# SITHERM S360R

SPECIFICATION SHEET

SITHERM S360R is a supreme hot-work tool steel produced by SIJ Metal Ravne and it excels itself in the following properties:

- good impact toughness
- high tensile properties and high working hardness
- improved thermal conductivity
- good polishability
- excellent hardenability
- high cleanliness
- excellent homogeneity

## CHEMICAL COMPOSITION (%)

Chemical composition with a minimal content of detrimental elements compared to standard steel grades.

Chemical element content is in wt.%

| SIJ Metal Ravne | AISI | W. Nr. | C | Si | Mn | Cr | Mo | V | Ni |
|---|---|---|---|---|---|---|---|---|---|
| **SITHERM S360R** | - | - | 0.52 | 0.25 | 0.30 | 4.80 | 3.00 | 0.60 | 0.60 |

## Conditions as Delivered

SITHERM S360R is supplied in annealed condition, max. 229 HBW.

## COMPARISON OF STRENGTH AND TOUGHNESS

In comparison with other conventional steels of this group, SITHERM S360R has an increased amount of carbon and it is modified by Ni-addition which improves toughness and increases hardenability and thermal conductivity of steel (tool). This contributes to more homogeneous properties throughout tool volume.

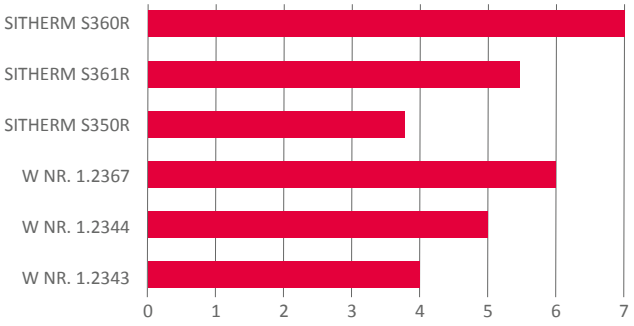


Fig.1: Comparison of strength for hot-work tool steels

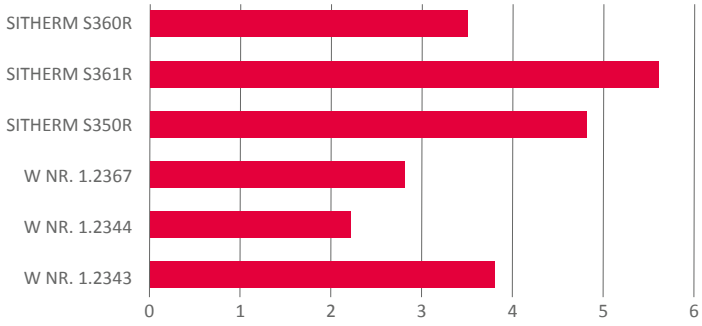


Fig. 2: Comparison of hot- work tool steels
Reference data for toughness in hardness range 44-46HRc. (NADCA#229-2016)


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## APPLICATIONS

Typical applications for SITHERM S360R hot-work tool steel:

- DIE FORGING: production of forging dies and parts of forging dies – die forging inserts
- DIE CASTING: production of dies or pressure casting inserts for non-ferrous metals and alloys
- EXTRUSION: production of extrusion dies
- HOT STAMPING: production of tools for hot stamping
- OTHER AREAS: e.g. industrial cutting knives for hot cutting

