Industeel

ArcelorMittal

# ISOTROP

## ISOTROP: Hot work tool steel for die casting dies

**ISOTROP** is a hot work tool steel, developed by Industeel to offer a cost efficient alternative to ESR grades in the die casting die industry.
**ISOTROP** is produced through a unique and original solidification process developed by Industeel ensuring a good structural homogeneity of forged blocks.
It exhibits improved properties such as a very high level of toughness and high resistance to heat checking.
It is very well adapted to ensure extended life time of aluminium or magnesium die casting dies: long production runs, pressure casting, water cooled elements...
**ISOTROP** meets most International technical standards governing die casting applications (NADCA, CNOMO, SEP).

## PROPERTIES

### STANDARDS

- **> W1.2343 mod, X37CrMoV5.1 mod, AISI H11 mod, SKD6 mod**
- **> W1.2344 mod, X40CrMoV5.1 mod, AISI H13 mod, SKD61 mod**
- **> Meets requirements of NADCA # 207-2017grade F**
- **> Meets requirements of SEP1614 / VDG M82**
- **> Meets requirements of CNOMO E 01.17.221.N**

### STEELMAKING PROCESS

Electric Arc Furnace / VAD + unique Industeel solidification process.
Although **ISOTROP** is not produced through ESR / VAR process, it meets very similar properties as ESR/VAR products (toughness, microstructure,...)

### CHEMICAL ANALYSIS WEIGHT %

Typical heat analysis of ISOTROP

| | C | S | P | Si | Mn | Cr | Mo | V |
|---|---|---|---|---|---|---|---|---|
| Typical value | 0.36 | 0.001 | 0.010 | 0.30 | 0.40 | 5.10 | 1.40 | 0.35 |
| Guaranteed value | 0.34<br>0.39 | 0.002<br>max. | 0.012<br>max. | 0.25<br>0.40 | 0.30<br>0.50 | 4.90<br>5.40 | 1.30<br>1.50 | 0.30<br>0.45 |

## CLEANLINESS

Maximum values of ISOTROP

| | A | B | C | D |
|---|---|---|---|---|
| ASTM E45 (A method) | 0.5 (t & h) | 1.5(t) 1.0(h) | 0.5 (t & h) | 1.5(t) 1.0(h) |

## PHYSICAL PROPERTIES

Typical values of ISOTROP

| Temperature | | Density | | Modulus of elasticity | | Coefficient of thermal expension | | Thermal conductivity | |
|---|---|---|---|---|---|---|---|---|---|
| °C | °F | kg.m$^{-3}$ | lbs.in$^{-3}$ | N.mm$^{-2}$ | psi | °C$^{-1}$ from 20°C | °F$^{-1}$ from 68°F | W.m$^{-1}$.°C$^{-1}$ | Btu.in.h$^{-1}$.°F$^{-1}$ |
| 20 | 68 | 7800 | 0.281 | 205 000 | 29,7.10$^{6}$ | X | X | 28 | 194 |
| 400 | 750 | 7700 | 0.277 | 177 000 | 25,7.10$^{6}$ | 12,6.10$^{-6}$ | 7,0.10$^{-6}$ | 30 | 208 |
| 800 | 1470 | 7540 | 0.273 | 127 000 | 18,4.10$^{6}$ | 13,8.10$^{-6}$ | 7,6.10$^{-6}$ | 33 | 229 |

## SOUNDNESS / UT GUARANTEE

All plates & blocks are 100% UT tested and meet following standards:

