# DATA SHEET

LATROBE SPECIALTY STEEL COMPANY
Latrobe, PA 15650-0031 USA

# LESCALLOY®
# BG42®
# VIM - VAR

HIGH PERFORMANCE BEARING STEEL
AMS 5749

LATROBE SPECIALTY STEEL COMPANY
Latrobe, Pennsylvania 15650-0031 U.S.A.
Phone: (724) 537-7711 Fax: (724) 532-6316
www.latrobesteel.com

# LESCALLOY® BG42® VIM-VAR

HIGH PERFORMANCE BEARING STEEL
AMS 5749

## A high performance Cr-Mo-V alloy for aircraft gears, ball screws, bearings, and other critical applications.

| TYPICAL | C | Si | Mn | Cr | Mo | V |
|---|---|---|---|---|---|---|
| ANALYSIS | 1.15 | 0.30 | 0.50 | 14.50 | 4.00 | 1.20 |

LESCALLOY BG42 VIM-VAR steel is a martensitic, stainless high speed steel that combines the tempering, hot hardness and hardness retention characteristics of M50 high speed steel with the corrosion and oxidation resistance of type 440C stainless. LESCALLOY BG42 VIM-VAR is double vacuum melted (vacuum induction followed by VAC-ARC® remelting) to consistently assure good cleanliness and superior properties. Although often used for aerospace bearings and other critical applications, its excellent wear resistance and corrosion resistance makes it a superior choice for use in cutlery applications.

This data sheet presents detailed information for LESCALLOY BG42 VIM-VAR steel as well as comparative data for other steels which typically present themselves as competitive candidates for material application. The merits of BG42 VIM-VAR are apparent.

## PHYSICAL PROPERTIES

Density: 0.28 lb/in (7.76 g/cm)
Poisson's Ratio: 0.27

| Temperature | | Modulus of Elasticity | | Modulus of Rigidity | |
|---|---|---|---|---|---|
| °F | °C | $10^6$ psi | $10^3$ MPa | $10^6$ psi | $10^3$ MPa |
| 78 | 26 | 31.99 | 221 | 12.55 | 87 |
| 450 | 232 | 29.95 | 207 | 11.53 | 80 |
| 900 | 482 | 26.19 | 181 | 10.21 | 70 |

**Coefficient of Thermal Expansion**

| Temp Range | | | in/in/°F x $10^{-6}$ | mm/mm/°C $^{-6}$ |
|---|---|---|---|---|
| | °F | °C | | |
| RT from | -100 | -73 | 5.45 | 981 |
| RT from | 0 | -18 | 5.63 | 1013 |
| RT to | 100 | 38 | 5.75 | 1035 |
| RT to | 200 | 93 | 5.96 | 1073 |
| RT to | 300 | 149 | 6.13 | 1103 |
| RT to | 400 | 204 | 6.25 | 1125 |
| RT to | 500 | 260 | 6.36 | 1145 |
| RT to | 600 | 316 | 6.46 | 1163 |
| RT to | 700 | 371 | 6.58 | 1184 |
| RT to | 800 | 427 | 6.67 | 1200 |
| RT to | 900 | 482 | 6.76 | 1217 |
| RT to | 1000 | 538 | 6.85 | 1233 |

## FORGABILITY

Due to the high alloy content of LESCALLOY BG42 VIM-VAR, forging requires care. The recommended forging temperature is 2125-2175°F (1163-1191°C) with a finishing temperature of 1800°F (982°C) minimum. Particular care must be directed at avoiding localized cooling, such as at corners and thin sections. The recommended cooling cycle following forging is: Charge into a furnace at 1600-1625°F (871-885°C), hold two hours. Furnace cool to 1300°F (704°C) in two hours, hold at 1300°F (704°C) for twelve hours. Furnace cool 50°F (28°C) per hour to 1000°F (538°C) or lower. Air cool to room temperature.

## WORKABILITY

LESCALLOY BG42 VIM-VAR should be machined similarly to a high speed steel.

