SITHERM ••• S353R

SITHERM S353R is a modified steel grade with high toughness and good thermal fatigue resistance within the normal range of hardness for hot-work applications like die casting, die forging and extrusion.

⬊ CHEMICAL COMPOSITION (%)

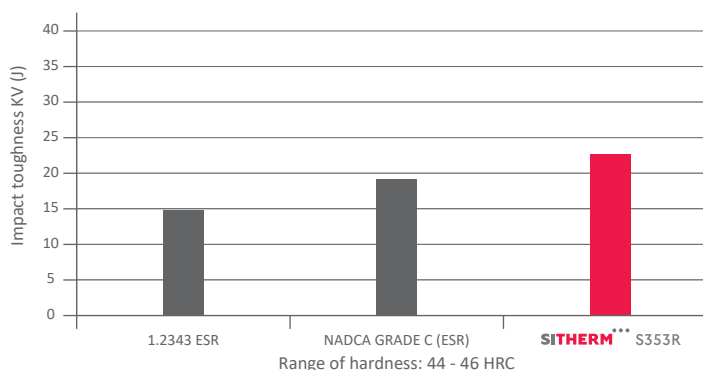| SIJ Metal Ravne	AISI	W. Nr.	C	Si	Mn	Cr	Mo	V
SITHERM ••• S353R	1.2367 mod	~1.2367	0.36	0.30	0.30	5.00	2.30	0.60

⬊ TOUGHNESS

Fig.1: Impact toughness

KV impact specimens (EN ISO148-1:2017 / ASTM A370-05-17) are used to test impact toughness in short transverse direction. Specimens are quenched and tempered to 45+/-1 HRC, and test is performed at 20°C. Average impact toughness of forged quality is higher than 23 Joule for the average forging size of blocks up a thickness of 500 mm. (NADCA#229-2016)

⬊ QUALITY COMPARISON

SITHERM S353R is a superior hot work tool steel of high toughness produced by SIJ Group. The chart below shows its toughness compared to SITHERM 2343 and SITHERM 2367 hot-work tool steels. Hot-work tool steel SITHERM S353R with increased toughness is especially suitable for applications requiring high toughness.
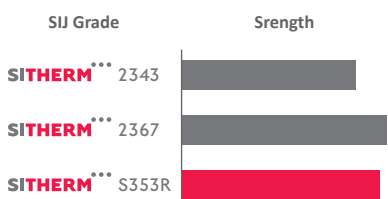

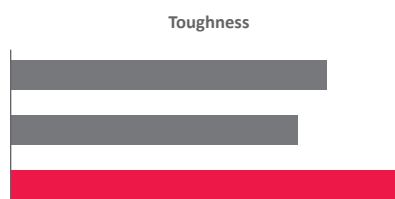Fig.2: Relative comparison of strength for hot-work tool steel

Fig.3: Relative comparison of toughness for hot-work tool steel

⬎ APPLICATIONS

SITHERM S353R is primarily designed for die casting of light metals and alloys as well as extrusion and die forging. It is often used for highly stressed hot-work structural parts where superior toughness is required.

SITHERM S353R is also recommended for die forging and extrusion. Because of its good polishability, the grade can be used for plastic molding applications.

SITHERM S353R is supplied in annealed condition, max. 229 HBW (735 N/mm²).

⬎ MICROSTRUCTURE IN THE CONDITION AS DELIVERED

SITHERM S353R is delivered in a soft annealed condition according to NADCA#229 standard.

NADCA#229-2016
Banding / Microsegregation Chart
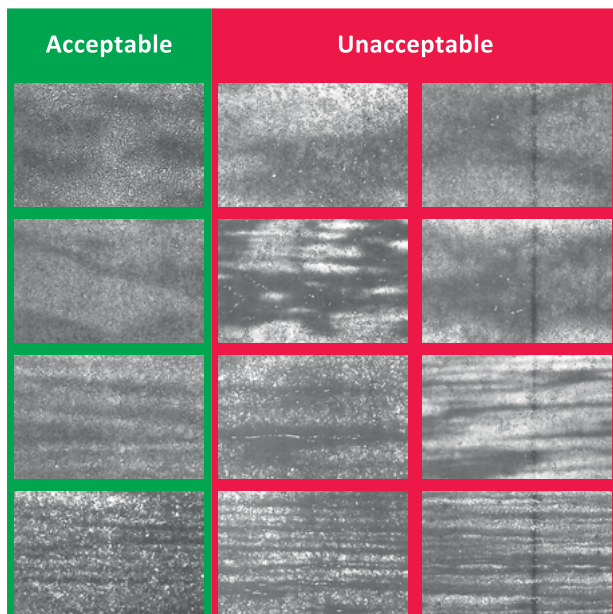All microstructures etched with Vilella's reagent