**> Euronorm EN 10228-3 class 4**

**> ASTM A681 S1.1**

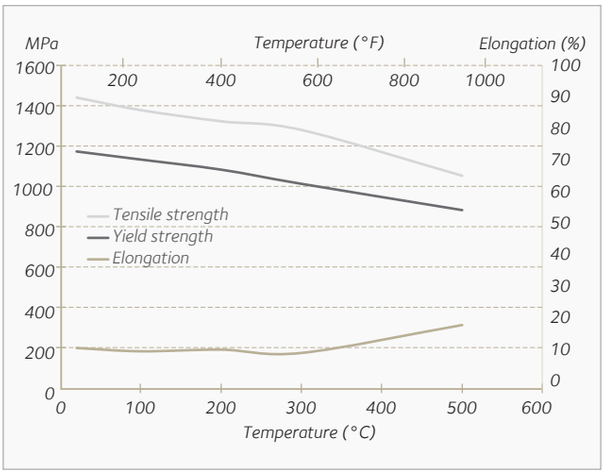
**> SEP1921 E/e**

## MECHANICAL PROPERTIES

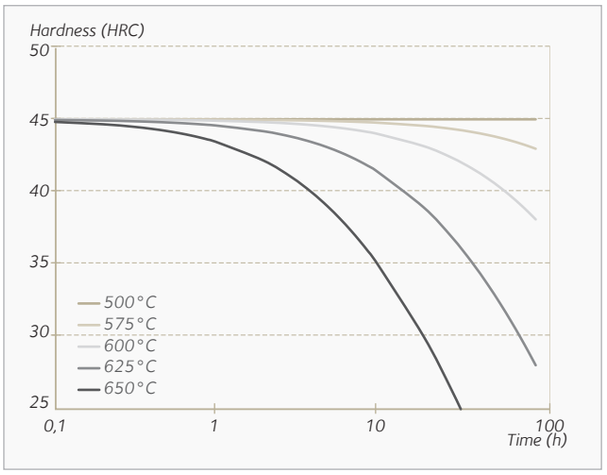
ISOTROP is delivered in soft annealed condition (hardness ≤ 229 HB - 20 HRC). It has to be hardened after roughing. Typical values of ISOTROP after hardening

| Hardness | Yield strength (Rp0,2) | | Ultimate tensile strength (Rm) | | Elongation (E) | Réduction of area (Z) |
|---|---|---|---|---|---|---|
| HRC | N.mm$^{-2}$ | psi | N.mm$^{-2}$ | psi | % | % |
| 44 | 1180 | 171 000 | 1440 | 208 000 | 13 | 55 |
| 48 | 1370 | 199 000 | 1600 | 232 000 | 12 | 53 |
| 52 | 1560 | 226 000 | 1830 | 265 000 | 12 | 52 |

## HOT TENSILE PROPERTIES

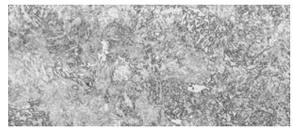



## SOFTENING RESISTANCE

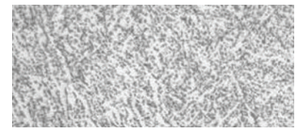


## ANNEALED MICROSTRUCTURE / BANDING SEGREGATION

ISOTROP meets structural requirements of following standards: SEP 1614 Premium quality / NADCA #207 - 2017. Typical microstructure of ISOTROP in delivery condition (thickness 250 mm / top / mid thickness)



*X50: Acceptable (NADCA # 207-2017) SA3 (SEP 1614)*



*X500:AS5/AS6 (NADCA # 207-20117 GB2/GC1 (SEP 1614)*

## TOUGHNESS

Toughness / high impact properties are necessary to minimize the risk of premature failure of dies. ISOTROP exhibits impact test results very similar to those of ESR grades.

