Rolling Mill Industry Training:

Bearing Fundamentals

TIMKEN

WORLDWIDE LEADER IN BEARINGS AND STEEL

Agenda

- Bearing Types and Features
- Tapered Roller Bearing Details
- TRB Setting
- TRB Mounting
- Bearing Metallurgy & Fatigue Mechanism
- TRB Fitting Practice
- Lubrication

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Bearing Types

- **Friction bearings**
  - Plain
  - Bushing
  - Oil sleeve
- **Anti-friction bearings**
  - Ball bearings
  - Needle roller bearings
  - Spherical roller bearings
  - Cylindrical roller bearings
  - Tapered roller bearings

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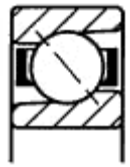
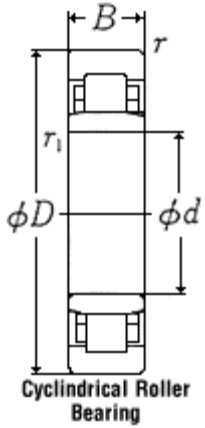
Bearing Types

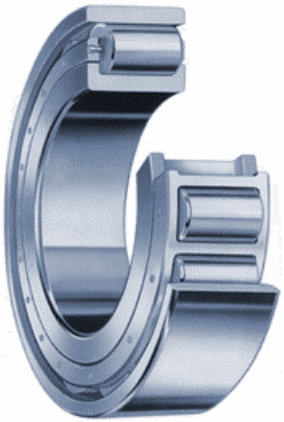


Angular Ball

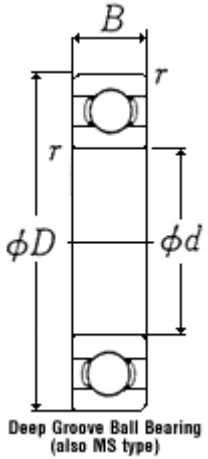
Needle



Cyclindrical Roller Bearing

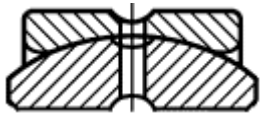


Cylindrical

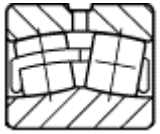


Deep Groove Ball Bearing (also MS type)

Ball



Plain



Spherical

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Spherical Roller Bearings

- **Features**
  - Self aligning… suitable for misalignment
  - Large diameter rollers provide high load rating
  - Mounted internal clearance is determined by fit and factory setting… C2, C0(N), C3, C4
  - Easy inspection
  - Repairable

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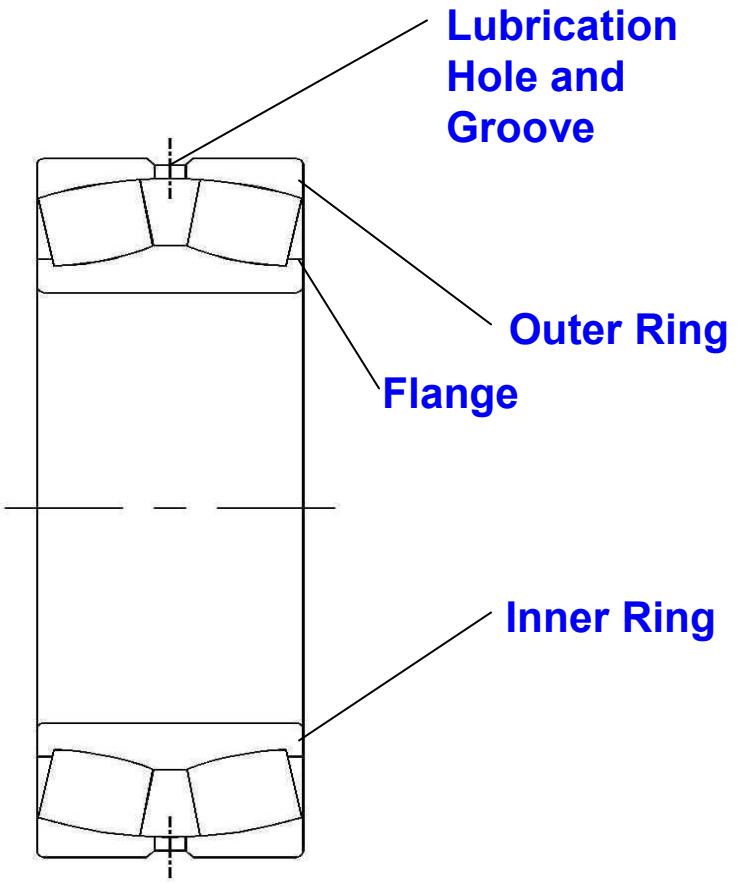
SRB Nomenclature



