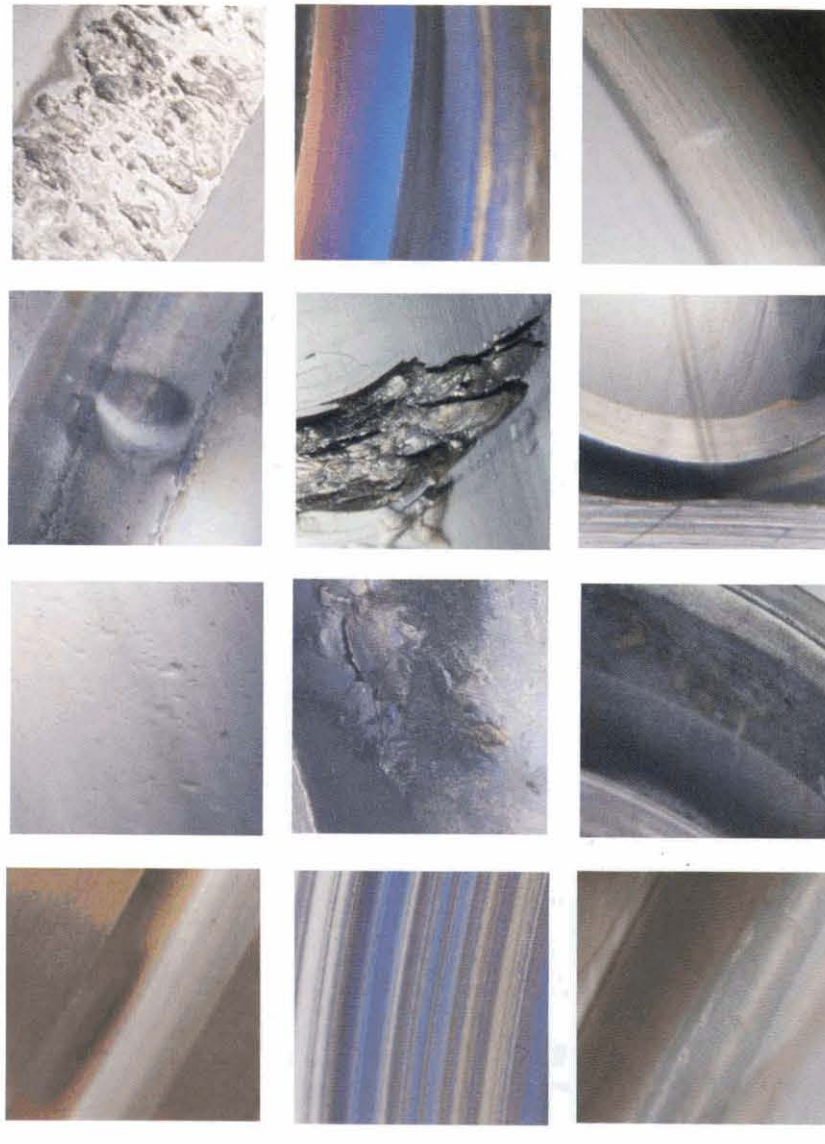
BEARING FAILURE: CAUSES AND CURES

BARDEN PRECISION BEARINGS



BARDEN
PRECISION
BEARINGS

Identifying and correcting causes of bearing failure.

Precision ball bearings are designed to have a long and useful life. Assuming the application is correct to begin with, maximizing longevity means bearings must be properly installed, lubricated and maintained. Poor operating environments, particularly moist or contaminated areas, and improper handling practices invite premature bearing failure.

When a bearing does fail, it is important to determine the *exact* cause so appropriate adjustments can be made. Examination of the failure mode often reveals the true cause of failure. This procedure is complicated by the fact that one failure mode may initiate another. For example, corrosion in a ball race leaves rust—an abrasive—which can cause wear, resulting in loss of preload or an increase in radial clearance. The wear debris can, in a grease-lubricated bearing, impede lubrication, resulting in lubrication failure and subsequent overheating.

This guide will assist in properly identifying and analyzing 12 primary causes of bearing failure. Each characteristic is described in detail and is shown in diagram form, accompanied by a color photograph. Flaws, in most cases, are readily apparent. In some cases, the imperfections may be virtually invisible to the naked eye. Specific remedies for each situation are also suggested.

Your Authorized Barden Representative will be happy to provide you with additional assistance upon request.