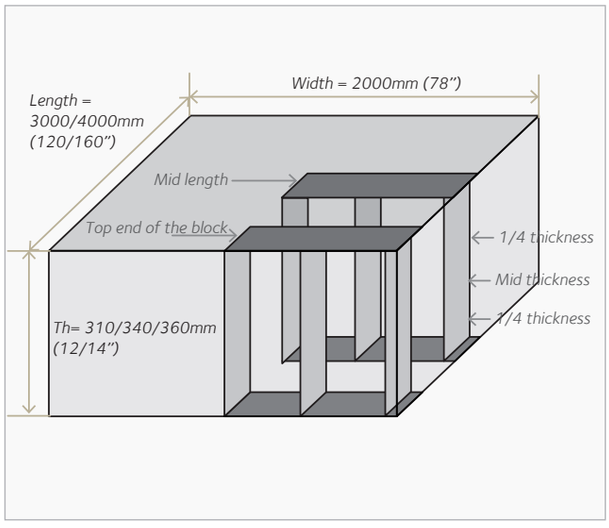
### Typical impact properties

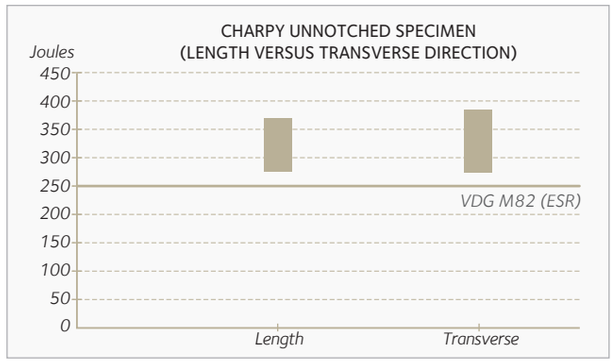
Toughness measurement at room temperature on samples prehardened at 45 HRC.

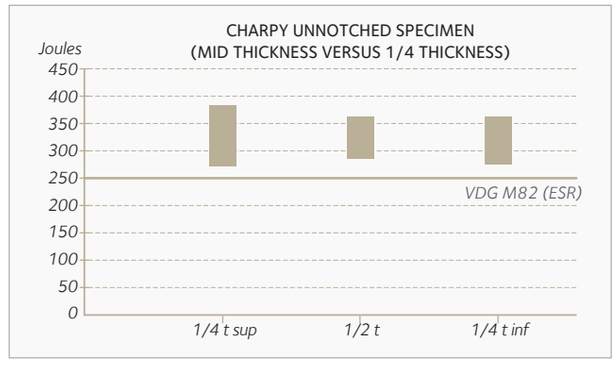
| | | Typical Values (average of 3 specimen) | Requirements | |
|---|---|---|---|---|
| | | | NADCA #207-2017 (E & F) | VDG M82 |
| Charpy V Notch (*) | ft.lb J | 15 to 21<br>20 to 28 | ≥ 14<br>≥ 19 | |
| Charpy unnotched (**) | J | 275 to 385 | | ≥ 200J (standard)<br>≥250J (premium) |

### Statistical evaluation of ISOTROP toughness

Performed on 3 blocks 300 mm / 340 mm / 360 mm - 12" / 13" / 14" sampling in 18 different locations of each blocks, longitudinal and transverse direction

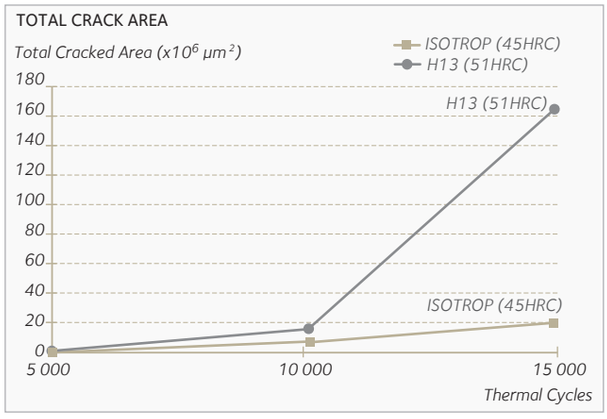


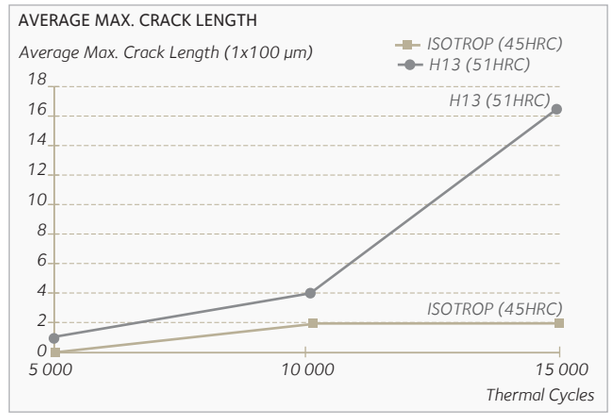



## THERMAL FATIGUE

Dunker test performed on ISOTROP (45 HRC) versus H13 (51 HRC) by Case Western Reserve University / Cleveland Ohio




# DELIVERY CONDITIONS

## DIMENSIONAL PROGRAM

| | Thickness | Width |
|---|---|---|
| ISOTROP | 60 to 360 mm<br>(2.36 to 14.1") | Up to 2000 mm<br>(78") |

For specific dimensions, please contact us.