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Cylindrical Roller Bearings

Features

- High radial load capability
- Separable races - this facilitates mounting & dismounting when interference fits are desired on inner and/or outer rings
- Mounted internal clearance is determined by fit and factory setting… C2, C0(N), C3, C4
- Thrust capability with 3 flanges
- Repairable

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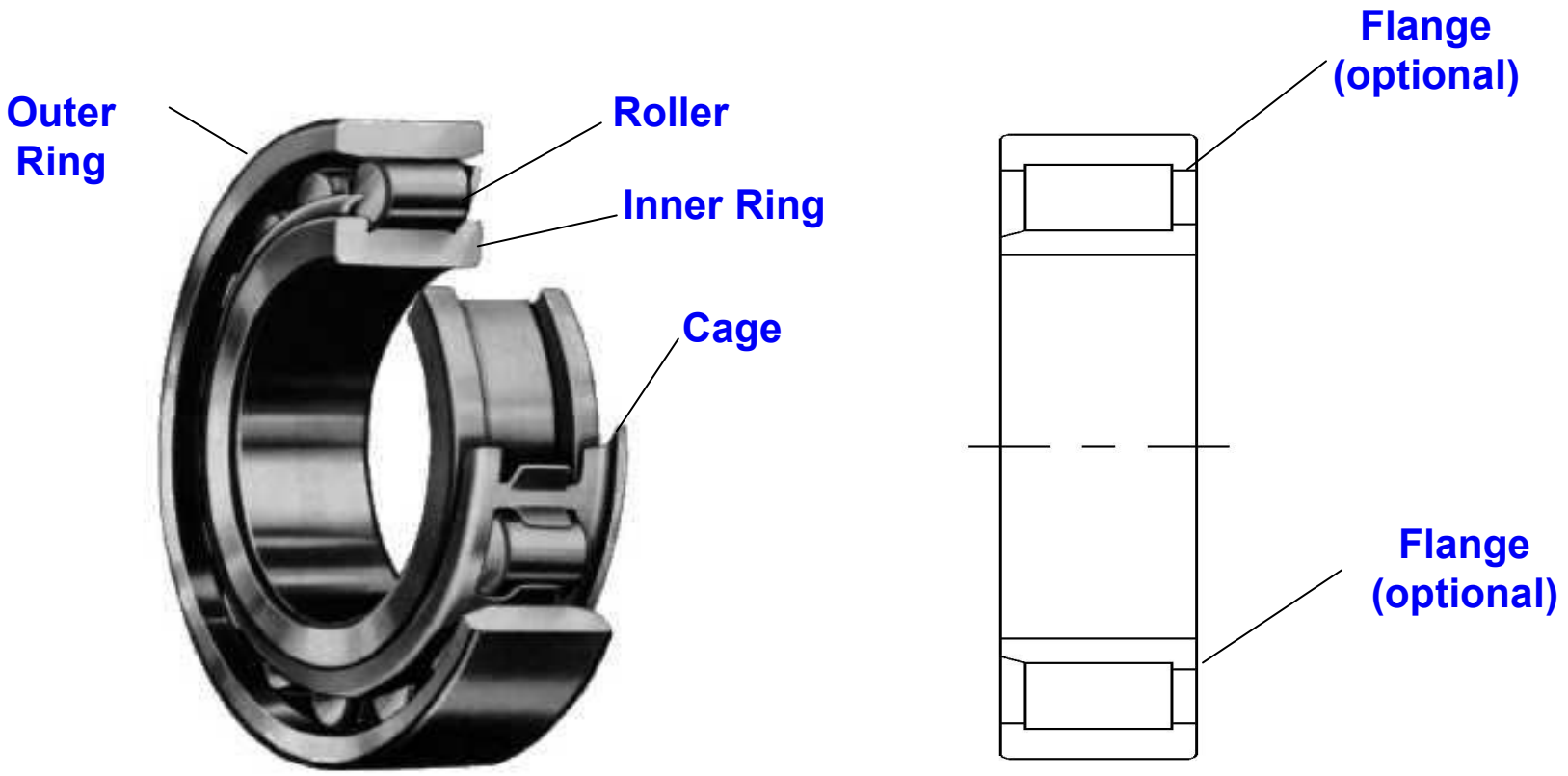
CRB Nomenclature