EXCESSIVE LOAD
Premature spalled area in ball path.

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OVERHEATING
Discoloration of rings, balls and cages.

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FALSE BRINELLING
Elliptical wear marks at each ball position.

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TRUE BRINELLING
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Heavy ball wear path at bottom of raceways.

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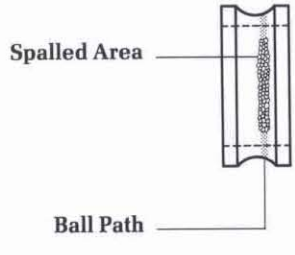
Severe spalling due to excessive load.

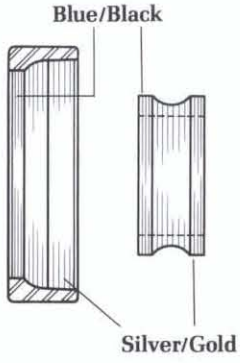
EXCESSIVE LOADS



Excessive loads usually cause premature fatigue. Tight fits, brinelling and improper preloading can also bring about early fatigue failure, (see Tight Fits, p. 15 and True Brinelling, p. 7). This type of failure looks the same as normal fatigue, although heavy ball wear paths, evidence of overheating and a more widespread spalling (fatigue area) are usually evident with shortened life.

The solution is to reduce the load or redesign using a bearing with greater capacity.

OVERHEATING

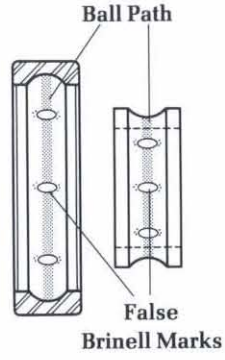


Symptoms are discoloration of the rings, balls, and cages from gold to blue. Temperatures in excess of 400°F can anneal the ring and ball materials. The resulting loss in hardness reduces the bearing capacity causing early failure. In extreme cases, balls and rings will deform. The temperature rise can also degrade or destroy lubricant.

Common culprits are heavy electrical heat loads, inadequate heat paths, and insufficient cooling or lubrication when loads and speeds are excessive. Thermal or overload controls, adequate heat paths, and supplemental cooling are effective cures.

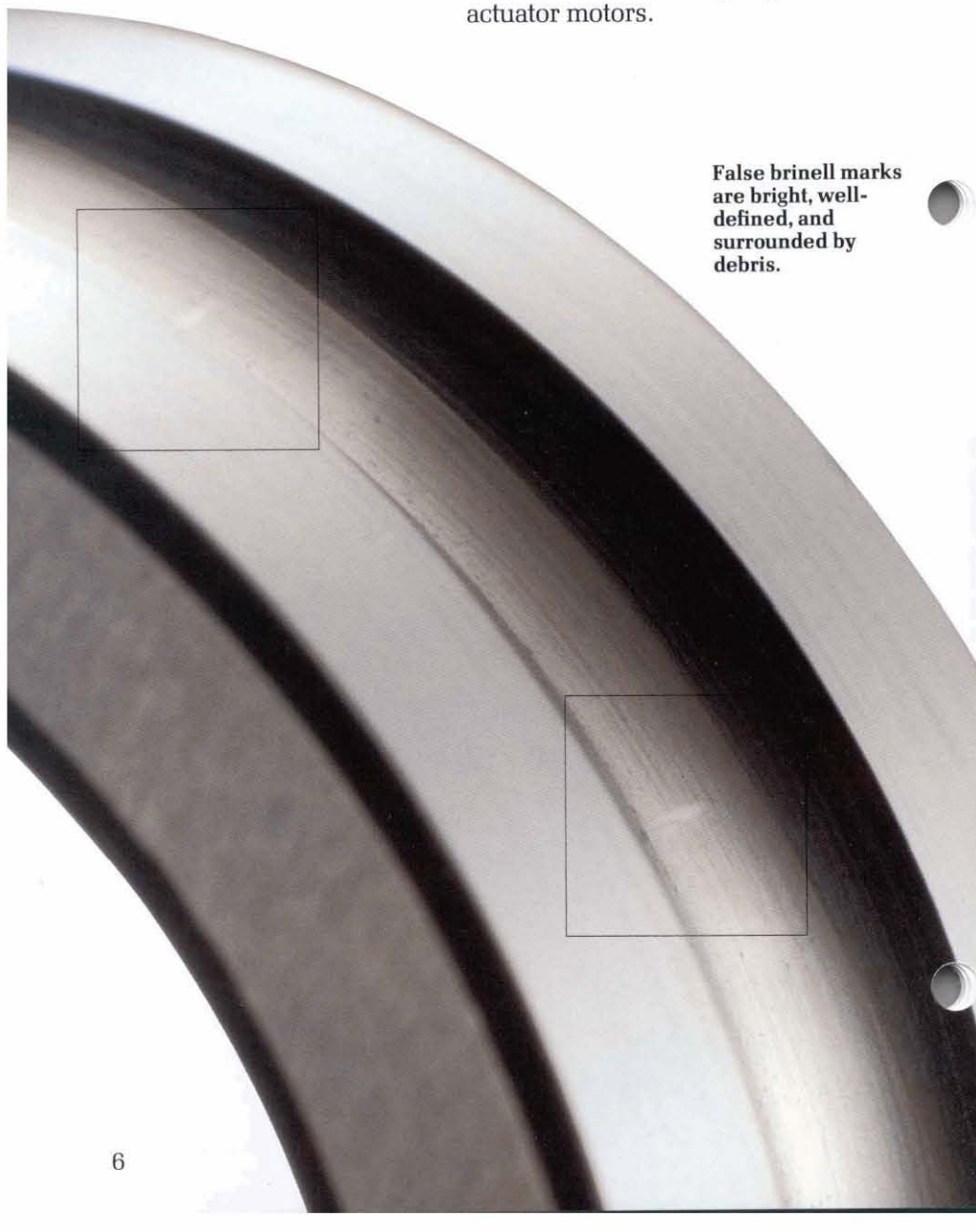
Look for blue/black and silver/gold discoloration. Balls will usually be blue/black.

