SKF steel and heat treatment solutions

Contents


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This brochure gives an overview of the most common steel and heat treatment solutions used by SKF. The purpose of this brochure is to illustrate the particular strengths of each solution and to indicate the likely application conditions where they could be used.

The classic 1% carbon 1,5% chromium bearing steel, called Grade 3 by SKF, has existed for over 100 years. The reason for its longevity is due to the attractive combination of availability, ease of manufacture and good bearing performance in conditions involving rolling contact fatigue. Despite this, for certain application conditions, there is a need for improved properties. These improvements can be achieved by altering the heat treatment process for the Grade 3 steel or by employing alternative steel and heat treatment combinations. As a result, SKF has a broad portfolio of steel and heat treatment solutions which are described in this brochure. Note that advice from materials experts must be sought when selecting solutions as there are additional factors related to economics, geography and supply logistics which are not covered in this overview.

The **first section** is a table showing the common names used for some SKF steel grades and the equivalent steel designations.

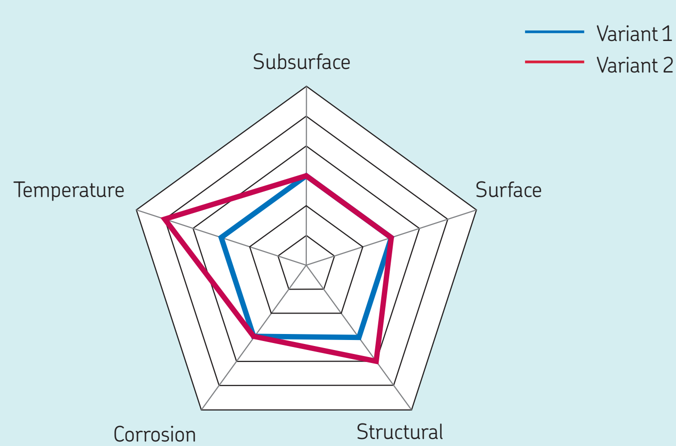
The **second section** gives a brief description of the characteristics of the hardening heat treatment processes most commonly used by SKF.

The **third section** focuses on the most commonly encountered application conditions and illustrates that there is more than one potential steel and heat treatment solution for each condition.

The **fourth section** describes the steel and heat treatment combinations. For each combination, a specific steel grade is given as an example. However, this does not exclude other steel grades from being used.

For each solution, a radar plot shows the relative performance, as indicated in the example below.

- Sub-surface initiated fatigue
  - High load, full film lubrication
- Surface initiated fatigue
  - Thin film lubrication
  - Particle contaminated lubrication
- Structural fatigue
  - High interference fits
  - Bending due to flexible housings
- Corrosion
- Elevated temperature



A specific steel grade will be used for the actual radar plots

Table of equivalent steel compositions

SKF designation	Comparable steel designation (composition)	Common SKF name(s)
Through hardening steels		
Grade 3	100Cr6, 52100, SUJ2, GCr15, 1. 3505	
Grade 24	100CrMo7, 1.3537	
Grade 4	100CrMnSi6-4, 1.3520	
Grade 5	100CrMo7-3, 1.3536	
Grade 6	100CrMo7-4, 1.3538	
Grade 7	100CrMnMoSi8-4-6, 1.3539	
Surface hardening steels		
Grade 152	20MnNiCrMo3-2, 8620H, 1.6522	
Grade 157	20NiCrMo7, 4320H, 1.3576	
Grade 159	18CrNiMo7-6, 1.6587	
Grade 236	19MnCr5	
Grade 170	8219	
Grade 255	18NiCrMo14-6, 1.3533	
Grade 55LS	C56E2, 1055/1060, 1.1219	
Grade 70LS	70Mn4, 1070M, 1.1244	
Grade 50	4147/4147H/4150/4150H, 1.7228	50CrMo4
Stainless steels		
Grade 307	1.4037	X65Cr13
Grade 306	X30CrMoN15-1, 1.4108	VC444, VC4444, N360, NitroMax
Secondary hardening steels		
Grade 400	80MoCrV42-16, 1.3551	M50
Grade 401	13MoCrNi42-16-14	M50NiL
Powder metallurgy steels		
Grade PM62	M62	PM M62

Note: A steel specification covers more quality aspects than just the chemical composition

Common requirements for bearing components

High fatigue strength

Contaminant resistant

High toughness

Corrosion resistant

High temperature

Cost considerations

Hardening heat treatments

Hardening heat treatments are divided into two basic categories: through hardening and surface hardening. Through hardening, either martenstic or bainitic, results in homogeneous microstructures and properties through the whole cross-section of the component. Surface hardening, either by carburising, carbonitriding or induction, results in a hardness profile from the surface to the core.

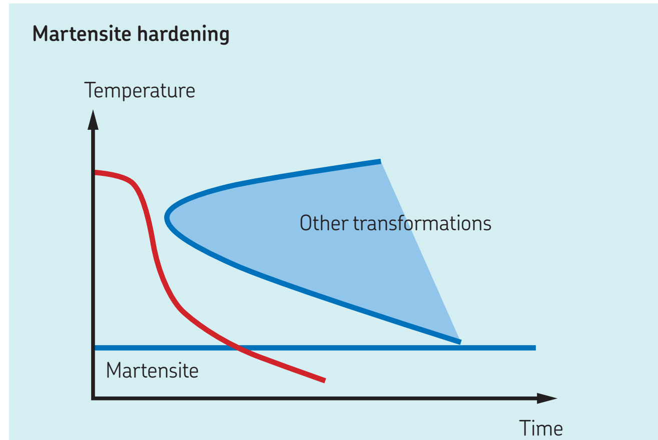
Martensite through hardening involves heating the steel component to high temperature followed by quenching to a low temperature, typically in oil or molten salt. See red line in the illustration. The martensite formed on quenching is very hard but also very brittle so it needs to be tempered to give it sufficient toughness to be used in applications, standard tempering is SN. More extensive tempering treatments are called stabilising treatments within SKF because they are intended to increase the dimensional stability of the components. Dimensional stability is the resistance to dimensional change due to the application conditions, primarily temperature, time and imposed stresses. There are a number of stability classes ranging from “SN” to “S4” and these are described in the section “Elevated temperatures”.

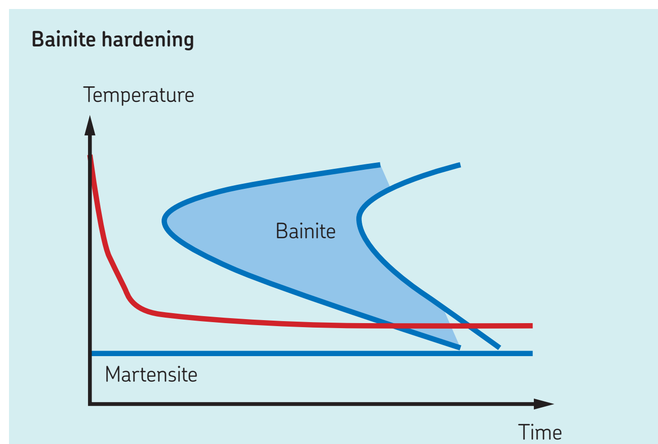
Bainite through hardening also involves heating the steel component to a high temperature followed by quenching to a temperature between 200 and 300 °C and holding at this temperature until a bainitic microstructure has been formed. See red line in the illustration. Although bainite hardening traditionally has an isothermal transformation, SKF also has a patented two-step bainite transformation process.