Flange Designations: N, NU, NJ, NF, NP, NUP, NJF, NU+HJ, NJ+HJ

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Ball Bearings

- **Features**
  - Most popular roller bearing
  - Simple design
  - Non-separable races
  - High speed capability due to point surface contact
  - Capacity based on point contact
  - Controlled internal clearances, adjustment achieved through interference fits
  - Grooves in the raceways allow ball bearings to handle axial loads

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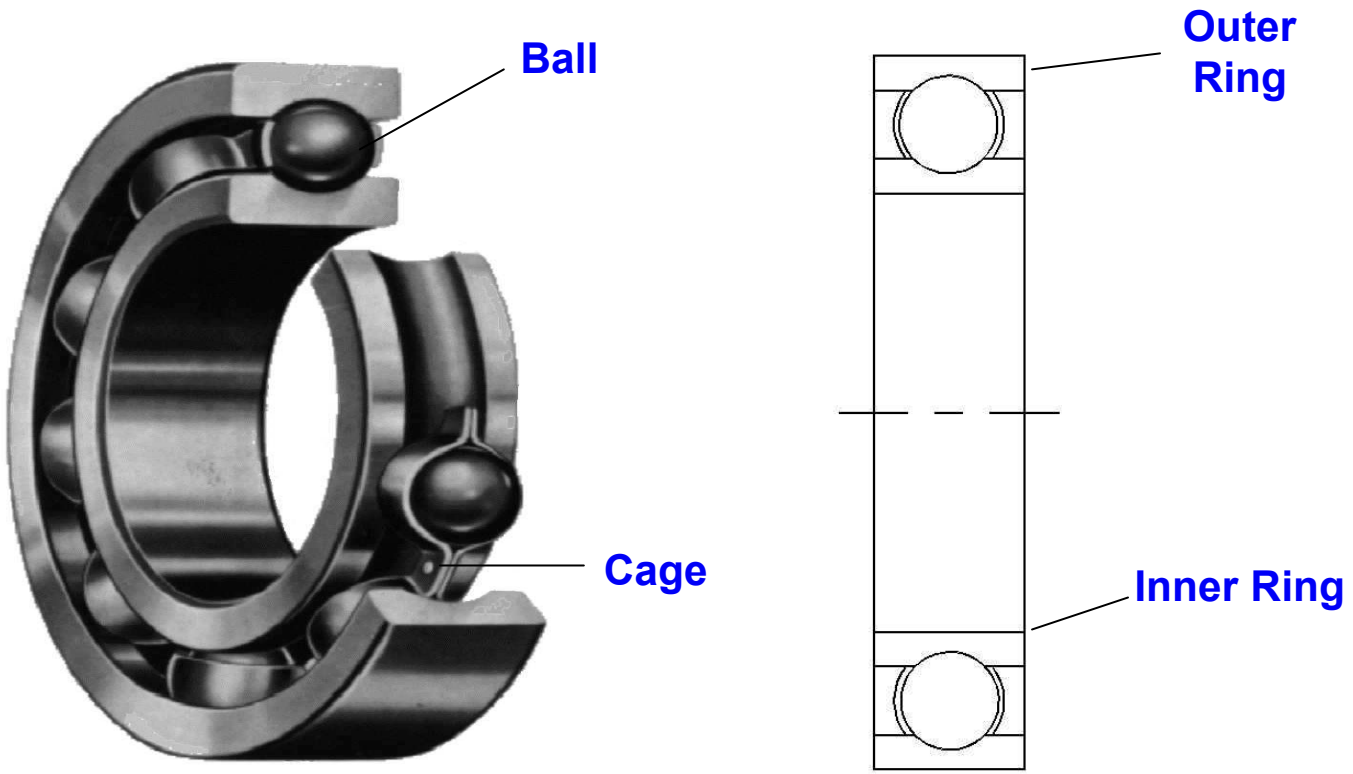
Ball Bearing Nomenclature