≅ 50 ×　　　　　　　　　≅ 50 ×

Fig. 4: Microhomogeneity

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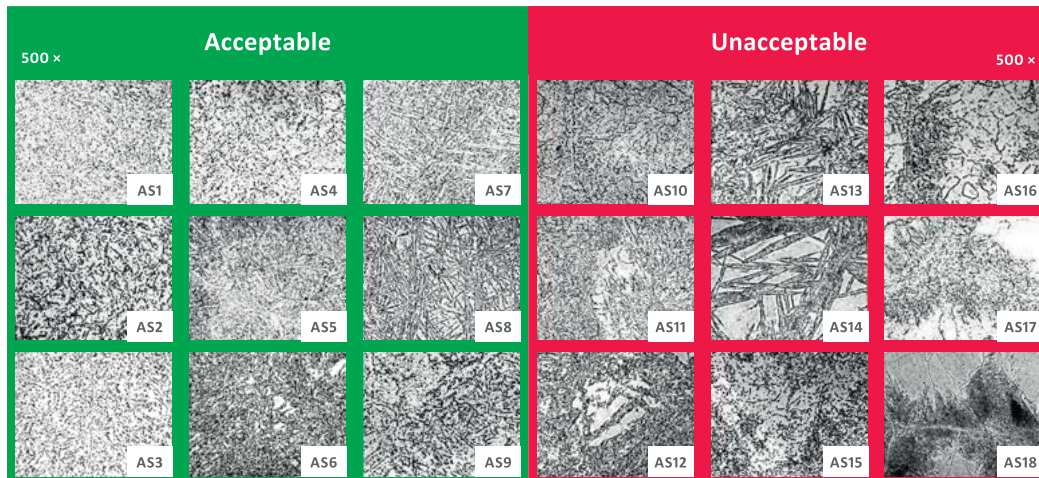(All microstructures etched with 5% Nital)

Fig. 5: „AS" – Rating acceptability criteria of annealed microstructure according to NADCA#229-2016, 500 × magnification

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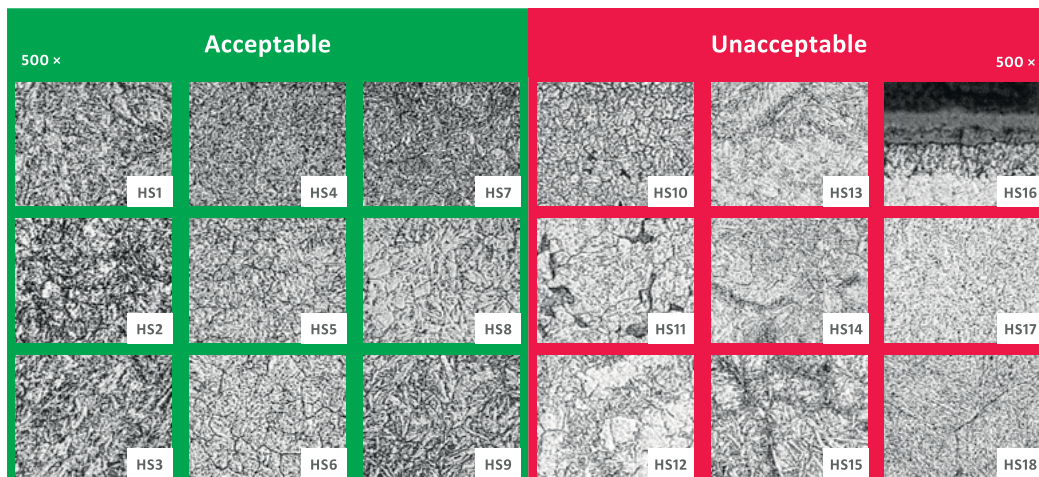(All microstructures etched with 5% Nital)