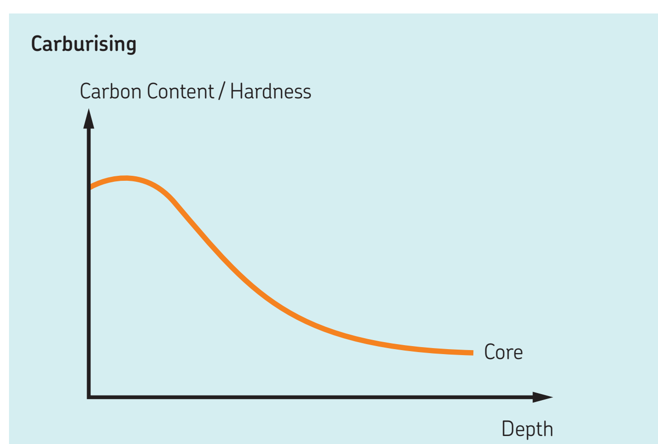
Carburising treatments involve the diffusion of carbon into the surface of the steel component which results in a carbon gradient from the surface to the core. After hardening, the high carbon content at the surface gives a high hardness while the low carbon content in the core gives a high toughness.

Carbonitriding treatments involve the diffusion of both carbon and nitrogen into the surface of the steel component.

Surface induction hardening involves selectively heating the surfaces of a steel component by electromagnetic induction coils followed by quenching. These treatments are much quicker than furnace heat treatments. Surface induction hardening is followed by tempering.







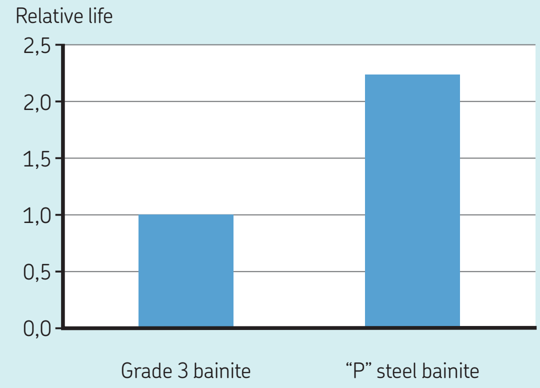
Subsurface fatigue

If a bearing is operating with clean, full film lubrication, then the maximum shear stress is below the raceway. The cyclic stressing of the bearing steel induces fatigue damage and ultimately leads to subsurface initiated failure. The subsurface failure is initiated at a non-metallic inclusion, which is an unavoidable impurity from the steelmaking process. This is the classical rolling contact fatigue failure mechanism.

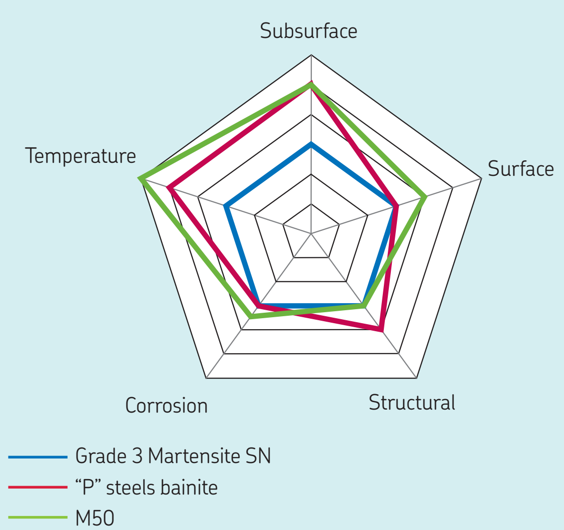
Standard bearing steels are very clean with regard to non-metallic inclusions. However, for some demanding applications, a premium quality “P” steel grade may be required. These “P” grades have very low limits for inclusion forming elements. The bar chart to the right shows the relative bearing life from very high load tests for Grade 3 and a “P” steel in the bainitically hardened condition.

For aerospace applications, the steels used are often melted twice under vacuum and are referred to as remelt steels. A typical example of a remelt steel is grade M50, which is a relatively highly alloyed steel grade. As such, the steel is more resistant to the cyclic fatigue damage in a rolling contact and has fewer non-metallic inclusions. Note that Grade 3 SN refers to standard martensite through hardening and tempering and that this steel and heat treatment combination will be used as a baseline throughout this document.

Subsurface fatigue solutions



Subsurface fatigue solutions



High fatigue strength

Surface fatigue

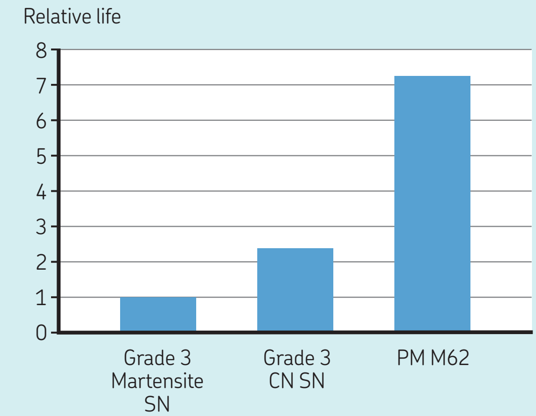
Many application related bearing failures occur due to surface initiated fatigue, mainly through insufficient lubrication film thickness or particle contamination of the lubricant.

A standard martensitically through hardened (SN) Grade 3 bearing steel will normally give satisfactory performance under such conditions. However, if increased performance is required, there are other solutions.

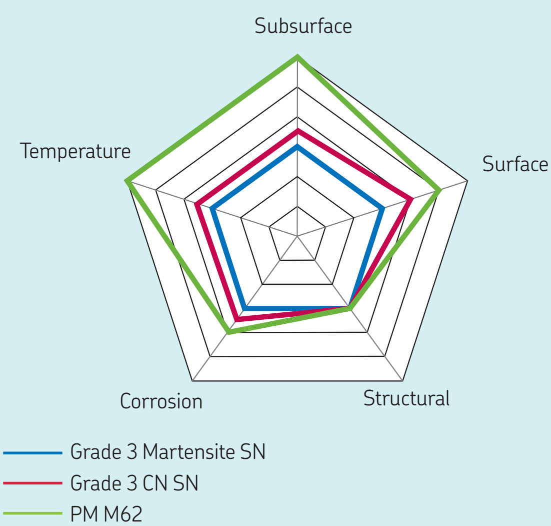
One option is to keep the standard Grade 3 bearing steel but to employ a carbonitriding (CN) heat treatment to strengthen the surface microstructure with both carbon and nitrogen. This has proved effective in a number of applications, particularly automotive and two-wheeler powertrains. An extreme solution, but one which is actively used, is to use a very highly alloyed steel made by the powder metallurgy (PM) route: steel grade PM M62. This steel has a very high hardness of HRC 67.

Bearing performance under particle contaminated conditions will be a function of the actual contaminant level (η_c) in the bearing. Performance differentiation between different SKF steel and heat treatment combinations may be possible for actual application conditions even if this is not reflected in the radar plots, which are based on data from rig tests with high levels of contamination.

Surface fatigue solutions



Surface fatigue solutions



Contaminant resistant

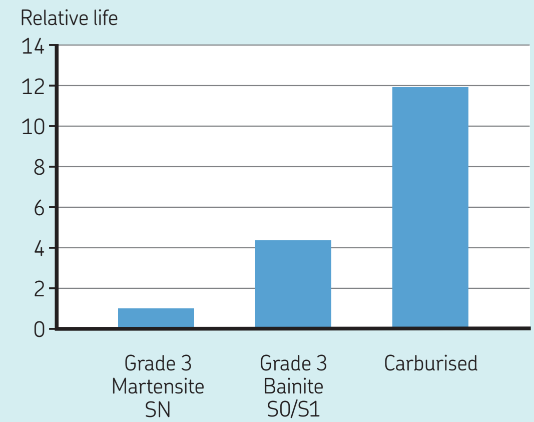
Structural fatigue

SKF distinguishes between rolling contact fatigue damage and other forms of fatigue, which are termed “structural fatigue”. These include bearing rings mounted with a high interference fit, which generates a tensile hoop stress, or rings mounted in flexible housings, which can result in bending stresses.