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Needle Roller Bearings

- **Features**
  - Thin cross sections - suitable where radial space is limited
  - Good radial load capability
  - Marginal thrust load capability
- **Nomenclature**
  - Same as for cylindrical

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Tapered Roller Bearings

- **Features**
  - Line contact
  - True rolling motion
  - Combined load capability
  - Adjustable internal clearance
  - Positive roller alignment
  - Increased system rigidity
  - Easy inspection
  - Repairable

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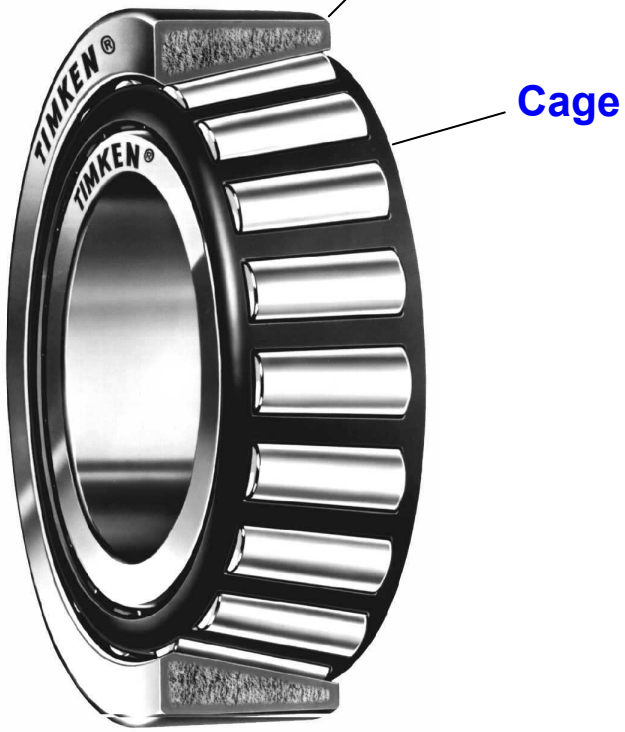
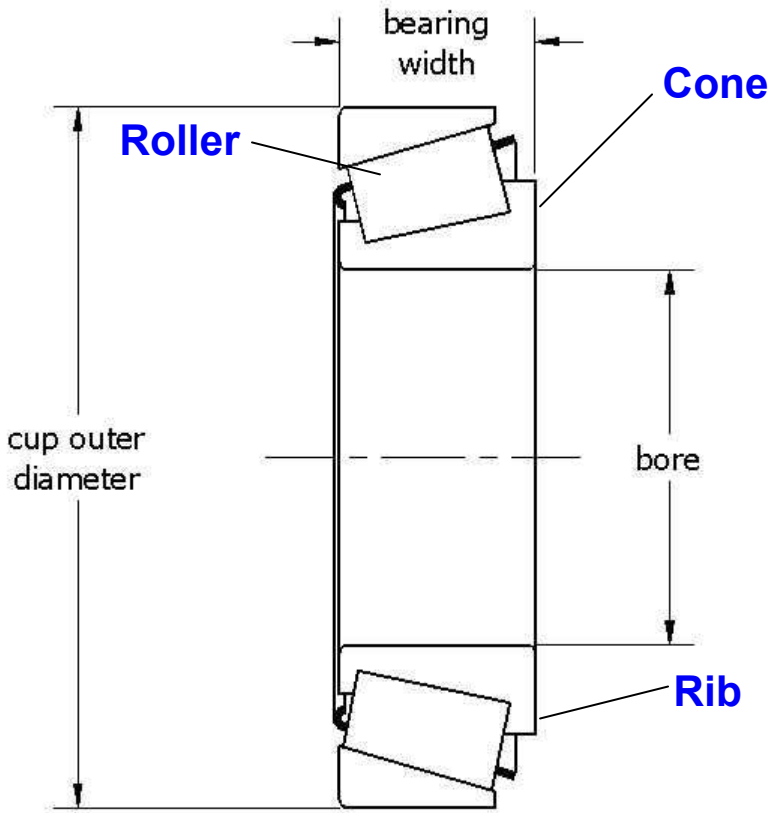
TRB Components