FALSE BRINELLING



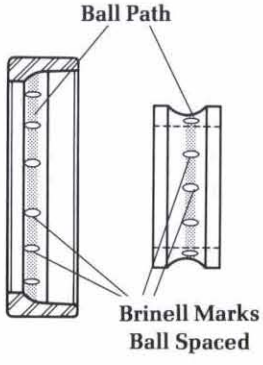
False brinelling—elliptical wear marks in an axial direction at each ball position with a bright finish and sharp demarcation, often surrounded by a ring of brown debris—indicates excessive external vibration. A small relative motion between balls and raceway occurs in non-rotating ball bearings that are subject to external vibration. When the bearing isn't turning, an oil film cannot be formed to prevent raceway wear. Wear debris oxidizes and accelerates the wear process.

Correct by isolating bearings from external vibration, and using greases containing antiwear additives such as molybdenum disulfide when bearings only oscillate or reverse rapidly as in actuator motors.



False brinell marks are bright, well-defined, and surrounded by debris.

TRUE BRINELLING



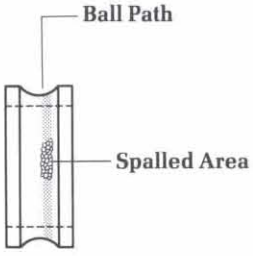
Brinelling occurs when loads exceed the elastic limit of the ring material. Brinell marks show as indentations in the raceways which increase bearing vibration (noise). Severe brinell marks can cause premature fatigue failure.

Any static overload or severe impact can cause brinelling. Examples include: using hammers to remove or install bearings, dropping or striking assembled equipment, and pressing a bearing onto a shaft by applying force to the outer ring.

Install bearings by applying force only to the ring being press-fitted, i.e., do not push the outer ring to force the inner ring onto a shaft.

Careful handling and installation practices can minimize or eliminate true brinelling problems.

NORMAL FATIGUE FAILURE



Fatigue failure—usually referred to as spalling—is the fracture of the running surfaces and subsequent removal of small, discrete particles of material.

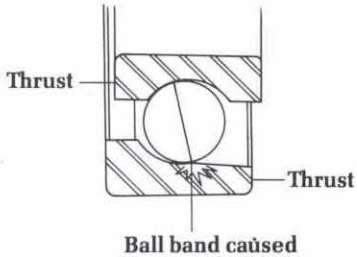
Spalling can occur on the inner ring, outer ring, or balls. This type of failure is progressive and once initiated will spread as a result of further operation. It will always be accompanied by a marked increase in vibration, indicating an abnormality.

The remedy is to replace the bearing or consider redesigning to use a bearing having a greater calculated fatigue life.