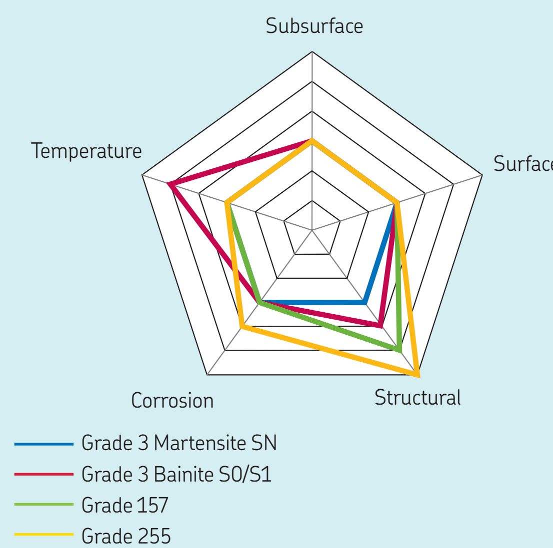
The high carbon chromium Grade 3 bearing steel has a high hardness when martensitically through hardened (SN) but has a modest toughness, which limits its resistance to structural fatigue loading. The toughness of Grade 3 bearing steel can be significantly increased if bainite hardening is used in place of martensite hardening. If the application demands even higher component toughness levels, then this can be achieved by using surface hardened components, either carburised, case carbonitrided or surface induction hardened (SIH). This is illustrated in the bar diagram which shows the relative life under extremly high interference fit conditions. Note that the structural strength of martensite and bainite is sufficient for common application conditions.

For illustration, four steel and heat treatment solutions with different structural strengths are shown in the radar plot. Grade 157 is representative of carburised solutions while Grade 255, is specifically suitable for very demanding structural load applications due to its alloy content.

Structural fatigue solutions
Relative life under extreme high interference fit



Structural fatigue solutions



High toughness

SKF Explorer spherical roller bearing.

Corrosion

Standard bearing steels, like Grade 3, are not classed as corrosion resistant or stainless steels because the chromium content is too low. Stainless steels achieve their corrosion resistance due to the high content of chromium, typically in excess of 12%, which produces a stable and passive chromium oxide layer on the surface. It is this passive oxide layer which gives the steel its rust and staining resistance. Grade 307 (X65Cr13), with 0.65% carbon and 13% chromium, is the standard SKF stainless steel for bearings operating in corrosive environments and has replaced Grade 301 (440C).

The corrosion resistance of a stainless steel can be dramatically increased by adding nitrogen. The nitrogen alloyed stainless steel used in SKF is Grade 306 (VC444/NitroMax), which contains nominally 15% chromium and 0,35% nitrogen. Note that 0,35% nitrogen is equivalent to an additional 10,5% chromium* for a stainless steel.

* Using the "Pitting Resistance Equivalence" number

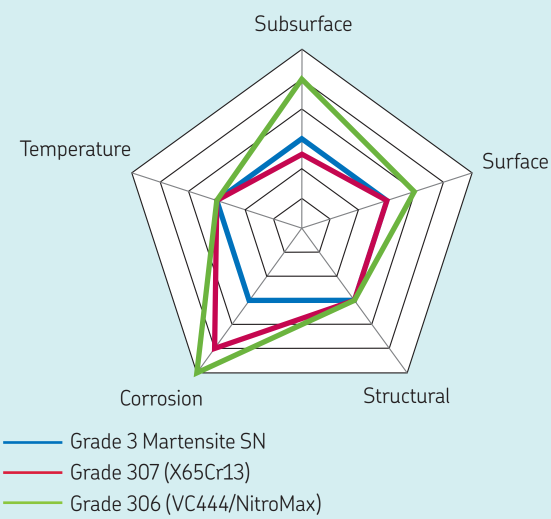
When choosing a stainless steel, it is important to understand the nature of the corrosive environment. For moderately corrosive environments, Grade 307 may be sufficient. For extreme environments, such as sour gas (hydrogen sulphide), Grade 306 would be a better solution.

Grade 301 (440C)

Grade 306 (VC444/NitroMax)

Corrosion testing in accordance with salt spray test DIN 50021

Corrosion solutions



Corrosion resistant

Angular contact ball bearing

Elevated temperatures

Elevated temperatures will potentially cause dimensional changes and reduced hardness of the material.

The temperature resistance of a martensitic Grade 3 steel component can be increased by increasing the tempering or stabilizing temperature or by employing bainitic hardening. The graph shows the dimensional change experienced by a Grade 3 martensitic SN bearing inner ring press fitted onto a shaft and exposed to an elevated temperature. In contrast, a Grade 3 bainite inner ring, subjected to the same application conditions, shows almost no dimensional change.

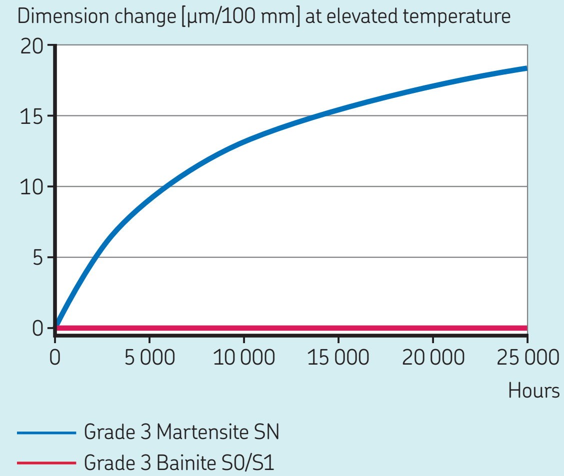
To avoid dimensional changes in operation, the bearings are stabilized. For sustained elevated temperature performance, a secondary hardening version of Grade 306 (named VC4444) can be used. M50 is the standard through hardening steel grade used for high temperature aerospace bearing applications.

Heat treatment is used to limit dimensional changes caused by metallurgical effects at extreme temperatures. There is a standardized classification system for dimensional stability (see table). The various SKF bearing types are stabilized to different classes as standard. The hardness and rolling contact fatigue may be affected.

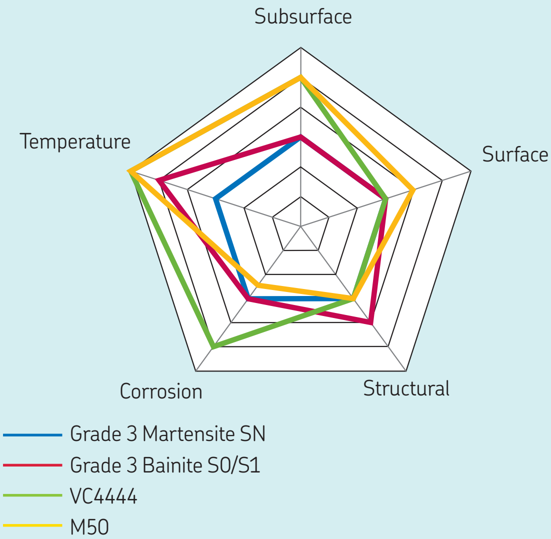
Dimensional stability

Stabilization class	Stabilized up to	
–	°C	*°F*
SN	120	*250*
S0	150	*300*
S1	200	*390*
S2	250	*480*
S3	300	*570*
S4	350	*660*

Dimensional stability



Elevated temperature solutions



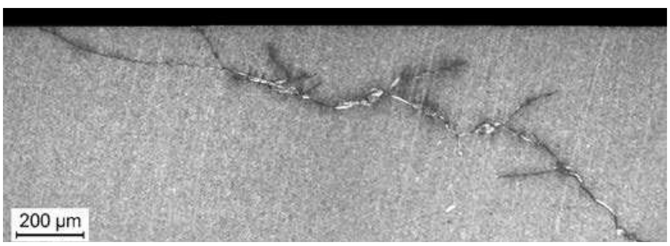
High temperature

Premature bearing failure

Bearings in large industrial gearboxes or other drive train applications are often subjected to a wide variety of operating conditions that may push them, under certain circumstances, beyond their limits. Damage may occur in these bearings, resulting in premature bearing failure (failures at 5 to 10% of the calculated rating life). One common feature of these premature failures is a network of small, white* cracks below the surface of the bearing, so-called white etching cracks (WEC) or white structure flaking (WSF).