# PLATE PROCESSING

## HEAT TREATMENT

ISOTROP is delivered in a soft annealed condition for easier machining. When machining is completed, ISOTROP can be hardened with a heat treatment procedure including preheating, austenitization, quenching and double tempering.
Heat treatment should be done under vacuum or under gas protection to avoid surface oxidation and decarburization. Surface and core temperature (Ts/Tc) should be controlled by thermocouples.

### Preheating

Heating rate should be limited to 220°C /h (400°F/h), measured in the core of cavity. First preheating has to be done at Ts≈620°C (1150°F) and hold until
Ts-Tc < 110°C (200°F) Second preheating has to be done at Ts≈830°(1530°F) and hold until Ts-Tc < 15°C (25°F).

### Austenitization

After second preheating,austenitization should be rapidly increased up to 1030°C (1885°F) and hold 30 mn after Ts-Tc < 15°C (25°F). In any case, soaking time shall never exceed 90 mn max after Ts reaches 1030°C (1885°F).

### Quenching

Quenching shall be performed in oil or pressurized gas. Pressurized gas should be preferred when quenching complex shapes. Fast cooling has to be applied from austenitization temperature down to 150°C (300°F)
Cooling rate, measured at the surface of the cavity, must be at least 30°C/min (55°F/min) between austenitization temperature and 530°C (990°F)
To limit stresses, a special attention shall be paid at the temperature difference between surface and core. Especially in the temperature range 400/450°C

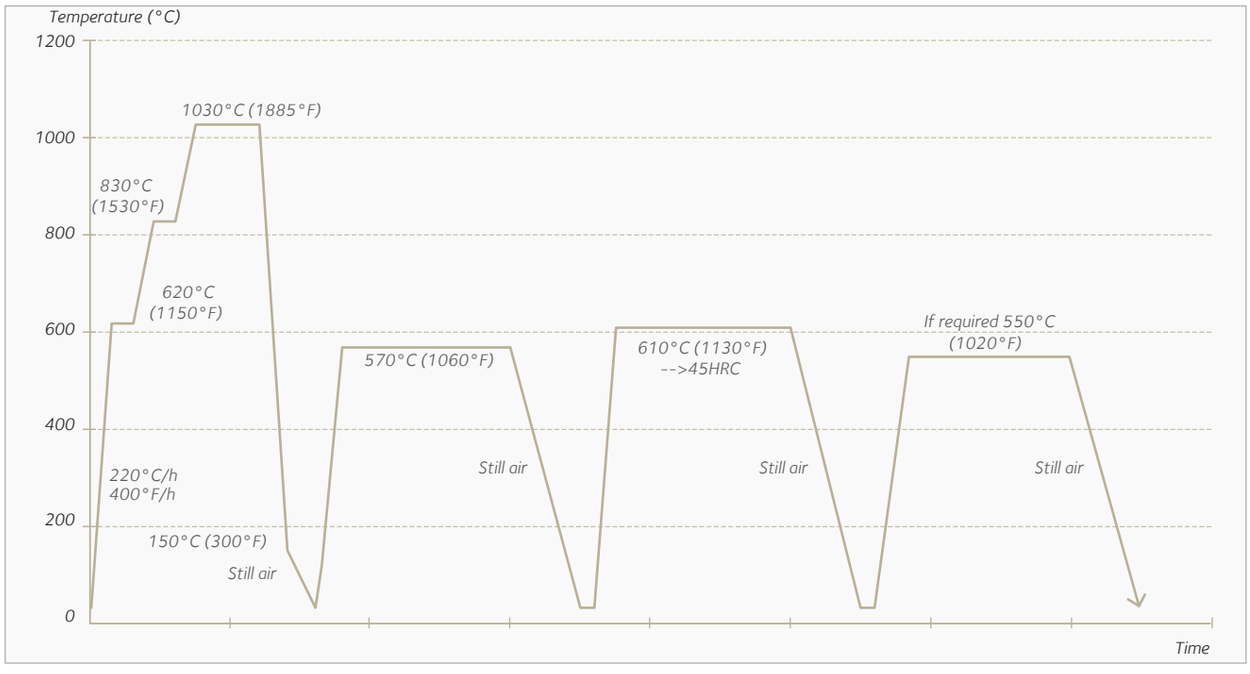
(750/840°F), the temperature difference between surface and core shall not exceed 100°C (180°F).
Below 150°C (300°F), cavity should be air cooled to 50/80°C and should then be immediately loaded in a furnace to perform a first tempering.