Moderately spalled area indicates bearing has reached the limits of its useful life.

Thrust load applied to wrong faces results in wear band on balls.

REVERSE LOADING



Ball band caûsed by ball riding over edge of raceway.

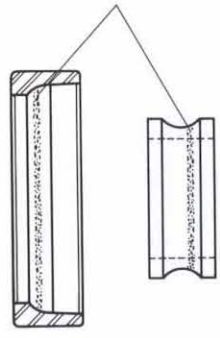
Angular contact bearings are designed to accept an axial load in one direction only. When loaded in the opposite direction, the elliptical contact area on the outer ring is truncated by the low shoulder on that side of the outer ring. The result is excessive stress and an increase in temperature, followed by increased vibration and early failure.

Failure mode is very similar to that of heavy interference (tight) fits. The balls will show a grooved wear band caused by the ball riding over the outer edge of the raceway.

Corrective action is to simply install the bearing correctly. Angular contact bearings must be installed with the resultant thrust on the wide face—which is marked "thrust"—of the outer ring and the opposite face of the inner ring.

CONTAMINATION

Irregular dents or material embedded in raceways.



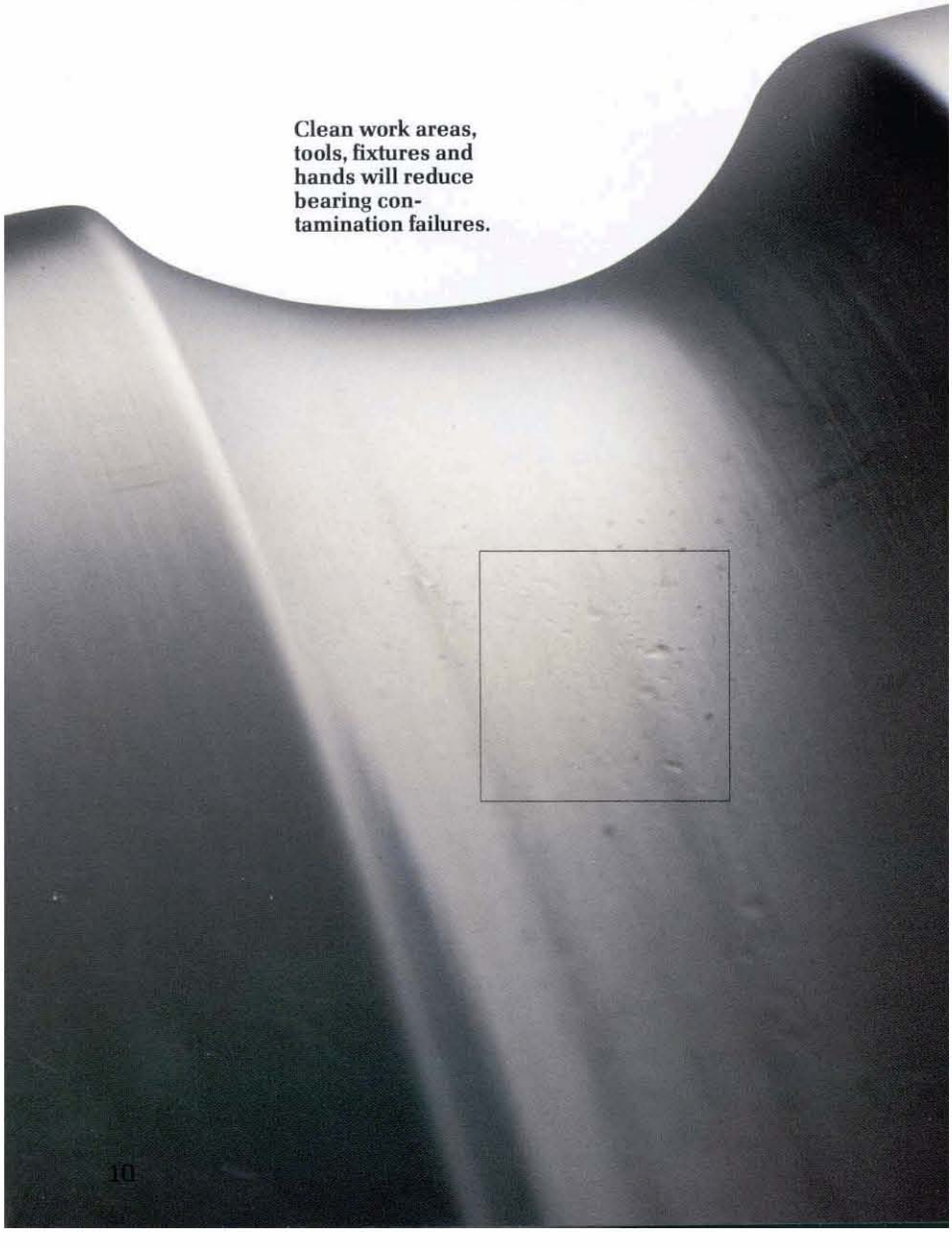
Balls will be similarly dented, dull, or scratched.