* Appears white in nital etched microstructure when studied in light optical microscope.

WEC are cracks or crack networks that are associated with white etching areas (WEA).



White etching areas (WEA) develop around cracks during over-rolling. WECs can be found not only in premature failed bearings, but also in long running bearings which have failed due to rolling contact fatigue. Thus, WECs can be found in all types of applications, in all types of bearings as well as in all standard heat treatments. WECs are a natural consequence of crack networks in failed bearings. Hence, WECs are only a visible symptom of the failure, and not part of the underlying cause.

By considering the possible drivers for WEC formation, solutions at bearing level or bearing system level can be nominated.

More information on WEC can be found in the SKF Group website, www.skf.com

Black oxide coated bearing

Drivers	Bearing system inside application	Bearing
Stresses higher than anticipated (tensile stresses, short heavy loads, etc.)	• Bearing arrangement • Bearing support • Limit housing deformations • Clearance / preload setting • Verify extreme load events (incl. grid events)	• High compressive residual stresses • Premium quality steels • Different steels and heat treatments
Material strength lower than anticipated "Environmental weakening" (corrosion, electrical current, mixed friction and lubricant, etc.)	• Limit water in oil • Limit humidity during standstill • Verify transport and mounting procedures • Avoid stray current • Limit vibrations	• SKF Black Oxide • Case carbonitriding • High strength stainless steels • INSOCOAT, hybrid bearings (related to electrical erosion protection)

Sustainability

Since the late 1980s, SKF has been driving its sustainability initiatives with increasingly tough targets and customer focus. SKF has a proven track record and is confident that the following climate goals will be reached:

- By 2030, all SKF production facilities, all over the world, will have net zero greenhouse gas emissions
- By 2050, SKF's full supply chain, from materials to the delivery of products and solutions, will be net zero

Reaching these goals requires major focus and commitment throughout the full value chain and SKF is off to a good start. SKF Steyr in Austria and SKF Tudela in Spain are the first two official carbon neutral SKF factories, achieved without carbon offsetting.

To monitor progress and to ensure transparency, SKF has measured and reported on our climate impact for many years. SKF's climate impact is determined by our own operations as well as activities throughout the full value chain. SKF's greenhouse gas emissions are described in the annual report which can be seen in the SKF Group website, www.skf.com.

SKF's plan to achieve the 2030 goal is based on continued measures in two main areas:

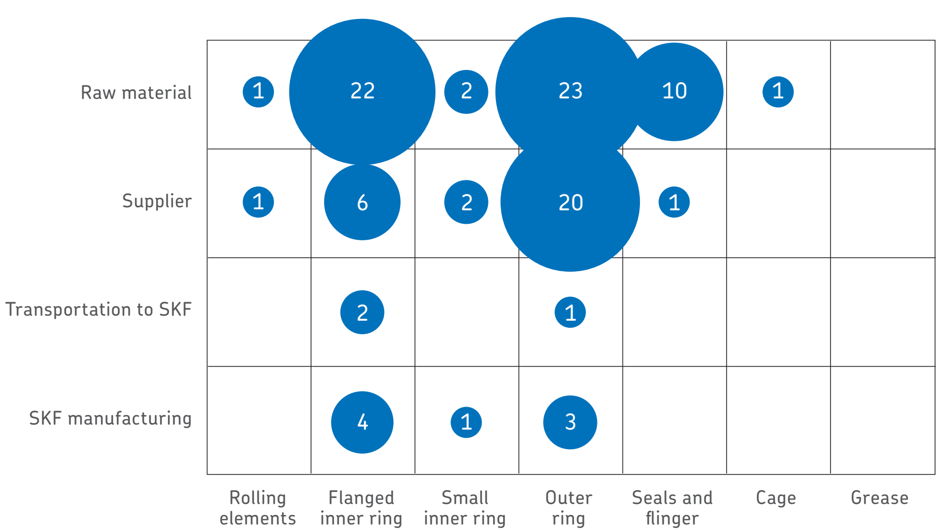
- Improving energy and resource efficiency within SKF's operations
- Switching to renewable energy sources

To fulfil the goal for SKF's supply chain, the approach is to influence energy intensive suppliers to implement energy management systems certified according to ISO 50001. In 2020, around 83% of SKF's suppliers had adopted the ISO 50001 standard. Greenhouse gas emissions will also be an important parameter when defining supply chains.

SKF is working with major steel suppliers and other energy intensive suppliers to reduce the carbon dioxide emitted per tonne of steel purchased. As part of this effort, SKF now publishes the data and, in the coming years, will increase the coverage to include all of the significant direct material suppliers.

In addition, SKF is developing tools to evaluate the sustainability footprint of different steel and heat treatment solutions in order to facilitate conscious selections.

For further reading, please see the SKF position paper in the SKF Group website, www.skf.com



The carbon footprint of an SKF wheel bearing (cradle to customer gate) for different bearing components. The numbers in the bubbles are the relative CO_2 equivalent emission in percentage. Source SKF

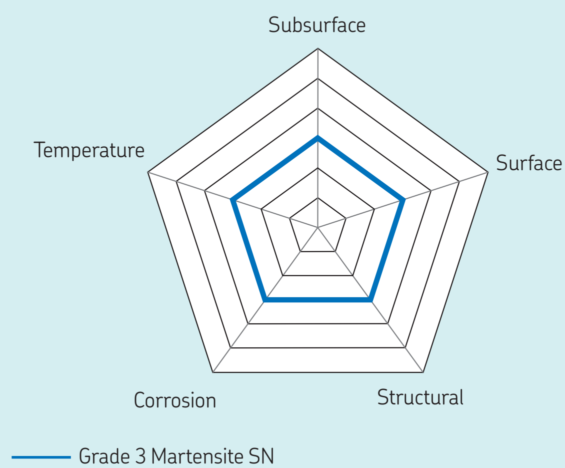
Solutions

Through-hardening bearing steels

Martensite SN

Grade 3 is the most common high carbon chromium through hardening bearing steel used for SKF catalogue bearings. Higher alloyed carbon chromium bearing steels are used for components with larger sections. Grades 24, 4, 5, 6 and 7 are examples of the higher alloyed grades.

"SN" refers to a martensitic through hardening stabilisation class with tempering typically below 200 °C. SN has a high hardness of ≥ HRC 62 and a controlled amount of retained austenite, usually < 15% by volume.



Considerations:

The exact steel grade required will depend on the component section thickness.