## MICROSTRUCTURE IN THE CONDITION AS DELIVERED

**SITHERM S360R** is inspected in a soft annealed and heat treated condition according to NADCA#229 standard.

**NADCA#229-2016**
**Banding / Microsegregation Chart**
All microstructures etched with 5% Nital and Vilella's reagent

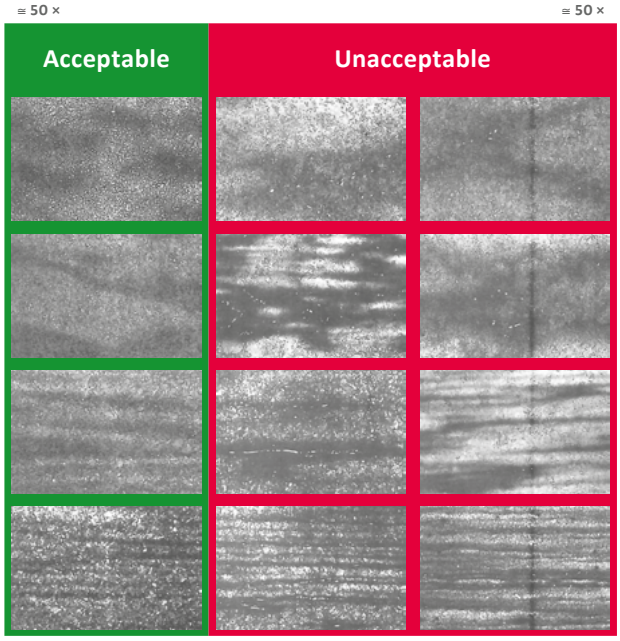


Fig. 3: Rating Chart Microhomogeneity

**NADCA#229-2016**
**Annealed Quality Microstructure Chart – "AS" Rating**
(All microstructures etched with 5% Nital)

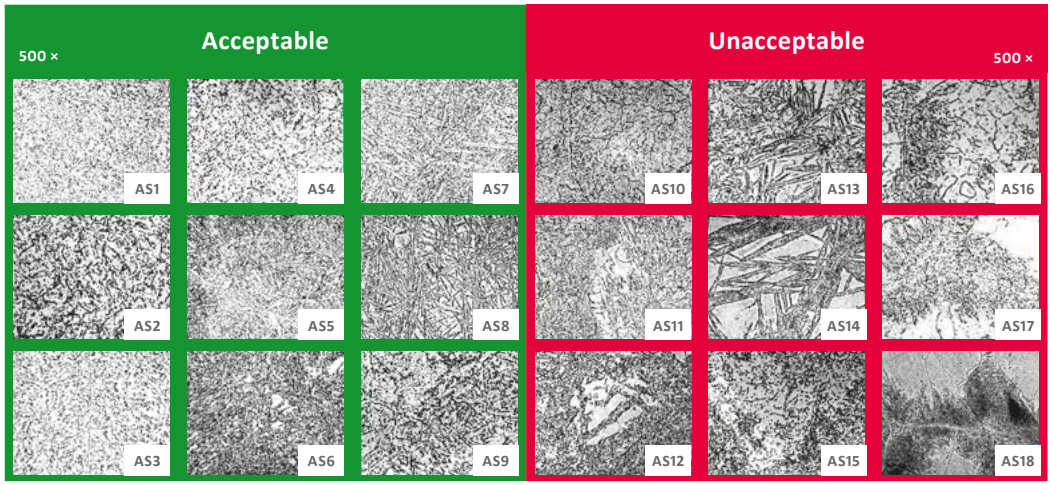


Fig. 4: „AS" – Rating acceptability criteria of annealed microstructure according to NADCA#229-2016, 500 × magnification

**NADCA#229-2016**
**Heat Treatment Quality Microstructure Chart – "HS" Rating**
(All microstructures etched with 5% Nital)

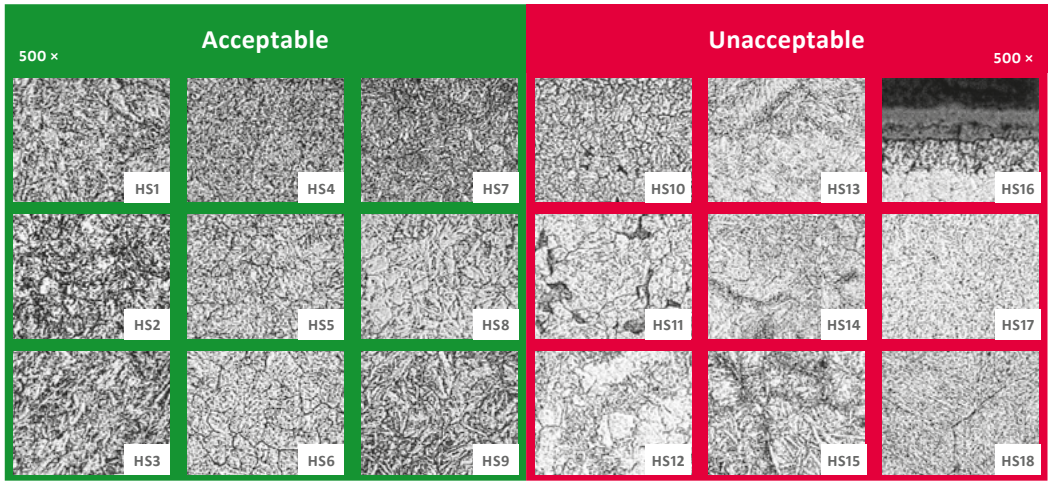


Fig. 5: „HS" – Rating Acceptability criteria of heat treated microstructure according to NADCA#229-2016, 500 × magnification

## Microstructure of SITHERM S360R steel

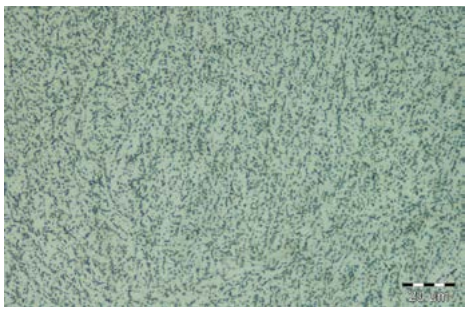

Fig. 6a: Annealed

Fig. 6b: Heat treated (Q+T)

## PHYSICAL PROPERTIES

Heat treated: hardened and 2× tempered.

