BÖHLER UDDEHOLM

Datasheet

BOHLER S693/S692 MICROCLEAN® (PM M4)

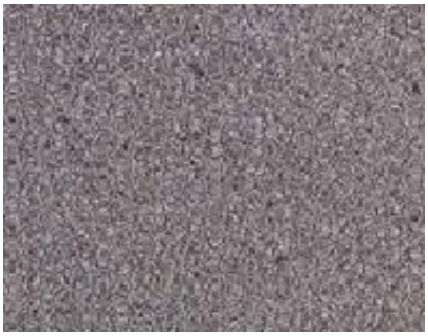
Characteristics

BOHLER S693/S692 MICROCLEAN are high-sulfur and low-sulfur versions of high-carbon PM M4 high speed steel that are produced using state-of-the-art "Generation 3" powder processing technology. This technology provides an exceptional degree of homogeneity and refinement of the primary carbide size distribution in the HIP-consolidated and forged or rolled product compared to conventionally ingot-cast tool steels.

The micro-cleanliness of MICROCLEAN PM is significantly improved compared to other PM tool steels that are not produced using this same technology – which can be critical for high performance tools or non-tooling components that require good surface integrity or optimum fatigue and toughness properties.

Comparison of primary carbide size and distribution (100x magnification)

Powder metallurgy



Conventionally Ingot-Cast HSS

Nominal composition (weight%)

C	Cr	W	Mo	V	S
1.45	4.0	5.60	5.25	4.0	0.03 max*

*Rounds ≥ 2.526" diameter only available in S692 which contains higher Mn and average 0.23 S for improved machining characteristics.

Delivered Condition: Annealed, 280 HB max

Color Code:
S693 MICROCLEAN: Black/Light Blue
S692 MICROCLEAN: Light Blue/Pink

APPLICATIONS

Premium Cutting Tools
- Milling cutters
- Broaches and shaper cutters
- Taps and reamers
- Circular and dovetail form tools

Cold Work Tooling
- Progressive dies
- Fine blanking
- Cold heading
- Roll forming
- Powder pressing
- Slitter knives

PHYSICAL PROPERTIES at 70 °F (20 °C)

Density	0.286 lb/in^3 (7.90 g/cm^3)
Thermal conductivity	11.56 BTU/hr-ft-°F (20 W/m-°K)
Specific heat	0.105 BTU / lb°F (440 J / kg°K)
Electrical resistivity	0.53 Ohm.mm^2/m
Modulus of elasticity	32.7 x 10^6 psi (226 GPa)
Thermal Expansion	(between 70°F / 20°C and...)

Temperature °F / °C	10^{-6} in/in / °F	10^{-6} m/m °C
212 / 100	6.4	11.5
392 / 200	6.5	11.7
572/ 300	6.8	12.2
752 / 400	6.9	12.4
932 / 500	7.0	12.7
1112 / 600	7.2	13.0
1292 / 700	7.2	12.9

This document is intended to provide a general guideline on material selection.
For optimal performance, consult with a Bohler-Uddeholm representative.

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HEAT TREATMENT

Annealing

Protect steel from scaling and/or decarburization. Heat through to 1420-1600°F (770-870°C) and hold for 2 hours. Cool slowly at 30°F (15°C) maximum per hour to 1000°F (540°C), then furnace cool or air cool to room temperature.

Stress relieving

Heat to 1100-1200°F (595-650°C) and hold for 2 hours once equalization has taken place. Cool slowly to 900°F (480°C) then air cool.

Hardening

Preheat (salt bath, vacuum or atmosphere):
FIRST: 1150-1200°F (620-650°C) and equalize.
SECOND: 1500-1575°F (815-855°C) and equalize
THIRD (optional): 1850-1900°F (1010-1040°C) and equalize.

Austenitize: 1875-2200°F (1025-1200°C) Temperature selection depends upon desired hardness after tempering. Soak time at temperature varies with hardening temperature (see chart).

Quench:

Atmosphere: Circulated gas quench to below 1000°F (540°C) / equalize / air cool to approximately 125°F (52°C).

Vacuum: Pressurized gas quench to below 1000°F (540°C) / equalize / continue rapid cooling to approximately 125°F (52°C) removing load from furnace as soon as possible to facilitate heat transfer. Minimum 4 Bar over-pressure recommended to attain optimum heat treat response after tempering.

Salt bath: Interrupted quench in salt or oil at 920-1050°F (490-570°C), followed by second quench at 700-800°F (370-430°C), then air cool to approximately 125°F (52°C).

Tempering: Temper immediately after cooling from the hardening temperature. A minimum of two tempers are required when hardening temperature is below 2100°F (1150°C). Three tempers are required when hardening from 2100°F (1150°C) or above. Hold time for temper is 2 hours once tool is at soak temperature. Air cool between tempers.

For thorough tempering and optimum stress-relieving, tempering in the range 1025-1050°F (550-565°C) is recommended. A final stress relief temper 25-50°F (15-25°C) below the original tempering temperature may be used to prevent hardness loss. Same times at temperatures apply.

Refer to the chart below for a combination of hardening and temperatures to achieve the desired application hardness.

Heat Treat Response (± 1 HRC)

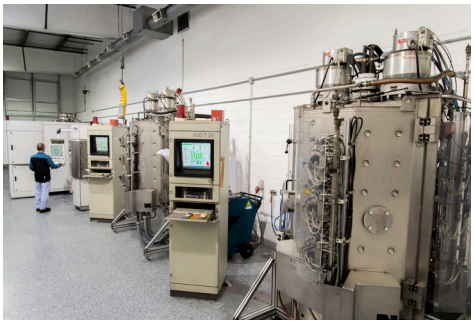
Austenitizing Temperature						
Tempering Temperature	1875°F / 1080°C	1975°F / 1080°C	2050°F / 1120°C	2100°F / 1150°C	2150°F / 1175°C	2200°F / 1205°C
As quenched 100°F / 540°C	59.5 58.5	62.5 61	64.5 62.5	65 63.5	65 65	63.5 66
Optimum for Maximum Tougness and Effective Stress Relieving						
1025°F / 550°C	58	60.5	62	63	64.5	65.5
1050°F / 565°C	57.5	59.5	61	62	63.5	64.5
1100°F / 595°C	54	56	58.5	60	61.5	62.5
1150°F / 620°C	50	53	55	56	58	59
1200°F / 650°C	44	48	51	52	54	55
Results may vary with hardening method and section size. Salt bath will give maximum heat treat response. Vacuum or atmosphere may result in up to 1-2 HRC points lower.						
Min. soak time	45 min	30 min	20 min	15 min	10 min	5 min
No. Tempers	2	2	2	3	3	3

SURFACE TREATMENTS

BOHLER S693/692 MICROCLEAN can be nitrided or coated using standard PVD, CVD or TD coating procedures after heat treatment. CVD and TD coating processes will require re-heat treatment after coating to obtain the desired final hardness.

eifeler COATINGS TECHNOLOGY

eifeler Coatings Technology provides state-of-the-art, Physical Vapor Deposition (PVD) coatings for a variety of tooling applications including metalforming and machining.
www.eifeler.us



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