LESCALLOY BG42 VIM-VAR can be cold worked in operations such as upsetting and heading, though in a general sense the cold working of this alloy must be considered difficult compared to that of lower-alloyed steels.

Welding or brazing of LESCALLOY BG42 VIM-VAR should be done in the annealed condition whenever possible. Any of the conventional methods will provide satisfactory results. Austenitic stainless steel welding rod may be used for non-critical welds but when a weldment must be hard to provide abrasion resistance a similar analysis welding rod should be used.

Welding in the heat treated condition is difficult with this alloy but can be accomplished with careful preheating and postheating. Silver soldering also may be done in the heat treated condition but caution should be taken to assure the original tempering temperature is not exceeded.

## METALLURGY

The metallurgy of LESCALLOY BG42 VIM-VAR is that of high speed steel except for how it is influenced by the higher carbon and chromium contents. These additions provide more carbides for improved wear

resistance, with the higher chromium also increasing corrosion resistance. Accordingly, BG42 VIM-VAR is handled like the classic high speed steel, except the higher alloy content requires that a longer austenitizing time be used, along with a refrigeration cycle during heat treatment to minimize retained austenite.

In the annealed condition, the alloy consists of a large volume of spheroidized carbides in a ferrite matrix. After hardening and tempering, the structure consists of approximately 19% by volume of carbide $(Cr,Mo)_{23}C_6$ in a hard martensitic matrix. Some VC type carbides are present, while no $Mo_6C$ or $Cr_7C_3$ types have been detected.

## HEAT TREATMENT

**Annealing:** Heat slowly to 1625-1650°F (885-899°C) and soak thoroughly (5 hours minimum at temperature). Furnace cool 50°F (28°C) per hour to 1100°F (593°C). Continue furnace cool (furnace may be shut off) to 800°F (427°C) to room temperature. Resulting hardness: 269 HBW maximum.

**Hardening and Tempering:** The normal recommendation for hardening and tempering LESCALLOY BG42 VIM-VAR is as follows:

Preheat 1500°F (816°C)
Austenitize 2050°F (1121°C)*
Oil Quench to room temperature or salt quench at 1050°F (566°C), then air cool to room temperature.
Stress relieve at 300°F (149°C)/one hour/air cool.
Refrigerate at -100°F (-73°C)/equalize/air warm.
Double temper at 975°F (524°C)/2 hours each/air cool.
Resulting hardness: 61-64 HRC.

*Time is 30 minutes at temperature. BG42 VIM-VAR requires a longer time cycle than normally associated with high speed steel.

The refrigeration cycle is incorporated into the treatment to assist in the transformation of retained austenite. To minimize the danger of cracking, the stress relief has been installed at no sacrifice of subsequent hardness response. Multiple tempering, perhaps four times, is recommended when minimum retained austenite is essential.

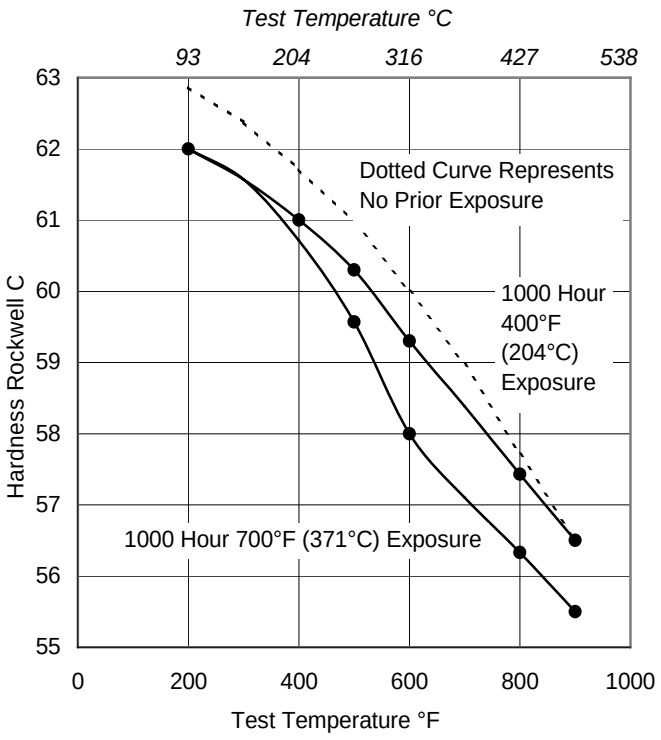
NOTE: All data presented in this brochure for BG42 VIM-VAR has been generated from material heat treated in the above manner.