### Density

| DENSITY (g/cm³), T: 20 °C |
|---|
| 7.80 |

### Electric resistivity

| ELECTRIC RESISTIVITY (Ohm.mm²/m) | | | | |
|---|---|---|---|---|
| 100 °C | 450 °C | 500 °C | 550 °C | 600 °C |
| 0.50 | 0.58 | 0.63 | 0.68 | 0.73 |

### Specific heat capacity

| SPECIFIC HEAT CAPACITY (J/(g. K)) |
|---|
| 20 °C |
| 0.45 |

### Modulus of elasticity

| MODULUS OF ELASTICITY (10³ × N/mm²) |
|---|
| 20 °C |
| 215 |

### Coefficient of linear thermal expansion

| COEFFICIENT OF LINEAR THERMAL EXPANSION between 20 °C and ... °C (10-6 °C-1, 20 °C) | | | | |
|---|---|---|---|---|
| 200 °C | 300 °C | 400 °C | 500 °C | 600 °C |
| 11.60 | 11.80 | 12.02 | 12.04 | 12.01 |

### Thermal conductivity

| THERMAL CONDUCTIVITY (W/(m.K) | | | |
|---|---|---|---|
| 20 °C | 200 °C | 400 °C | 550 °C |
| 32 | 34 | 35 | 38 |

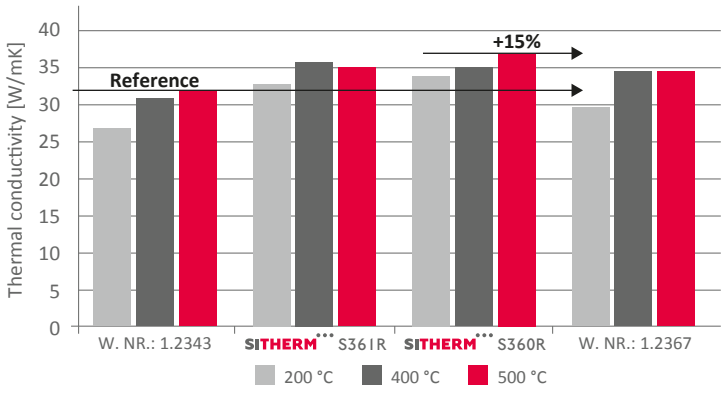


Fig. 7: Comparison of thermal conductivity for hot-work tool steels between W.Nr.: 1.2343 and SITHERM S360 R