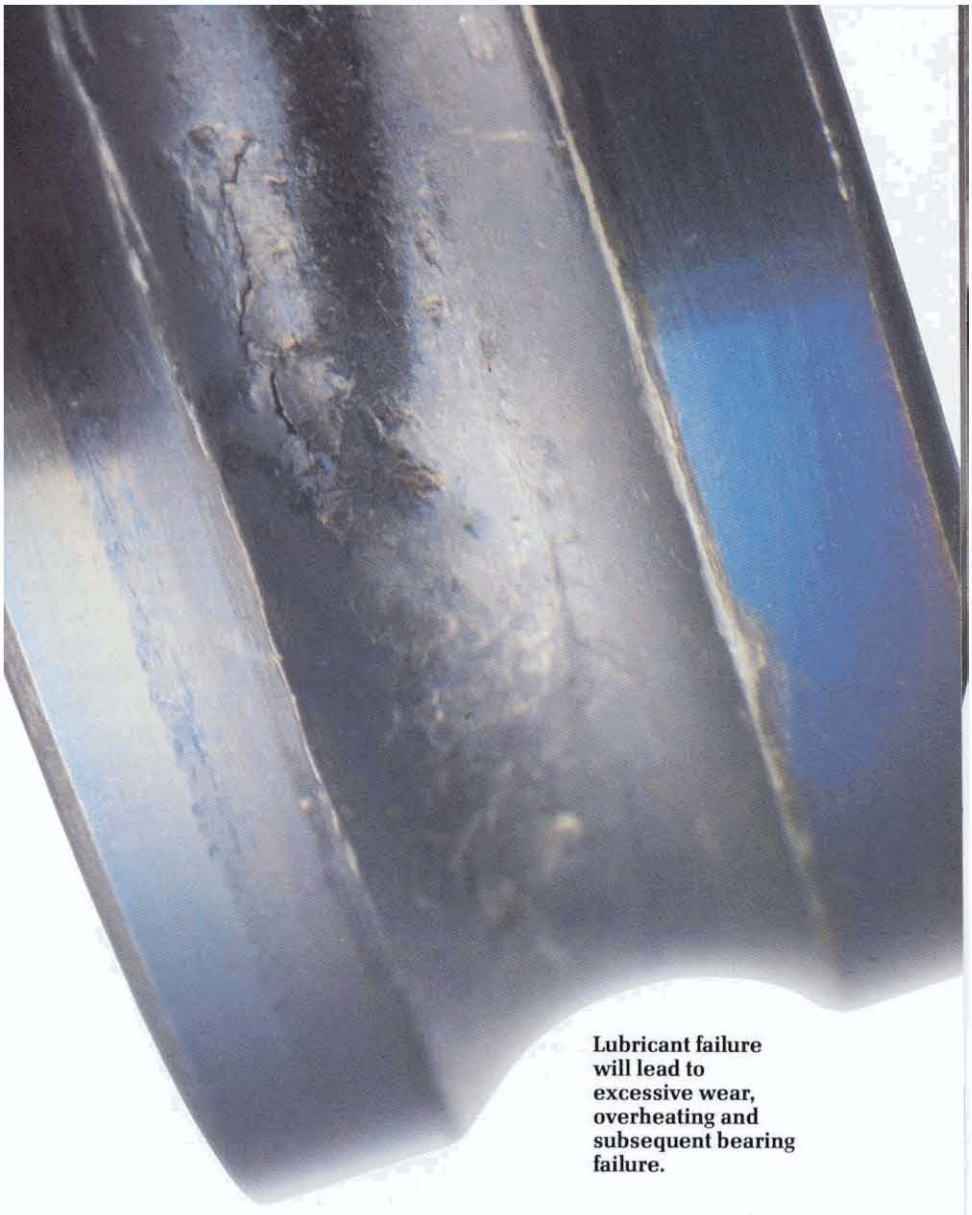
Contamination is one of the leading causes of bearing failure. Contamination symptoms are denting of the bearing raceways and balls resulting in high vibration and wear.

