SAB BEARINGS TECHNICAL ATTRIBUTES
SPEED, HEAT AND TORQUE SPEED RATINGS

There is no precise method for determining the maximum speed at which a bearing may operate. Bearing characteristics and features of surrounding parts, shafts, housing and other components as well as basic service conditions, are all variables dependent upon each other for continued satisfactory high-speed performance.

The safe operating speed of a bearing is often limited by the temperature within the bearing, which in turn is often dependent upon the temperature surrounding the application, accuracy of the bearings, shafts, housings, auxiliary parts and the type and amount of lubricant.

Bearings with proper internal refinements will operate at high speeds for long periods if properly installed and lubricated. Tolerance grade, cage design, and lubricant are bearings characteristics that affect speed limitations.

High speed applications require consideration of proper tolerance grade, lubrication, the effect of centrifugal force on rolling elements and other factors.

Conversely, under certain application conditions of load, temperature, contamination, etc., speed capabilities may be less than published within.

For spherical roller bearings, the thermal speed ratings are listed in the bearing tables. These values have been determined by balancing the heat generated within the bearing with the heat dissipated from the bearing. In calculating these numbers, the following assumptions can be made:

- The radial load is 5 percent of the static load rating.
- For oil, it is assumed to be in a bath with the fill to the middle of the lowest rolling element. For grease it is assumed a 30 percent bearing cavity fill.
- The oil viscosity* is assumed to be 12 cSt (ISO VG 32) operated at 70˚ C, (158˚ F) and the grease base oil viscosity is assumed to be 22 cSt operated at 70˚ C (158˚ F). The bearing and its components are at 70˚ C (158˚ F) and the bearing environment is at 20˚ C (68˚ F).

- The housing and shaft are steel or cast iron.
- The bearing rotational axis is horizontal.
- The outer ring is stationary, and the inner ring is rotating.
- The bearing radial internal clearance complies with class normal and standard fits are used.
- The bearing does not contain seals.
- The bearing does not experience misalignment or axial load. The speed ratings are for reference only and can be considerably lower or higher depending on your application.

Oil Viscosity*

Multiply with					
Convert from	Convert to				
	Poise (P)	*centiPoise (cP)*	*Reyn*	*Stoke (cm^2/sec)*	*centiStoke*
Poise (P)	1	100	$1.45\ 10^{-5}$	1 / *SG*	100 / *SG*
centiPoise (cP)	0.01	1	$1.45\ 10^{-7}$	0.01 / *SG*	1 / *SG*
Reyn	$6.9\ 10^{4}$	$6.9\ 10^{6}$	1	$6.9\ 10^{4}$ / *SG*	$6.9\ 10^{6}$ / *SG*
Stoke (cm^2/sec)	*SG*	100 *SG*	$1.45\ 10^{-5}$ *SG*	1	100
centiStoke	0.01 *SG*	*SG*	$1.45\ 10^{-7}$ *SG*	0.01	1

SG = specific gravity of the oil

1 Stoke = 100 mm^2/second

Example - Convert Viscosity in Stokes to centiStoke
Oil with kinematic viscosity *0.1 Stoke (10 mm^2/s)* equals to

0.1 Stoke (100 centiStoke/Stoke) = 10 centiStokes

Operating Temperatures

Temperature Limitations
Bearing equilibrium temperature is not simply a question of speed. It is also dependent on the heat generation rate of all contributing heat sources, nature of the heat flow between sources, and heat dissipation rate of the system. Seals, gears, clutches, and oil supply temperature affect bearing operating temperature.

Heat dissipation rate is governed by such factors as type of lubrication system; materials and masses of the shaft and housing and intimacy of contact with the bearing; and surface area and character of the fluid both inside and outside the housing.

Temperature of the outer surface of the housing is not an accurate indication of bearing temperature. The inner ring temperature is often greater than the outer ring temperature and both are usually greater than the outer surface of the housing. There are temperature gradients within the bearing, with the temperature of the internal parts usually being greater than the outer surfaces. Although the temperature of the outer ring O.D., the inner ring I.D., or the oil outlet often used as an indicator of bearing temperature, it should be recognized that these are generally not the highest bearing temperatures.

During transient conditions, such as at start up, bearing temperatures will often peak and then reduce to a lower level. This is due to the thermal changes taking place between the bearing, shaft and housing, causing variations in internal clearance and internal loading. Also, a new bearing will usually generate more heat until it runs in.
The allowable operating temperature depends on:

- Equipment requirements
- Lubrication limitations
- Bearing material limitations
- Reliability requirements

Each factor is an area of increasing concern as operating temperatures rise.
The equipment designer must decide how operating temperature will affect the performance of the equipment being designed. Precision machine tools, for example, can be very sensitive to thermal expansions.

In many cases it is important that the temperature rise over ambient be minimized and held to 20 to 25° C (36 to 45° F) for some precision spindles.
Most industrial equipment can operate satisfactorily with considerably higher temperature rises. Thermal ratings on gear drives, for example, are based on 93° C (200° F). Some equipment such as plastic calendars and gas turbine engines operate continuously at temperatures well above 100° C (212° F).
Standard bearing steels cannot maintain the desired minimum hot hardness of 58 Rc much above 135° C (275° F).

SAB spherical roller bearings are dimensionally stabilized up to 200° C (392° F). Although bearings can operate satisfactorily at higher temperatures, an upper temperature limit of 80 to 95°C (176 to 203°F) is usually more practical for small, high volume equipment where prototype testing is possible. Higher operating temperatures increase the risk of damage from some unforeseen, transient condition. If prototype testing is not practical, an upper design limit of 80°C (176°F) is appropriate, unless prior experience on similar equipment suggests otherwise.

It is the responsibility of the equipment designer to weigh all relevant factors and make the final determination of what operating temperature is satisfactory for a particular machine.

SAB technical team depending on the application, selects the steel materials for use in rings and rollers at various operating temperatures with data on chemical composition, hardness, and dimensional stability.

Heat Generation and Dissipation

One of the major benefits of oil-lubricated systems is that the heat generated by the bearings is carried away by the circulating oil and dissipated through the system.
Heat Generation Under normal operating conditions, most of the torque and heat generated by the bearing is due to the elastic hydrodynamic losses at the roller/race contacts.

Heat Dissipation

The heat dissipation rate of a bearing system is affected by many factors. The modes of heat transfer need to be considered. Major heat transfer modes in most systems are conduction through the housing walls, convection at the inside and outside surfaces of the housing, and convection by the circulating lubricant.
In many applications, overall heat dissipation can be divided into two categories.

a. Heat removed by circulating oil and Heat removed through the housing.
b. Heat Dissipation by Circulating Oil

Other Considerations

Until now, temperature limitation has been discussed with reference to metallurgical considerations.
However, installations which operate at high temperatures for extended periods may lose the quality of shaft and housing fits. Carefully machined and heat-treated shafts and housings will minimize trouble from this source. In some applications the internal clearance of bearings may be partially absorbed.

For example, during the first few seconds of rotation, a massive housing may keep the outer race cooler than the inner race and rolling elements even if the housing is already at some elevated temperature.

Also, during heat soak back when rotation stops, heat may flow back to the bearing along the shaft. If, while stationary, the effects of heat soak back more than remove the radial internal clearance, radial brinell of the races may occur, and the bearing will be rough during subsequent rotation. Bearings with extra internal looseness may be required to compensate for the above conditions.