SKF designation	Comparable steels (composition)
Grade 3	100Cr6, 52100, SUJ2, 1.3505

Typical applications:

- Catalogue ball and roller bearings
- Automotive
- Electric motors

Martensite S0/S1

Benefits:

- Suitable for higher application temperatures

The through hardening steels typically used are Grades 3, 24, 4, 5, 6 and 7. “S0” and “S1” refer to the use of stabilizing treatments, typically > 200 °C.

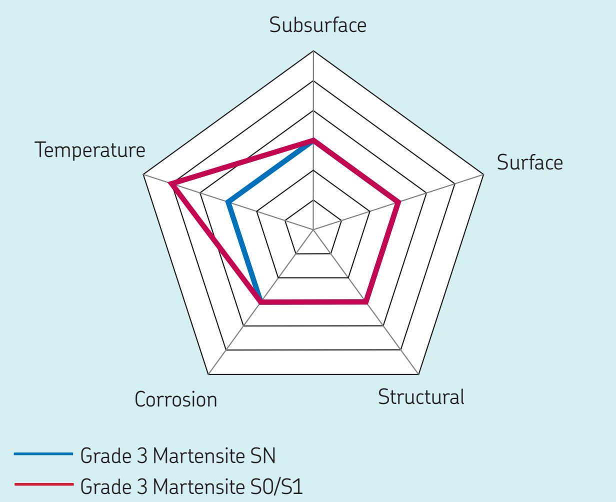
The aim of S0 and S1 stabilising is to reduce the content of the retained austenite phase to negligible levels to give improved dimensional stability.

Considerations:

The increased stabilising temperature does result in a decreased hardness as compared to SN tempering.

Typical applications:

- Catalogue ball and roller bearings



SKF designation	Comparable steels (composition)
Grade 3	100Cr6, 52100, SUJ2, 1.3505

High temperature

Bainite

Benefits:

- High toughness for resistance to structural loads
- Suitable for higher application temperatures

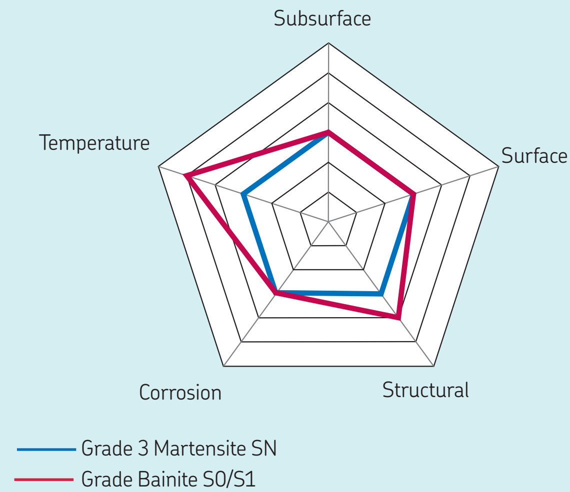
The through hardening steels typically used are grades 3, 24, 5, 6 and 7.

The bainite transformation of the high carbon chromium bearing steel results in a microstructure with a high hardness, a good toughness and a modest surface compressive residual stress.

The bainitic heat treatment ensures that the component will have S0 or S1 dimensional stability.

Typical applications:

- Catalogue roller bearings
- Mining
- Industrial gearboxes
- Pulp and paper



SKF designation	Comparable steels (composition)
Grade 3	100Cr6, 52100, SUJ2, 1.3505


High temperature


High toughness

Bainite Grade 7P

Benefits:

- High rolling contact fatigue strength
- High toughness for resistance to structural loads
- Suitable for higher application temperatures

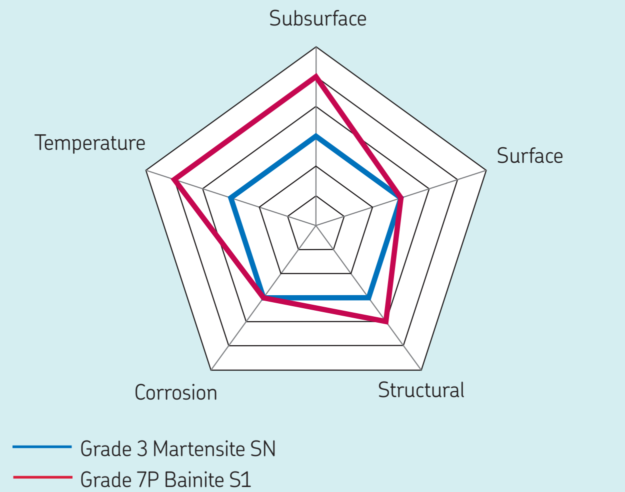
The “P” steels are premium quality bearing steels resulting in improved fatigue performance. Grade 7P is a high carbon chromium bearing steel with a bainitic microstructure with a high dimensional stability and structural fatigue strength.

Considerations:

The “P” steels are produced by a proprietary steelmaking process and are only available from specific suppliers.

Typical application:

- Marine propulsion



SKF designation	Comparable steels (composition)
Grade 3	100Cr6, 52100, SUJ2, 1.3505
Grade 7P	Proprietary steel grade

High fatigue strength

High temperature

High toughness

Cost considerations

Grade 3M

Benefits:

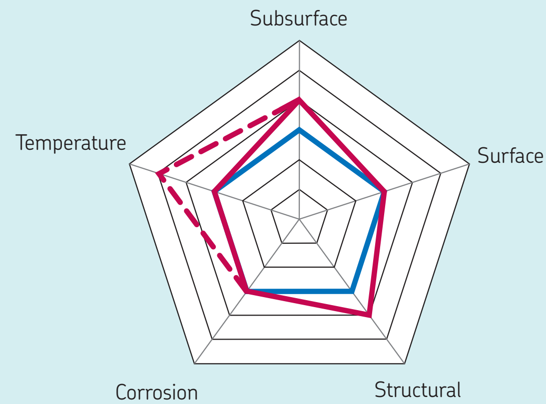
- High rolling contact fatigue resistance
- Resistance to higher temperatures and structural loads

Grade 3M is a molybdenum alloyed high carbon chromium bearing steel which is unique to SKF. Endurance tests have shown the benefits of molybdenum alloying in resistance to rolling contact fatigue damage. Molybdenum alloying also gives some benefit with regard to toughness, particularly when combined with the S1 dimensional stability heat treament .

This combination is used for alternator bearing outer rings, which are subjected to structural bending and vibration loads.

Typical application:

- Alternators



SKF designation	Comparable steels (composition)
Grade 3 Grade 3M	100Cr6, 52100, SUJ2, 1.3505 Proprietary steel grade

High fatigue strength

High temperature

High toughness

Carbonitrided

Benefits:

- Resistance to poor lubrication conditions

Carbonitriding (CN) strengthens the surface of high carbon chromium bearing steels for particle contaminated lubrication conditions.

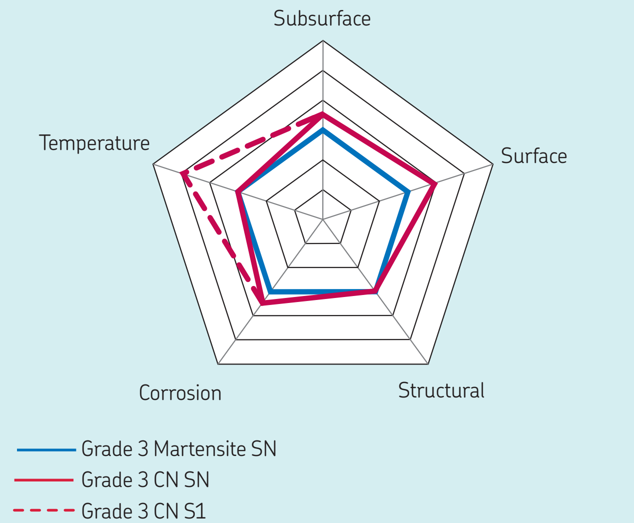
The surface nitrogen content gives temperature resistance to the carbonitrided layer. This means that a high surface hardness can be retained for higher stability classes.

