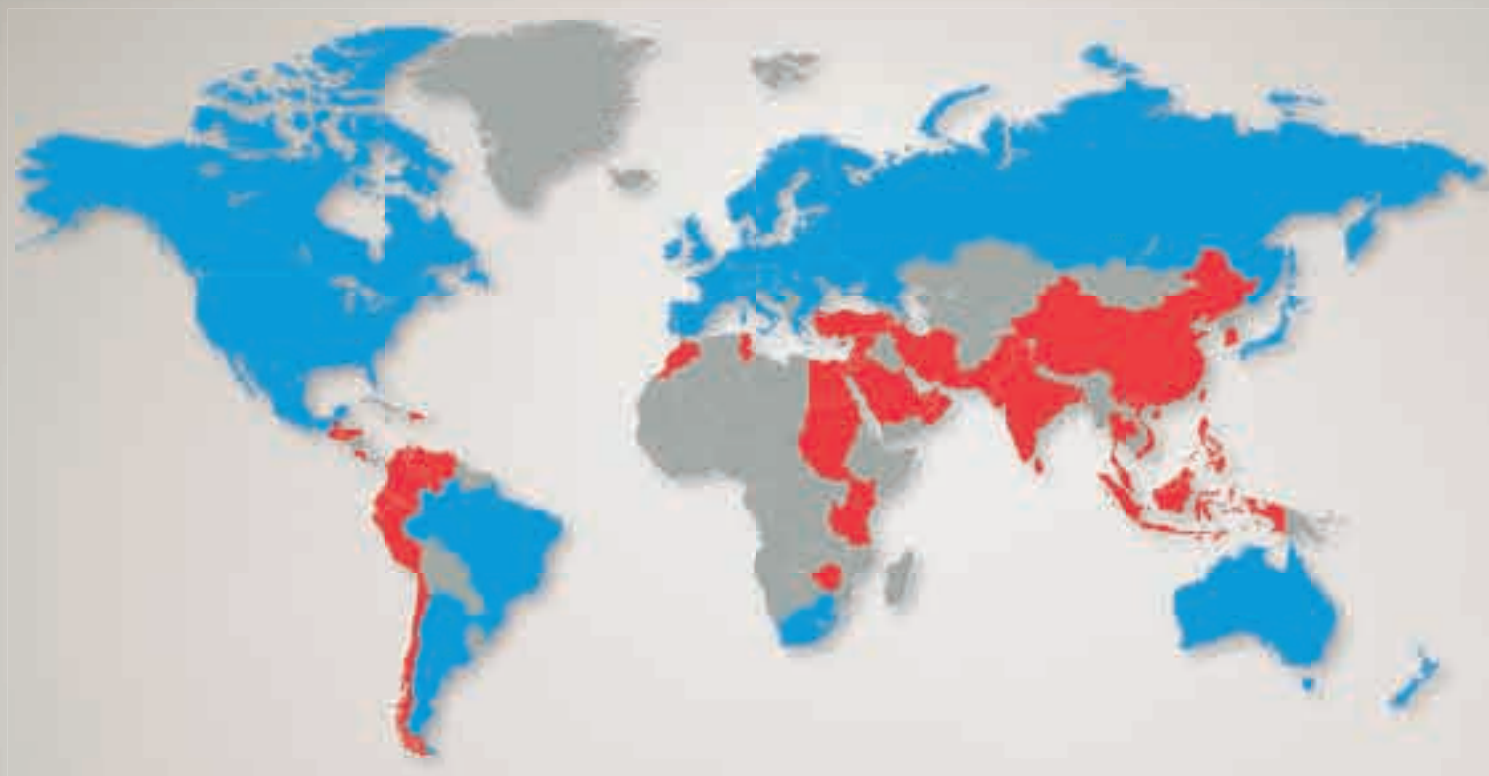
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