## CONTINUOUS COOLING TRANSFORMATION (CCT) DIAGRAM

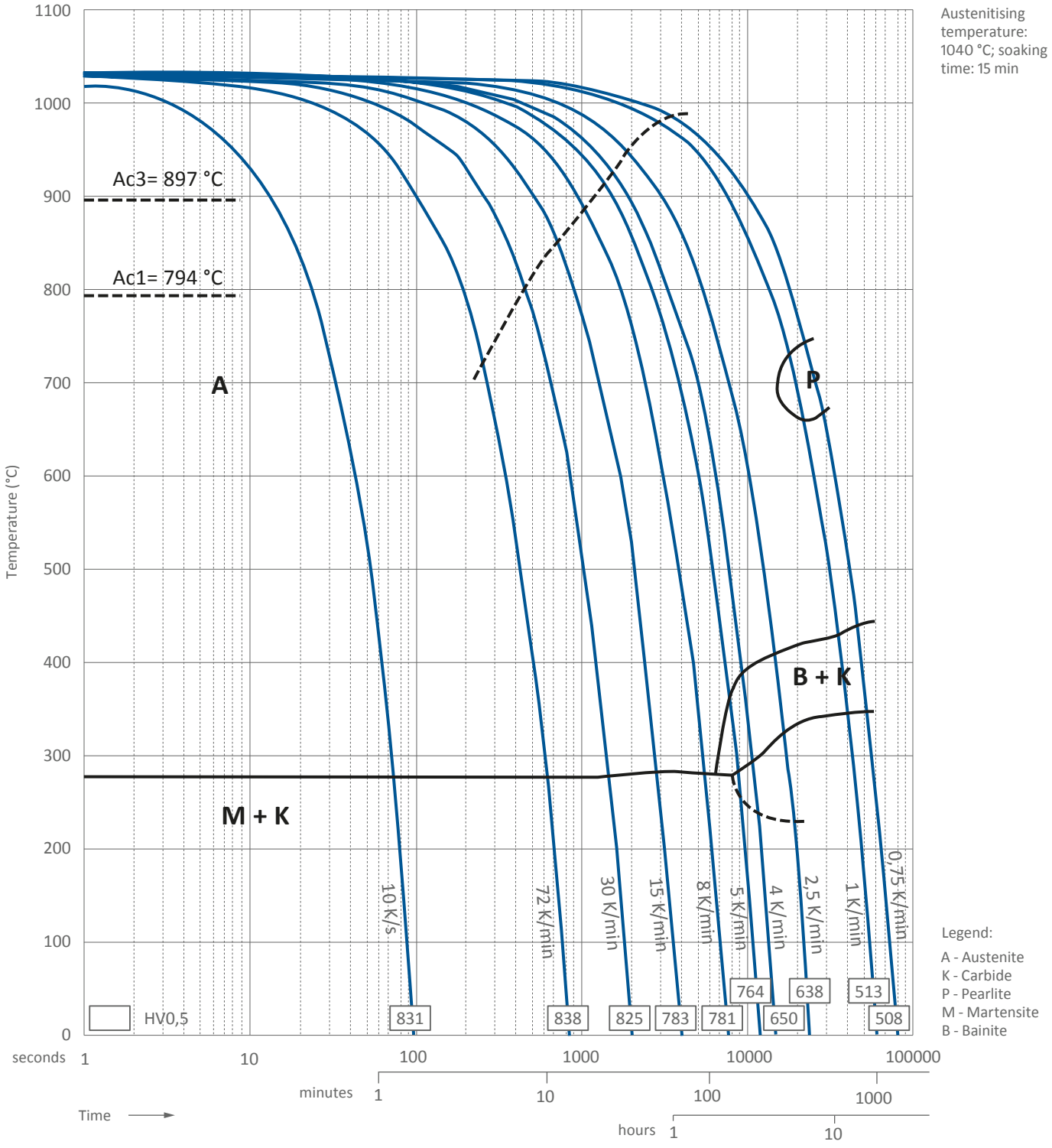


Fig. 8: Continuous Cooling Transformation (CCT) diagram

## TEMPERING DIAGRAM AND IMPACT TOUGHNESS

Hardness/Tempering temperature:

| Tempering (°C) | 100 | 200 | 300 | 400 | 500 | 550 | 600 | 650 |
|---|---|---|---|---|---|---|---|---|
| Hardness HRc | 62.5 | 58 | 57 | 57.5 | 58.5 | 59 | 52 | 43 |

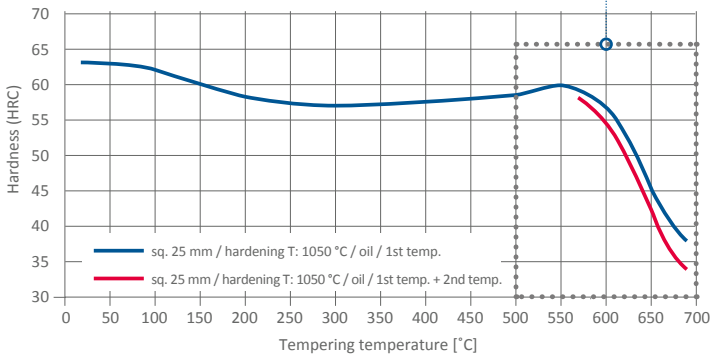


Fig. 9: Tempering diagram SITHERM S360R

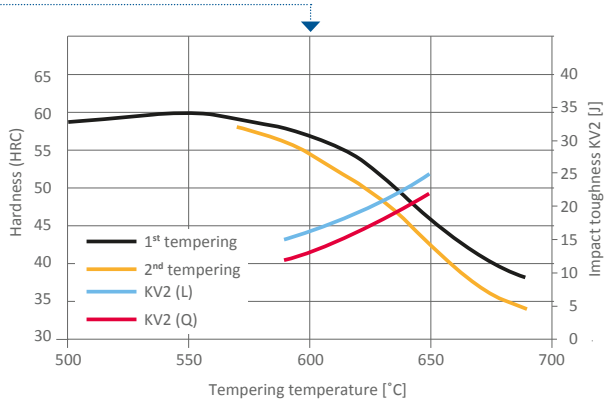


Fig. 10: Tempering diagram and impact toughness

Impact specimens KV2 (EN ISO 148-1) are used to test impact toughness in a longitudinal and transverse direction. Specimens are quenched and 2× tempered, tested at 20 °C