Considerations:

The appropriate stability class should be chosen for the application.

Typical applications:

- Automotive transmissions
- Two wheelers



SKF designation	Comparable steels (composition)
Grade 3	100Cr6, 52100, SUJ2, 1.3505

 Contaminant resistant  High fatigue strength

Surface hardening bearing steels

Carburised

Benefit:

- High toughness for resistance to structural loads

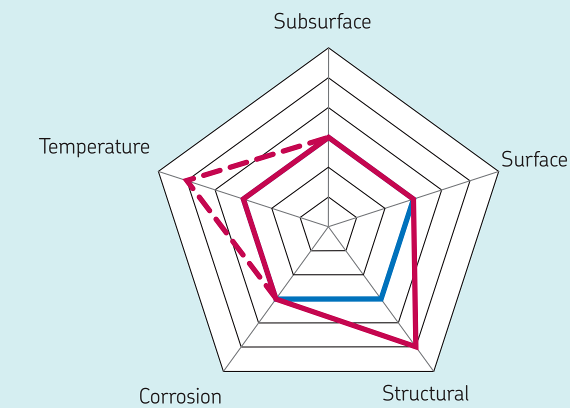
SKF uses low carbon steels for carburised components such as Grades 152, 157, 159, 170, 236 and 255. Carburising results in a tough component, to resist structural loads, and a beneficial surface compressive residual stress.

Considerations:

- The surface hardness and case depth must be sufficient to achieve the required load carrying capability
- The exact steel grade required will depend on the component section thickness
- The appropriate stability class should be chosen for the application

Typical applications:

- Off-highway
- Railway
- Wind
- Papermills
- Metalworking



SKF designation	Comparable steels (composition)
Grade 3	100Cr6, 52100, SUJ2, 1.3505
Grade 157	20NiCrMo7, 4320H, 1.3576

High toughness

Case carbonitrided

Benefits:

- Resistance to poor lubrication conditions
- High rolling contact fatigue strength
- High toughness for resistance to structural loads

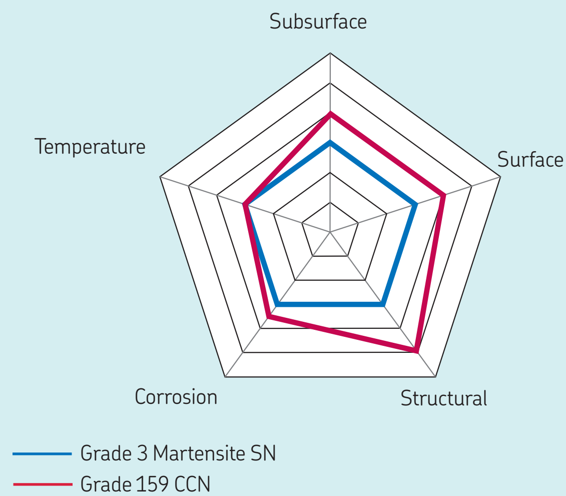
Case carbonitriding (CCN) strengthens the surface of carburized bearing steels for particle contaminated lubrication conditions.

Case carbonitriding is also beneficial for sub-surface rolling contact fatigue.

Case carbonitriding results in a tough component, to resist structural loads, and a beneficial surface compressive residual stress.

Considerations:

- The surface hardness and case depth must be sufficient to achieve the required load carrying capability
- The exact steel grade required will depend on the component section thickness.



SKF designation	Comparable steels (composition)
Grade 3	100Cr6, 52100, SUJ2, 1.3505
Grade 159	18CrNiMo7-6, 1.6587

Contaminant resistant

High toughness

High fatigue strength

Surface induction hardened

Carbon steels

Benefit:

- High toughness for resistance to structural loads

Surface induction hardening (SIH) of carbon steels, such as Grade 55LS, was introduced for flanged wheel bearings.

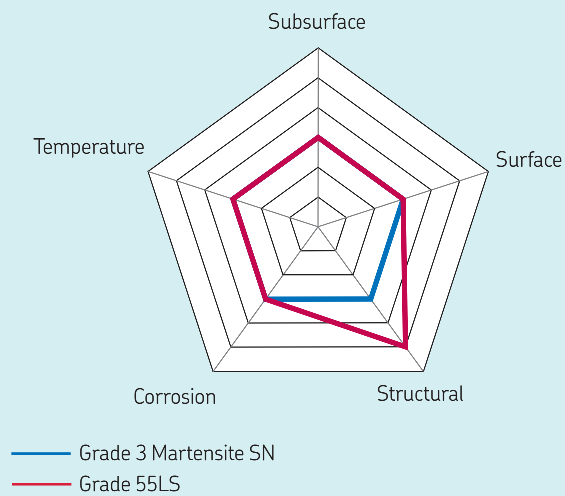
The use of SIH means that the wheel bearing will have resistance to rolling contact fatigue in the raceways and structural strength at the flanges. SIH gives a beneficial surface compressive residual stress.

Considerations:

- The surface hardness and case depth must be sufficient to achieve the required static and dynamic capacity levels

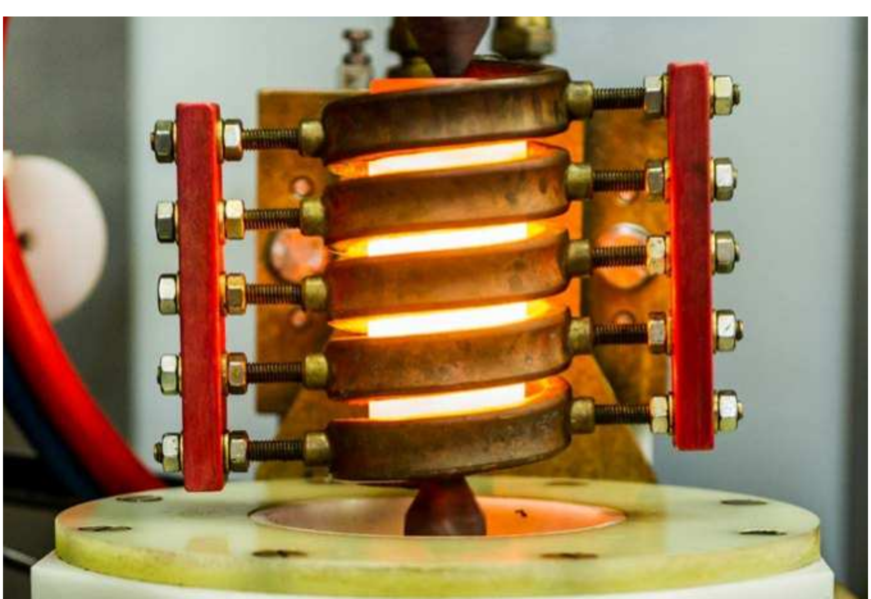
Typical applications:

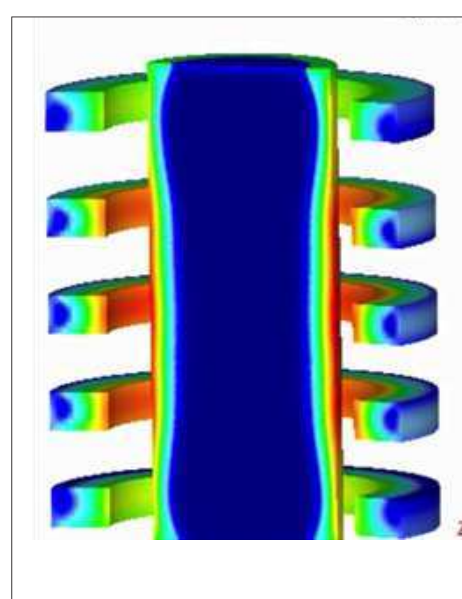
- Wheel and truck wheel bearing units



SKF designation	Comparable steels (composition)
Grade 3	100Cr6, 52100, SUJ2, 1.3505
Grade 55LS	C56E2, 1055/1060, 1.1219