Fig. 6: „HS" – Rating Acceptability criteria of heat treated microstructure according to NADCA#229-2016, 500 × magnification
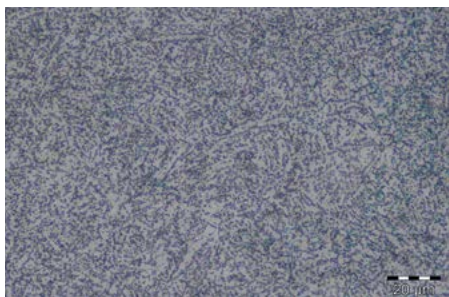
MICROSTRUCTURE OF SITHERM S353R STEEL
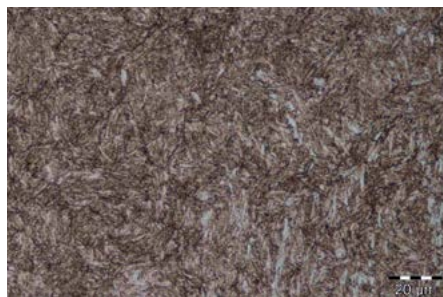

Fig. 7a: Annealed

Fig. 7b: Heat treated (Q+T)

↘ PHYSICAL PROPERTIES

Heat treated: hardened and 2× tempered.

DENSITY

DENSITY (g/cm³)				
20 °C	450 °C	500 °C	550 °C	600 °C
7.85	7.80	7.69	7.67	7.65

THERMAL CONDUCTIVITY

THERMAL CONDUCTIVITY [W/mK]				
200 °C	400 °C	500 °C	550 °C	600 °C
29.0	31.1	32.0	29.7	28.5

ELECTRIC RESISTIVITY

ELECTRIC RESISTIVITY [Ω mm²/m]				
20 °C	450 °C	500 °C	550 °C	600 °C
0.50	0.68	0.86	0.90	0.86

SPECIFIC HEAT CAPACITY

SPECIFIC HEAT CAPACITY [J/gK]				
20 °C	400 °C	500 °C	550 °C	600 °C
0.47	0.50	0.55	0.57	0.59

MODULUS OF ELASTICITY

MODULUS OF ELASTICITY [10³ N/mm²]				
20 °C	450 °C	500 °C	550 °C	600 °C
215	185	176	171	165

COEFFICIENT OF LINEAR THERMAL EXPANSION

COEFFICIENT OF LINEAR THERMAL EXPANSION BETWEEN 20 °C AND [10^{-6} °C^{-1}]						
100 °C	200 °C	300 °C	400 °C	500 °C	600 °C	700 °C
10.7	11.4	11.7	11.8	11.9	12	12

↘ HEAT TREATMENT

ANNEALING:

HEATING	ANNEALING TEMPERATURE	COOLING
50 °C/h	800 - 850 °C	20 °C/h
Protect against oxidation, scaling and decarburisation.	Min. 4 hours.	Slow cooling in furnace. Air cooling is possible from 600 °C.

STRESS RELIEVING:

HEATING	STRESS RELIEVING	COOLING
100 °C/h	600 - 650 °C or 50 °C below the last tempering temperature.	20 °C/h
Protect against oxidation and decarburisation.	Min. 3 hours.	Slow and uniform cooling in furnace to prevent formation of additional residual stress. Air cooling is possible from approximately 200 °C.

HARDENING:

Hardness after hardening is 50-54 HRC (1680 - 1916 N/mm²).

HEATING	AUSTENITISING	COOLING
25 - 650 °C, 150-220 °C/h 650 - 850 °C, ≤150 °C/h 850 - 1000 °C, ≤150 °C/h	1020-1040 °C	See CCT diagram
Hold in furnace at T = 650 °C / 850°C until $T_{SURFACE}$-T_{CORE} ≤ 110 °C / 60 °C.	Soaking time: 30 min. after soaking of die surface and core: $T_{SURFACE}$-T_{CORE} ≤ 12 °C (25) F, or 90 minutes maximum after die surface reaches the specified hardening temperature, whichever occurs first.	Fast cooling is recommended in pressurized N_2. For large dimensions of hot-work tooling, see NADCA#207 or GM DC-9999-1Rev.18 specification.