Contaminants include airborne dust, dirt or any abrasive substance that finds its way into the bearing. Principal sources are dirty tools, contaminated work areas, dirty hands and foreign matter in lubricants or cleaning solutions.

Clean work areas, tools, fixtures and hands help reduce contamination failures. Keep grinding operations away from bearing assembly areas and keep bearings in their original packaging until you are ready to install them. Seals are critical—damaged or inoperative seals cannot protect bearings from contamination.

Clean work areas, tools, fixtures and hands will reduce bearing contamination failures.

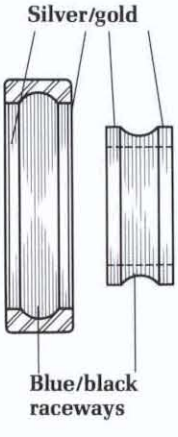




Lubricant failure will lead to excessive wear, overheating and subsequent bearing failure.

LUBRICANT FAILURE

Balls will also be blue/black.

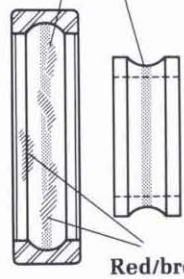


Discolored (blue/brown) ball tracks and balls are symptoms of lubricant failure. Excessive wear of balls, ring, and cages will follow, resulting in overheating and subsequent catastrophic failure.

Ball bearings depend on the continuous presence of a very thin—millionths of an inch—film of lubricant between balls and races, and between the cage, bearing rings, and balls. Failures are typically caused by restricted lubricant flow or excessive temperatures that degrade the lubricant's properties.

Barden engineers can advise users on the most suitable lubricant type and quantity to use. Refer to lubricant section of Barden C-10 catalog for more information. Also, any steps taken to correct improper fit, control preload better, and cool the shafts and housings will reduce bearing temperatures and improve lubricant life.

CORROSION



Red/brown areas on balls, raceways, cages, or bands of ball bearings are symptoms of corrosion. This condition results from exposing bearings to corrosive fluids or a corrosive atmosphere. The usual result is increased vibration followed by wear, with subsequent increase in radial clearance or loss of preload. In extreme cases, corrosion can initiate early fatigue failures.

Correct by diverting corrosive fluids away from bearing areas and use integrally sealed bearings whenever possible. If the environment is particularly hostile, the use of external seals in addition to integral seals should be considered. The use of stainless steel bearings is also helpful.