High toughness





Alloyed steels

Benefits:

- High toughness for resistance to structural loads

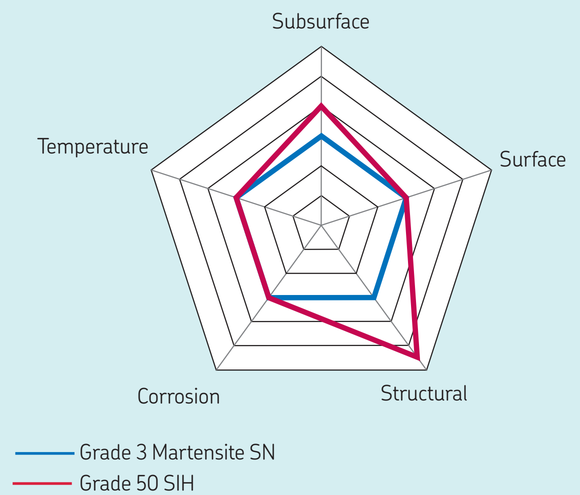
Surface induction hardening (SIH) of alloyed steels, such as Grade 50, is a recent development for large rolling bearings. SIH of alloyed steels will give a tough component, to resist structural loads, and to provide beneficial surface compressive residual stress.

Considerations:

- The geometry of the component will influence the suitability for surface induction hardening

Typical applications:

- Wind energy



SKF designation	Comparable steels (composition)
Grade 3	00Cr6, 52100, SUJ2, 1.3505
Grade 50	50CrMo4, 1.7228

High toughness

High fatigue strength

Stainless bearing steels

Stainless steels

Benefit:

- Corrosion resistance

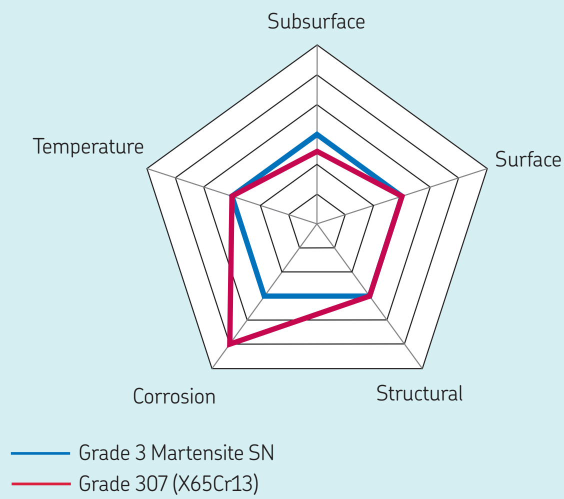
Grade 307 (X65Cr13) is a stainless steel with 0,65% carbon and 13% chromium. Although stainless steels are typically penalised regarding rolling contact fatigue performance due to their relatively low hardness, they will outperform standard bearing steels in corrosive environments. X65Cr13 is now preferred to 440C, which was used previously for reasons of manufacturability and product performance.

Considerations:

- The nature of the corrosive environment must be taken into consideration

Typical applications:

- Food and beverage



SKF designation	Comparable steels (composition)
Grade 3	100Cr6, 52100, SUJ2, 1.3505
Grade 307	1.4037

Corrosion resistant

High nitrogen stainless steels

Benefits:

- Very high corrosion resistance
- Rolling contact fatigue resistance
- Suitable for poor lubrication conditions

Grade 306 is a high nitrogen stainless steel. The nitrogen content results in extremely good corrosion resistance characteristics. The steel must be made using the Pressure Electro-slag Remelting (PESR) process.

There are a number of solutions based on Grade 306. The two main variants are VC444 and VC4444.

VC444 is tempered at < 200 °C, which is the optimum for corrosion resistance. VC444 is also called NitroMax by SKF.

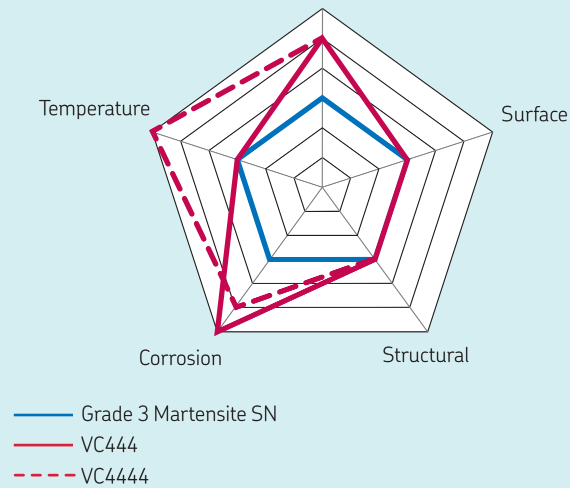
VC4444 is tempered at much higher temperatures to give optimum temperature resistance combined with corrosion resistance.

Considerations:

- Grade 306 components must be hardened in a vacuum furnace
- The choice of heat treatment variant can be tailored to the application requirements

Typical application:

- Aerospace
- Compressors
- Racing
- Super-precision bearings
- Cryogenic pumps



SKF designation	Comparable steels (composition)
Grade 3 Grade 306	100Cr6, 52100, X30CrMoN15-1, 1.4108

Corrosion resistant | High temperature

High fatigue strength | Cost considerations

Secondary hardened steels

M50

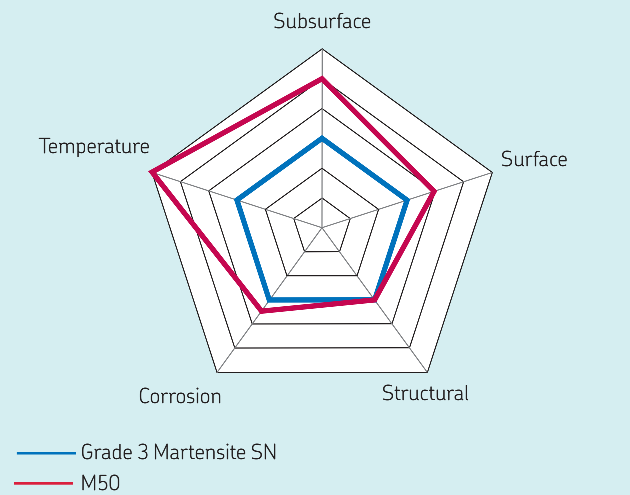
Benefits:

- Suitable for very high application temperatures
- Rolling contact fatigue resistance
- Suitable for poor lubrication conditions

Aerospace application conditions, specifically high temperatures, mean that more appropriate steels than normal bearing steels must be used. A typical through hardening steel for high temperature aerospace applications is M50 (SKF Grade 400). M50 is a secondary hardening steel, which is melted twice under vacuum and is known as M50 VIM VAR (Vacuum Induction Melted, Vacuum Arc Remelted).