⬎ TEMPERING DIAGRAM AND IMPACT TOUGHNESS

Tempering must start immediately after quenching is completed (when part reaches 90-70 °C). Three tempering treatments are recommended. First tempering destabilizes the retained austenite. Second tempering tempers newly formed microstructure constituents.

| HEATING	TEMPERING TEMPERATURE	COOLING
150 °C/h – 250 °C/h	1st: ~550 °C 2nd: choose working hardness (see tempering diagram). 3rd 50 °C bellow 2nd tempering.	Cool in air or in the furnace to room temperature between tempering cycles.
Protect against oxidation, scaling and decarburisation.	1 hour per 25 mm wall thickness based on furnace temperature. Minimum 2 hours.	

TEMPERING DIAGRAMS

sq. 25mm/Tq: 1020 °C/oil ——— HRC
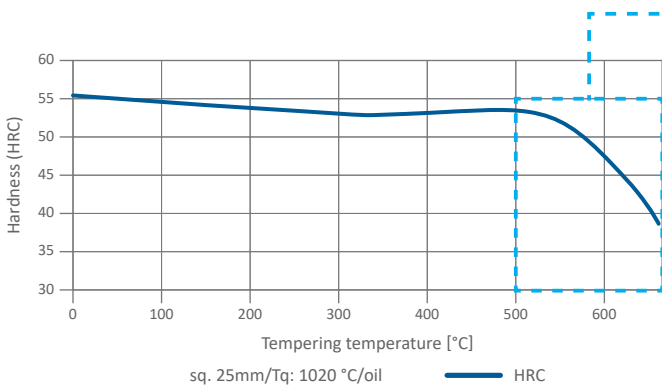
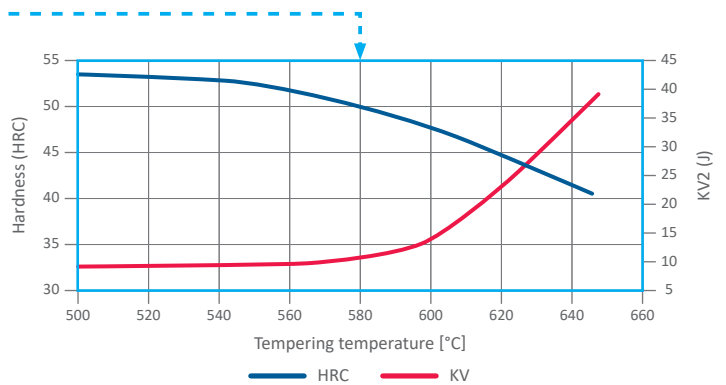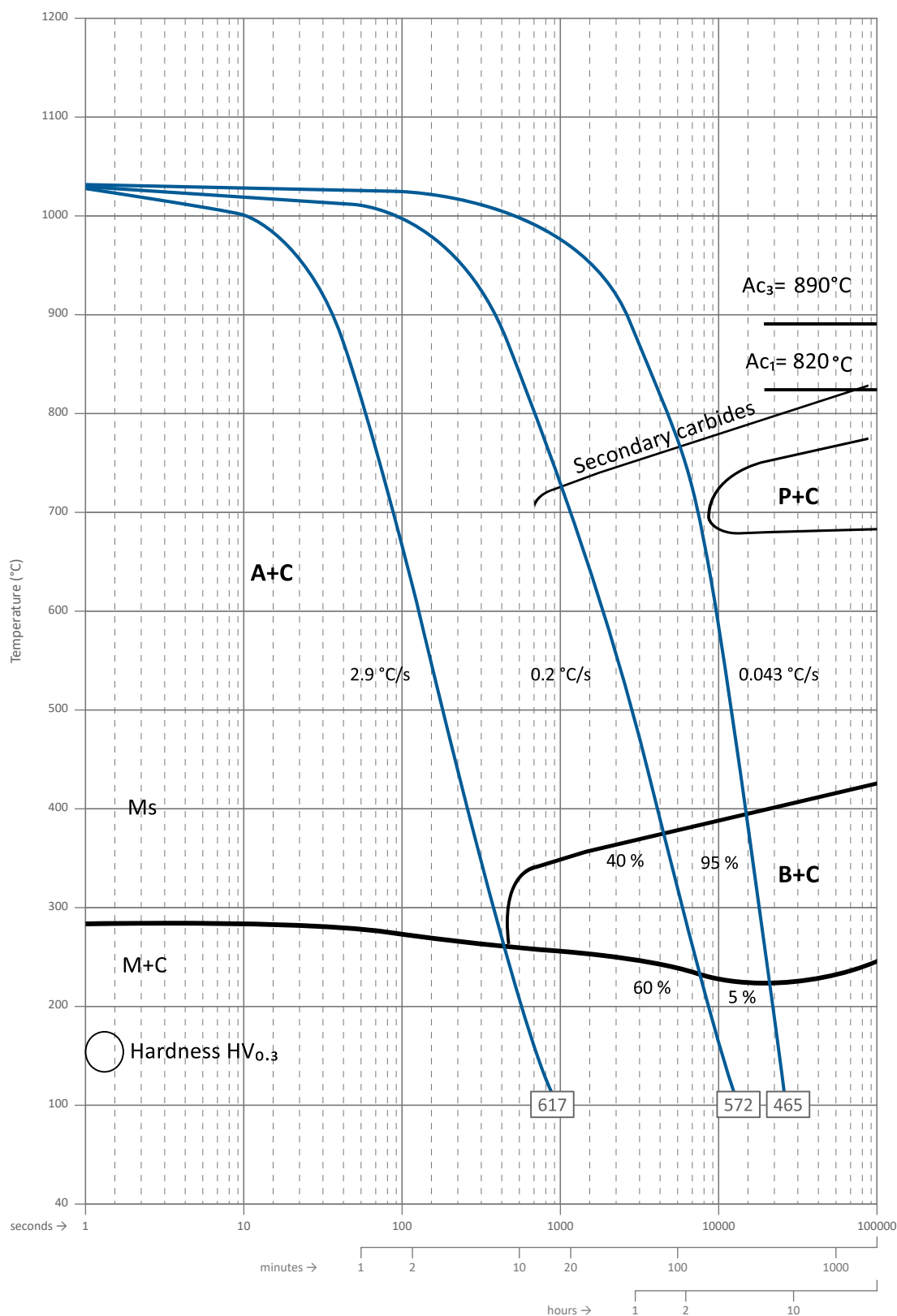Fig. 8: Tempering diagram