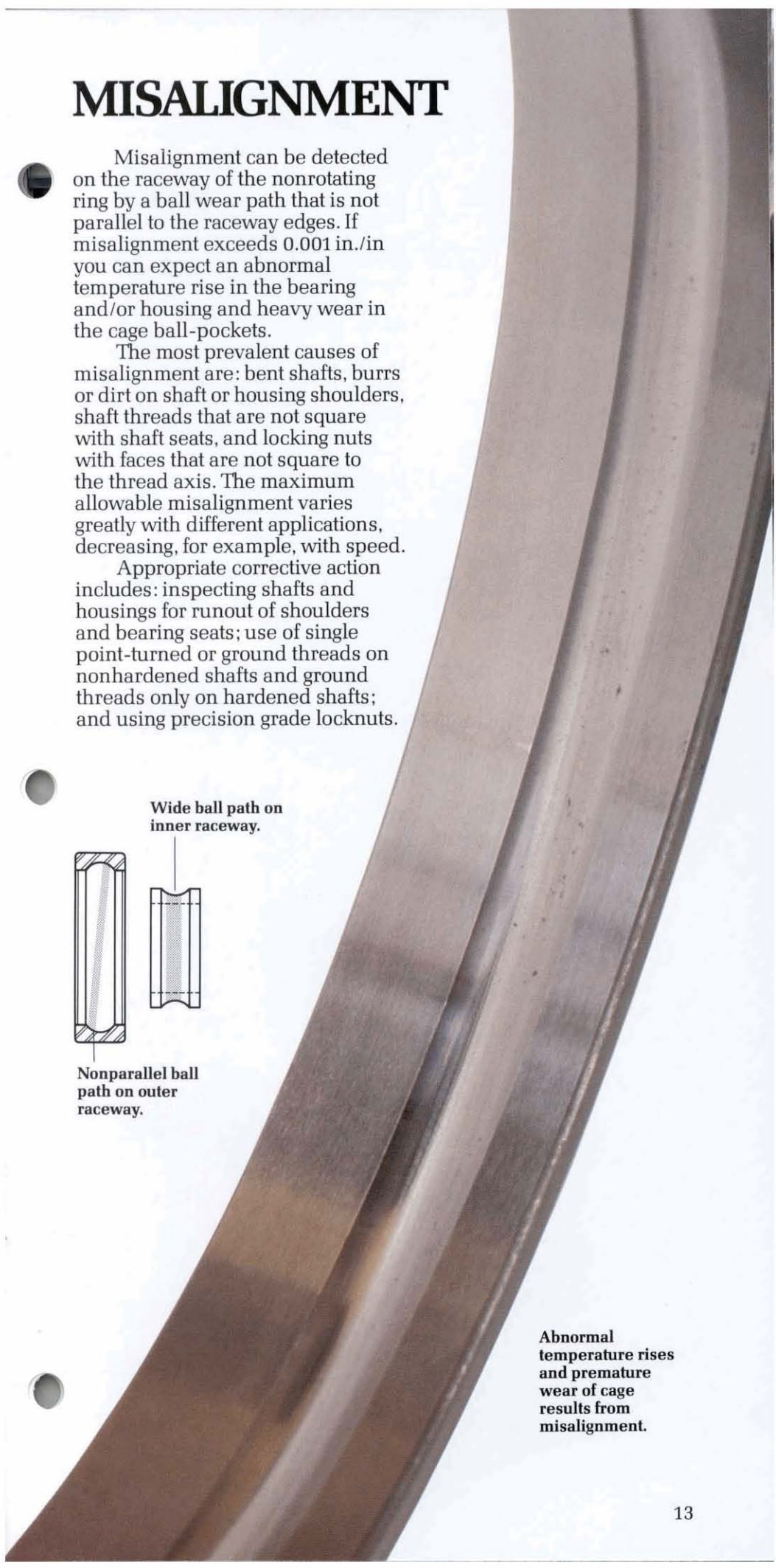
Corrosion results from the chemical attack on the metal by hostile fluids or atmospheres.

MISALIGNMENT

Misalignment can be detected on the raceway of the nonrotating ring by a ball wear path that is not parallel to the raceway edges. If misalignment exceeds 0.001 in./in you can expect an abnormal temperature rise in the bearing and/or housing and heavy wear in the cage ball-pockets.

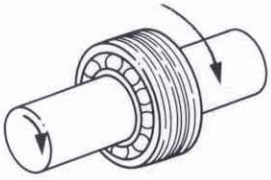
The most prevalent causes of misalignment are: bent shafts, burrs or dirt on shaft or housing shoulders, shaft threads that are not square with shaft seats, and locking nuts with faces that are not square to the thread axis. The maximum allowable misalignment varies greatly with different applications, decreasing, for example, with speed.

Appropriate corrective action includes: inspecting shafts and housings for runout of shoulders and bearing seats; use of single point-turned or ground threads on nonhardened shafts and ground threads only on hardened shafts; and using precision grade locknuts.



Abnormal temperature rises and premature wear of cage results from misalignment.