## HOT HARDNESS AFTER EXPOSURE

Supplementing short time data shown elsewhere, presented here are elevated temperature hardness data after a long time exposure at 400°F (204°C) and 700°F (371°C). For comparison, data from specimens with no prior exposure are also presented.

### LESCALLOY BG42 VIM-VAR HOT HARDNESS

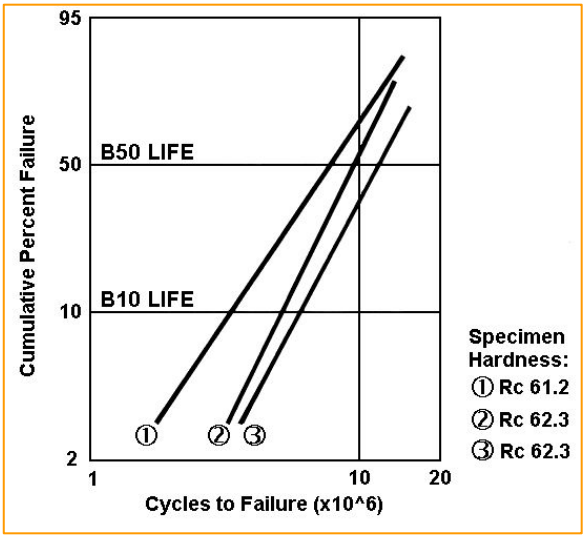
Hot Hardness Data for BG42 After 1000 Hour Exposure at 400°F (204°C) and 700°F (371°C)




## FATIGUE RESISTANCE

Detailed studies have characterized the rolling contact fatigue properties of BG42 VIM-VAR. The Rc Rig test has been selected to generate applicable data; information for three heats is presented here:
Test conditions were as follows:

Stress: 700,000 psi (4830 MPa) maximum Hertzian stress
Speed: 20,000 stress cycles/minute
Lubricant: MIL-L-7808 (Stauffer)
Test temperature: Room temperate
Tester wheel finish: 8-10 microinch (ground)
Specimen hardness-HRC: ①61.2 ②62.3 ③62.3



## CORROSION RESISTANCE

Available data indicate the corrosion resistance of BG42 VIM-VAR heat treated for maximum hot hardness at elevated temperature, as detailed elsewhere in this brochure, is equal or slightly superior to that of standard AISI 440C with either a 400°F (204°C) or a 900°F (482°C) temper. Obviously then, it is significantly superior to AISI 52100 or M50 in this regard.

## OXIDATION RESISTANCE

Resistance to oxidation is associated with the amount of chromium content in the alloy. Classically, 12% chromium content assures resistance to scaling; thus, BG42 VIM-VAR exhibits this beneficial characteristic.

## DIMENSIONAL STABILITY

The dimensional stability of BG42 VIM-VAR is excellent. Tests conducted at 800°F (427°C) for 1250 hours have described a minimum growth of 0.00008 inches/inch (0.00008 mm/mm).

## The Need for Tomorrow's Steel … NOW

The selection of LESCALLOY BG42 VIM-VAR for critical aerospace bearing applications is logical. It was originally applied to jobs where no other material would provide satisfactory performance, such as jet engine thrust reverser bearing mechanisms which demand resistance to wear, corrosion and elevated temperatures up to 900°F (482°C). BG42 is specified for applications where it is simply more effective and more reliable than competitive steels.

For example, BG42 ball bearings are in both domestic and worldwide service in advanced military aircraft, both wide body and supersonic. Specific applications include pneumatic actuator motor rotors, pneumatic valves, gearbox and ball screw support bearings.