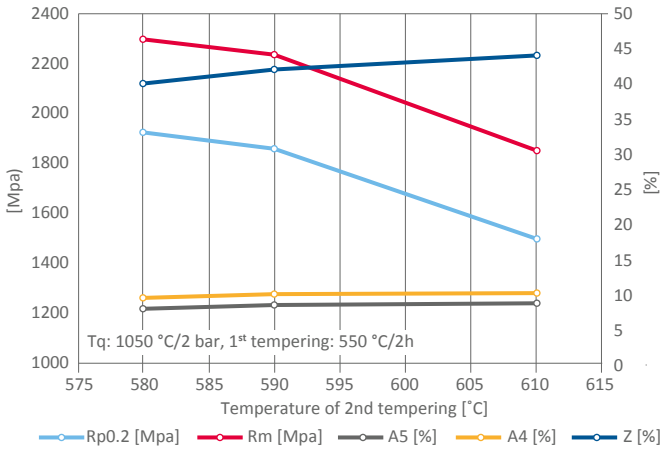


Fig.11: Mechanical properties

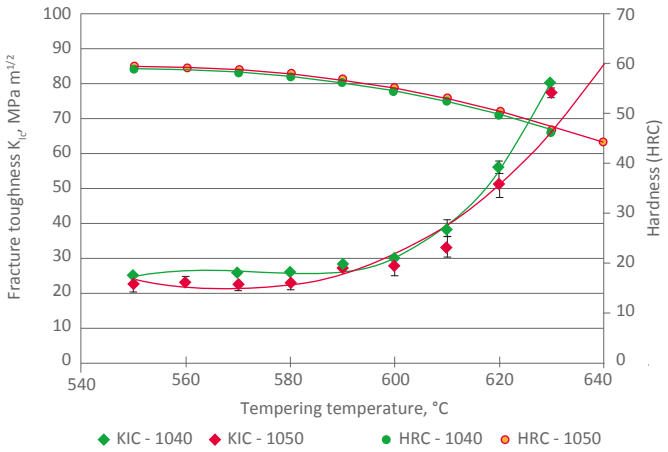


Fig.12: Diagram fracture tougness K vs. hardness HRC

## HEAT TREATMENT

| | |
|---|---|
| SOFT ANNEALING | ANNEALING TEMPERATURE: 780–840 °C cooling in furnace at 10/20 °C/h to 600 °C, later on air |
| HARDNESS AFTER ANNEALING | Maximum: 229 HBW |
| STRESS RELIEF ANNEALING | TEMPERATURE: 650–700 °C, 2 h, slow cooling in furnace at: 20 °C/h |

To reduce stress after machining of tools prior to final heat treatment of tools.

| | |
|---|---|
| HARDENING | TEMPERATURE: 1040–1060 °C air, oil, vacuum, salt bath (500–550 °C) |
| HARDNESS AFTER HARDENING | 62 – 64 HRC |

### Hardening:

Preheating practice:

- Hold in furnace at T = 650 °C until the difference in temperature $T_{SURFACE} - T_{CORE} \leq 200$ °F / 110 °C
- Hold in furnace at T = 850 °C until the difference in temperature $T_{SURFACE} - T_{CORE} \leq 25$ °F / 14 °C

Recommendations NADCA#229

Austenitising:

- soaking time: 30 min. after equalization of temperature on the surface and in the center of die: $T_{SURFACE-CORE} \leq 14$ °C/(25) ° F, or max. 90 min. after die surface temperature has reached the required austenitising temperature and/or whichever condition is fulfilled first.

Fast cooling is recommended in pressurized N2. For large-dimension hot-work tooling see NADCA#229 or GM DC-9999-1Rev.18 specification.

## Tempering:

Tempering must start immediately after the end of quenching (when part reaches 90–70 °C). Three tempering treatments are recommended. The first tempering transforms the retained austenite. The second tempering tempers newly formed martensite, third tempering stabilizes the microstructure.

| HEATING | TEMPERING TEMPERATURE | COOLING |
|---|---|---|
| 150 °C/h – 250 °C/h | 1st tempering: 540/550 °C/min. 2 h<br>2nd tempering: to the range of working hardness<br>3rd tempering: 20–30 °C under the temperature of 2nd tempering | Cool in air or in the furnace to room temperature between tempering cycles. |
| Protect against oxidation and decarburisation. | 1 hour per 25 mm wall thickness based on furnace temperature. Minimum 2 hours. | |

## DISCLAIMER

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