——— HRC ——— KV

Fig. 9: Tempering diagram: Hardness HRC and impact toughness KV2

DIMENSIONAL CHANGES DURING HARDENING AND TEMPERING

It is recommended to leave machining allowance before hardening of minimum 0.2 % per dimension, equal in all three directions.

⤵ CONTINUOUS COOLING TRANSFORMATION (CCT) DIAGRAM

Austenitising temperature: 1020 °C; soaking time: 15 min

Legend:
A - Austenite
C - Carbide
P - Pearlite
M - Martensite
B - Bainite

Fig. 12: Continuous cooling transformation (CCT) diagram

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⬂ SURFACE TREATMENT

NITRIDING AND NITROCARBURISING

Nitriding treatment is commonly recommended to enhance surface properties of SITHERM S353R.

Nitriding for hot-work applications is performed by producing a diffusion zone only in the depth depending on application requirements, and completely inhibiting a surface compound layer. Nitriding times are shorter compared to Wr. Nr. 1.2343

Nitriding treatment for plastic molding or cold-work applications with wear resistance requirements is performed by producing a surface compound layer of a composition and thickness as determined by particular application requirements.

For applications with a requirement for additional surface protection, improvement of sliding properties, or improvement of corrosion resistance, it is recommended that oxidation treatment (Fe_3O_4) follows the nitriding.

For details on surface preparation and nitriding parameters to obtain the required surface properties, please consult our certified nitriding specialists.

⬂ DISCLAIMER

The name you can trust

RAVNE QUALITY

VER. 01

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