## COMPARING CANDIDATES… BG42 IS BEST

Shown below is an evaluation of five candidate steels. They are graded on six critical properties required by their in-service demands. The (•) symbol denotes relative superiority.

| Property | 52100 | M50 | 440C | 440C Mod. | BG42 VIM-VAR |
|---|---|---|---|---|---|
| Hardness | • | • | • | • | • |
| Hot Hardness | | • | | | • |
| Red Hardness | | • | | | • |
| Corrosion Resistance | | | • | • | • |
| Oxidation Resistance | | | • | • | • |
| Wear Resistance | | | | | • |

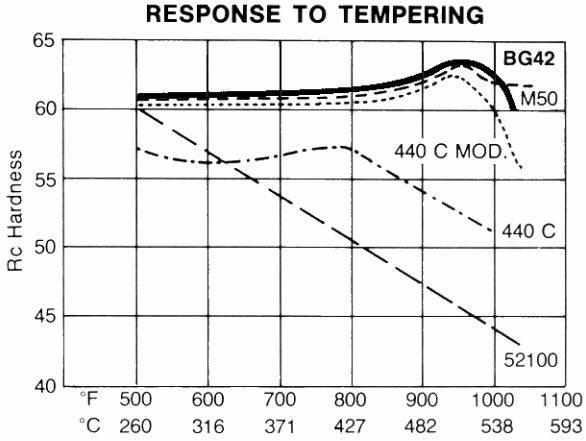
## COMPARISONS

To put the characteristics of LESCALLOY BG42 VIM-VAR in perspective, comparisons are presented here for chemistry, tempering response, hot hardness and room temperature hardness after long time exposure at elevated temperature.

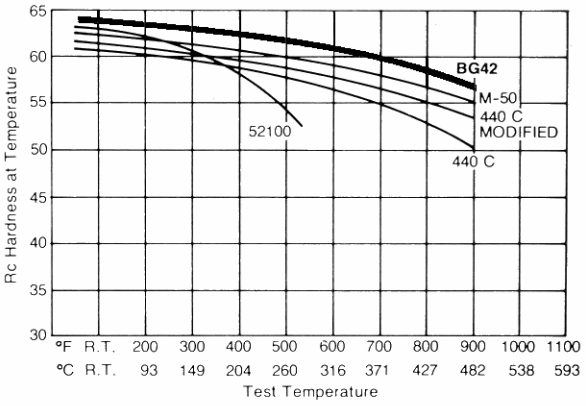
## COMPARISON OF CHEMISTRIES

| Grades | C | Cr | Mo | V |
|---|---|---|---|---|
| 52100 | 1.00 | 1.50 | - | - |
| M50 | 0.85 | 4.1 | 4.5 | 1.0 |
| 440C | 1.04 | 17.1 | 0.5 | - |
| 440C Modified | 1.15 | 14.5 | 4.0 | - |
| BG42 | 1.15 | 14.5 | 4.0 | 1.20 |

**RESPONSE TO TEMPERING**

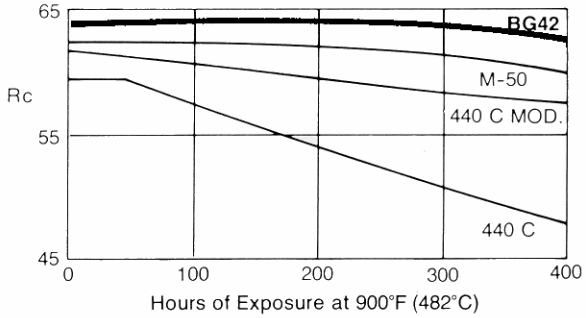



**HOT HARDNESS**




**Note:** 52100 has virtually no resistance to softening at 900°F (482°C)

**ROCKWELL C ROOM TEMPERATURE AFTER EXPOSURE AT 900°F (482°C)**




**Note:** 52100 has virtually no resistance to softening at 900°F (482°C)