### Tempering

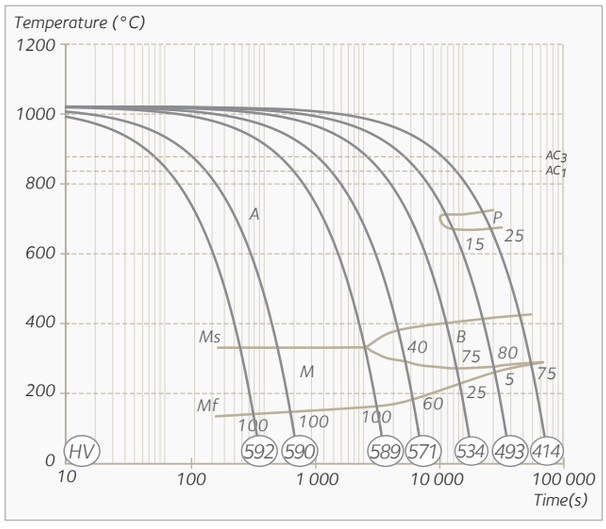
A minimum of 2 tempering should be performed on ISOTROP immediately after quenching. First tempering should be done at 570°C (1060°F) Second tempering shall be performed at a temperature depending on required temperature (see tempering curve below).

For a required hardness of 45HRC, second tempering should be performed at 610°C (1130°F)
In both cases, tempering temperature should be hold 2 hours minimum or 30mn per 25 mm of thickness (30mn/inch).
After tempering pieces should be air cooled to room temperature.
When a third tempering is required, it should be done at 550°C (1020°F).

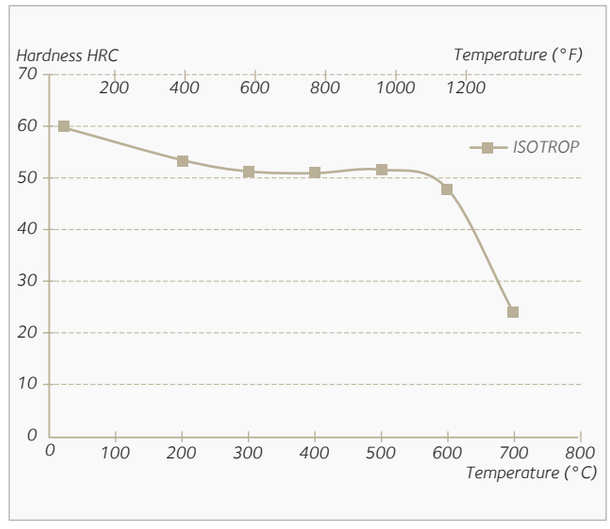
## HARDENING CHART




### CCT Diagram




### Tempering curve



## NITRIDING

Typical properties of nitrided layers depending on processes and parameters

| Process | Temperature (°C - °F) | Time (h) | Depth | Compound layer (µm) | Hardness (HV1) |
|---|---|---|---|---|---|
| Gas nitriding | 520°C 970°F | 25 | 0.2 mm 0.00787 inch. | [4;6] | [1072;1090] |
| | | 50 | 0.35 mm 0.01377 inch. | [11;16] | [1029;1091] |
| Plasma nitriding | 520°C 970°F | 15 | 0.1 mm 0.00393 | 0 | [1045;1065] |