Typical applications:

- Aerospace
- Racing



SKF designation	Comparable steels (composition)
Grade 3 Grade 400	100Cr6, 52100, SUJ2, 1.3505 80MoCrV42-16, 1.3551

M50NiL

Benefits:

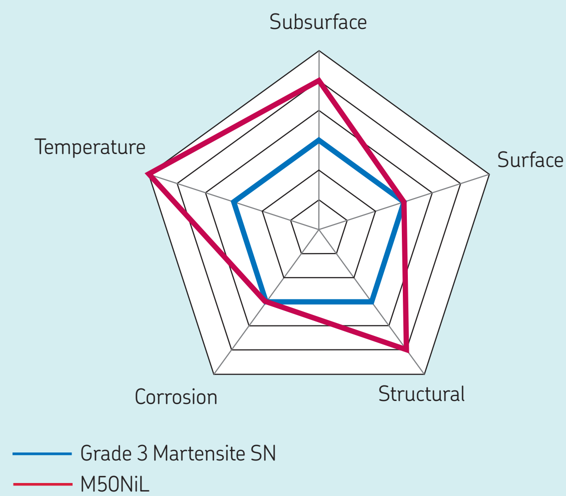
- Very high application temperatures
- High toughness for resistance to structural loads
- Rolling contact fatigue resistance

A carburising version of M50 is M50NiL (SKF Grade 401), where Ni=Nickel and L=Low carbon. It is also a VIM VAR steel, which is double vacuum melted for aerospace applications.

M50NiL was introduced to provide a solution for aerospace applications which required increased toughness as compared to M50, while maintaining its temperature resistance properties.

Typical application:

- Aerospace



SKF designation	Comparable steels (composition)
Grade 3	100Cr6, 52100, SUJ2, 1.3505
Grade 401	13MoCrNi42-16-14

High temperature

High fatigue strength

High toughness

Cost considerations

32CDV13 (AMS 6481)

Benefits:

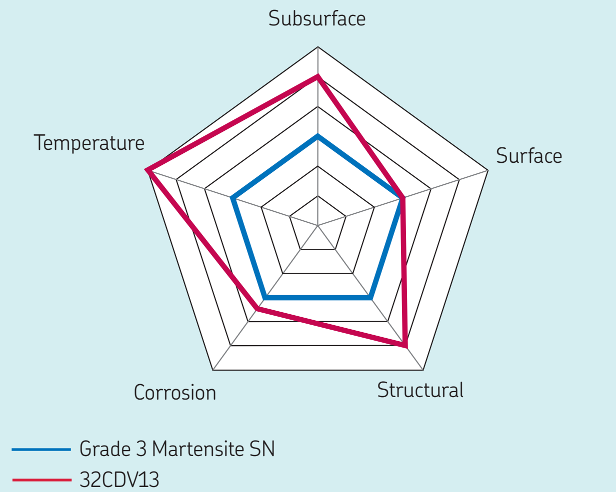
- Very high application temperatures
- High toughness for resistance to structural loads
- Rolling contact fatigue resistance

32CDV13 is a medium carbon VIM VAR nitriding steel that has been developed for aerospace applications.

This steel solution with deep nitriding provides good rolling contact fatigue performance combined with wear resistance and a high level of structural fatigue strength. With its high level of fracture toughness, this is a suitable solution for use in bearings with flexible cages and in integrated gear-bearing applications.

Typical application:

- Aerospace



SKF designation	Comparable steels (composition)
Grade 3	100Cr6, 52100, SUJ2, 1.3505
32CDV13	33CrMoV12-9, EN 1.7765

PM M62

Benefits:

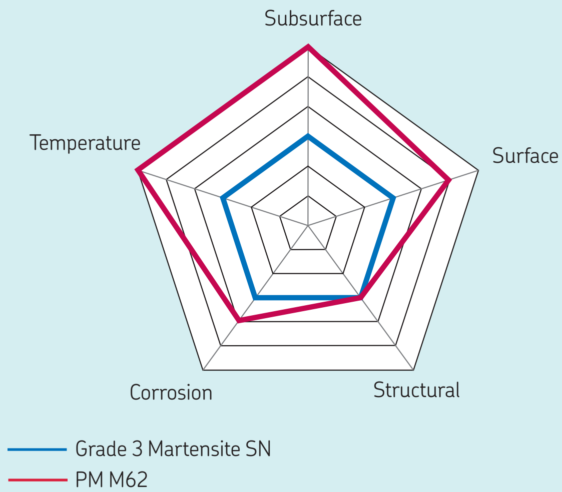
- Suitable for poor lubrication conditions
- Suitable for very high application temperatures
- Rolling contact fatigue resistance
- Corrosion resistance

PM M62 is the powder metallurgy version of the M62 tool steel. PM M62 is secondary hardened to give a hardness up to HRC 67 and high temperature resistance.

Endurance tests have shown that PM M62 gives exceptional fatigue performance under particle contaminated lubrication conditions.

Typical applications:

- Racing



SKF designation	Comparable steels (composition)
Grade 3	100Cr6, 52100, SUJ2, 1.3505
Grade PM62	M62

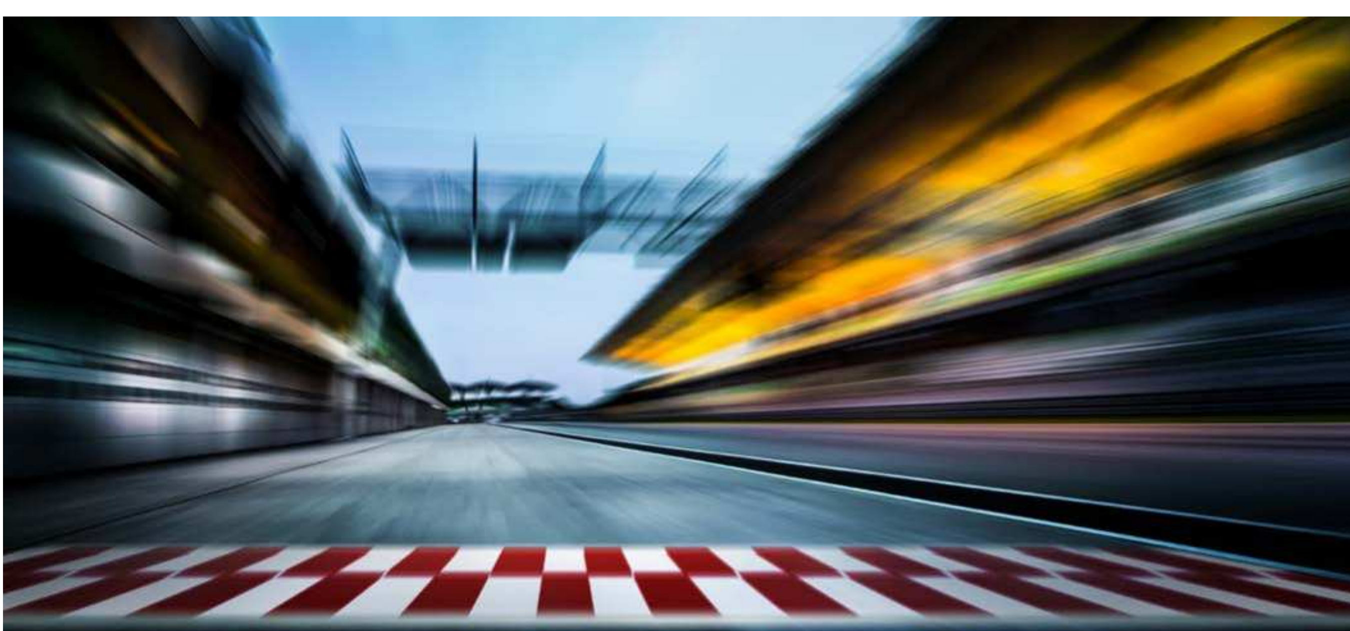
High fatigue strength

Contaminant resistant

Cost considerations

High temperature

Corrosion resistant



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