LOOSE FITS



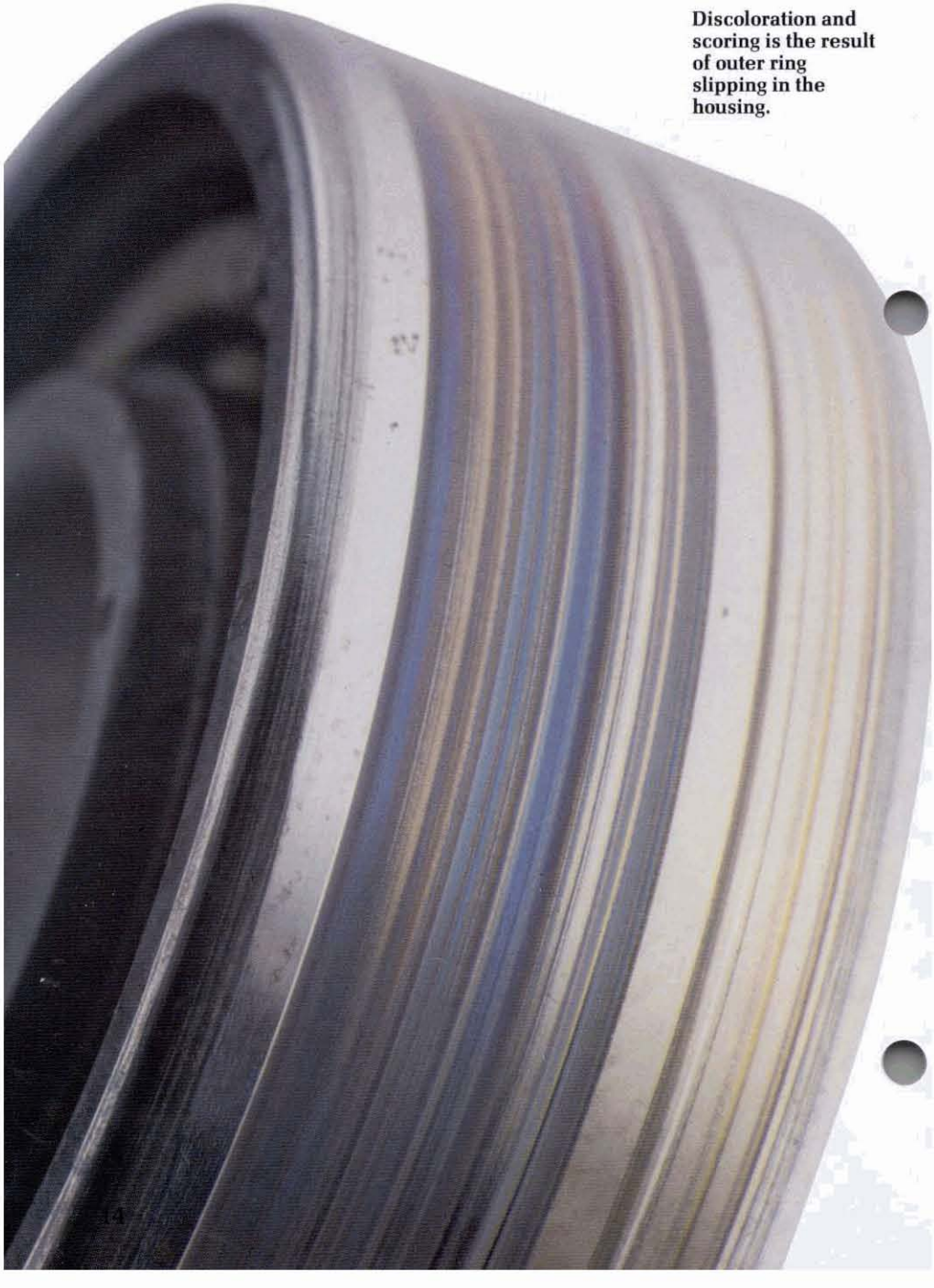
Outer ring slippage caused by improper housing fits.

Loose fits can cause relative motion between mating parts. If the relative motion between mating parts is slight but continuous, fretting occurs.

Fretting is the generation of fine metal particles which oxidize, leaving a distinctive brown color. This material is abrasive and will aggravate the looseness. If the looseness is enough to allow considerable movement of the inner or outer ring, the mounting surfaces (bores, outer diameters, faces) will wear and heat (see photo), causing noise and runout problems.

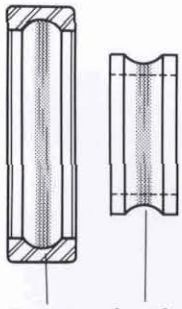
Consult Barden C-10 catalog or Barden Engineering for fit recommendations.

Discoloration and scoring is the result of outer ring slipping in the housing.



Heavy ball path wear indicates tight fit.

TIGHT FITS



Discolored, wide ball path at bottom of raceways.

A heavy ball wear path in the bottom of the raceway around the entire circumference of the inner ring and outer ring indicates a tight fit.

Where interference fits exceed the radial clearance at operating temperature, the balls will become excessively loaded. This will result in a rapid temperature rise accompanied by high torque. Continued operation can lead to rapid wear and fatigue.

Corrective action includes a decrease in total interference—better matching of bearings to shafts and housings—taking into consideration the differences in materials and operating temperatures. Increased radial clearance will also increase bearing life under the above conditions.