## MACHINING

### In soft annealed condition

| MILLING (with Carbide) | | | |
|---|---|---|---|
| Parameters and tools | | Isotrop: 160 HB | |
| | | Rough | Fine |
| Cutting speed ($V_c$) | m/min ft/min | [140;180] [459;590] | [180;220] [590;721] |
| Depth of cut ($a_p$) | mm inch | [2;4] [0.079;0.157] | [0;2] [0;0.079] |
| Feed (fz) | mm/min inch/tooth | [0.2;0.4] [0.079;0.0157] | [0.1;0.2] [0.0039,0.0079] |
| Carbide désignation | ISO US | [P20;P40] [C6;C5]* | P10 C7** |

* coated carbide
** coated carbide or cermet

| TURNING (with Carbide) | | | |
|---|---|---|---|
| Parameters and tools | | Isotrop: 160 HB | |
| | | Rough | Fine |
| Cutting speed ($V_c$) | m/min ft/min | [140;200] [459;565] | [200;250] [656;820] |
| Depth of cut ($a_p$) | mm inch | [2;4] [0.079;0.157] | [0,5;1,5] [0.020;0.039] |
| Feed (fz) | mm/rev inch/rev | [0.2;0.4] [0.0079;0.0157] | [0.05;0.2] [0.0020;0.0079] |
| Carbide désignation | ISO US | [P20;P30] [C6;C5]* | P10 C7** |

* coated carbide
** coated carbide or mixed ceramic

### In hardened condition

| MILLING (with Carbide) | | | |
|---|---|---|---|
| Parameters and tools | | Isotrop: 43-45 HRC | |
| | | Rough | Fine |
| Cutting speed ($V_c$) | m/min ft/min | [45;90] [148;295] | [90;140] [295;459] |
| Depth of cut ($a_p$) | mm inch | [2;4] [0.079;0.157] | [0;2] [0;0.079] |
| Feed (fz) | mm/min inch/tooth | [0.2;0.4] [0.0079;0.0157] | [0.1;0.2] [0.0039;0.0079] |
| Carbide désignation | ISO US | [P20;P40] [C6;C5]* | P10 C7** |

* coated carbide
** coated carbide or cermet

| TURNING (with Carbide) | | | |
|---|---|---|---|
| Parameters and tools | | Isotrop: 43-45 HRC | |
| | | Rough | Fine |
| Cutting speed ($V_c$) | m/min ft/min | [35;60] [115;197] | [70;90] [230;295] |
| Depth of cut ($a_p$) | mm inch | [1;2] [0.039;0.079] | [0,5;1] [0.020;0.039] |
| Feed (fz) | mm/rev inch/rev | [0.2;0.4] [0.039;0.079] | [0.05;0.2] [0.0079;0.0157] |
| Carbide désignation | ISO US | [P20;P30] [C6;C5]* | P10 C7** |

* coated carbide
** coated carbide or mixed ceramic

## WELD REPAIR

| WELDING | | |
|---|---|---|
| Method | TIG | MMA |
| Preheating | 320-380°C / 610 - 710°F | |
| Limit of Interpass température | 480°C - 900°F | |
| Filler material | AISI H11 | |
| Post welding cooling | 30°C - 54°F/h max during 3 hours | |
| Post welding Heat Treatment in hardened condition | 600°C - 1H / 25 mm<br>1110°F - 1H /inch | |
| Post welding Heat Treatment in annealed condition | 850°C - 1560°F/30 mn per 25 mm - per inch + cooling at 5°C - 9°F/h until 620°C - 1150°F and air cooling | |

## YOUR CONTACTS

**Perrine Lavalley**
**Tel.** +33 3 85 80 52 56
*perrine.lavalley@arcelormittal.com*

*http://industeel.arcelormittal.com*

**Industeel France**
*Le Creusot Plant*
*56 rue Clemenceau*
*F-71202 Le Creusot Cedex*