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2-Row Bearing Types

TDO

- 2 single cones/ Double cup
- Set w/ cone spacer (cone adjusted)
- Lube hole/ groove in cup
- "Indirect" mounting
- Float through outer race

TDI

- Double cone/ 2 single cups
- Set with cup spacer (cup adjusted)
- "Direct" mounting
- Float through inner race

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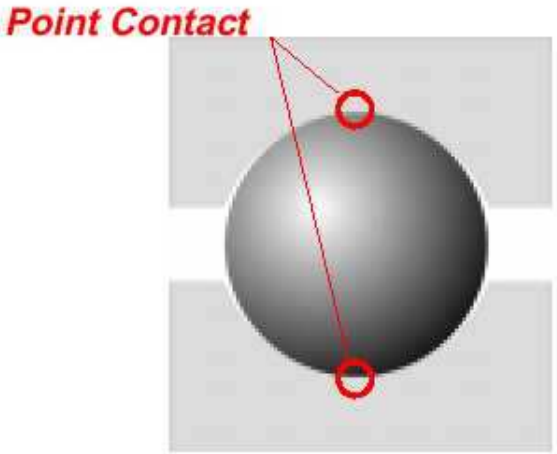
Roller Bearing Comparison

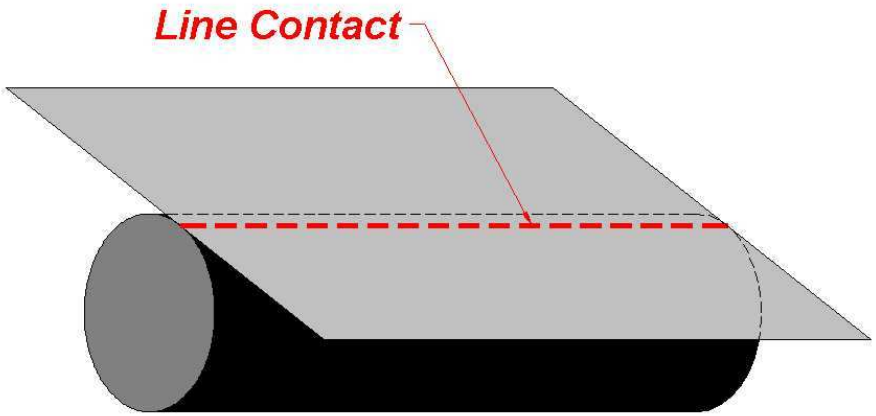
CHARACTERISTIC	TRB RADIAL DOUBLE ROW	TRB THRUST	CRB CAGED SINGLE ROW	CRB FULL COMPLEMENT SINGLE ROW	CRB THRUST	SRB RADIAL DOUBLE ROW
Pure Radial Load	Excellent	Unsuitable	Excellent	Excellent	Unsuitable	Excellent
Pure Axial Load	Good	Excellent	Unsuitable	Unsuitable	Good	Fair
Combined Load	Excellent	Fair	*Fair	Poor	Unsuitable	Excellent
Moment Load	Fair	Poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable
High Stiffness	Excellent	Excellent	Good	Excellent	Excellent	Good
Quiet Running	Fair	Fair	Good	Poor	Poor	Fair
Low Friction	Fair	Fair	Good	Poor	Poor	Fair
Misalignment	Poor	Poor	Poor	Poor	Unsuitable	Excellent
Locating Position (Fixed)	Excellent	Good	*Fair	Fair	Fair	Good
Non-Locating Position (Floating)	Good	Unsuitable	**Excellent	Fair	Unsuitable	Fair

* Fair with Flanges on Inner and Outer Ring / Unsuitable Without

Point vs. Line Contact

- Less friction and heat
- Higher Speeds
- Lower stress
- Higher load capacity





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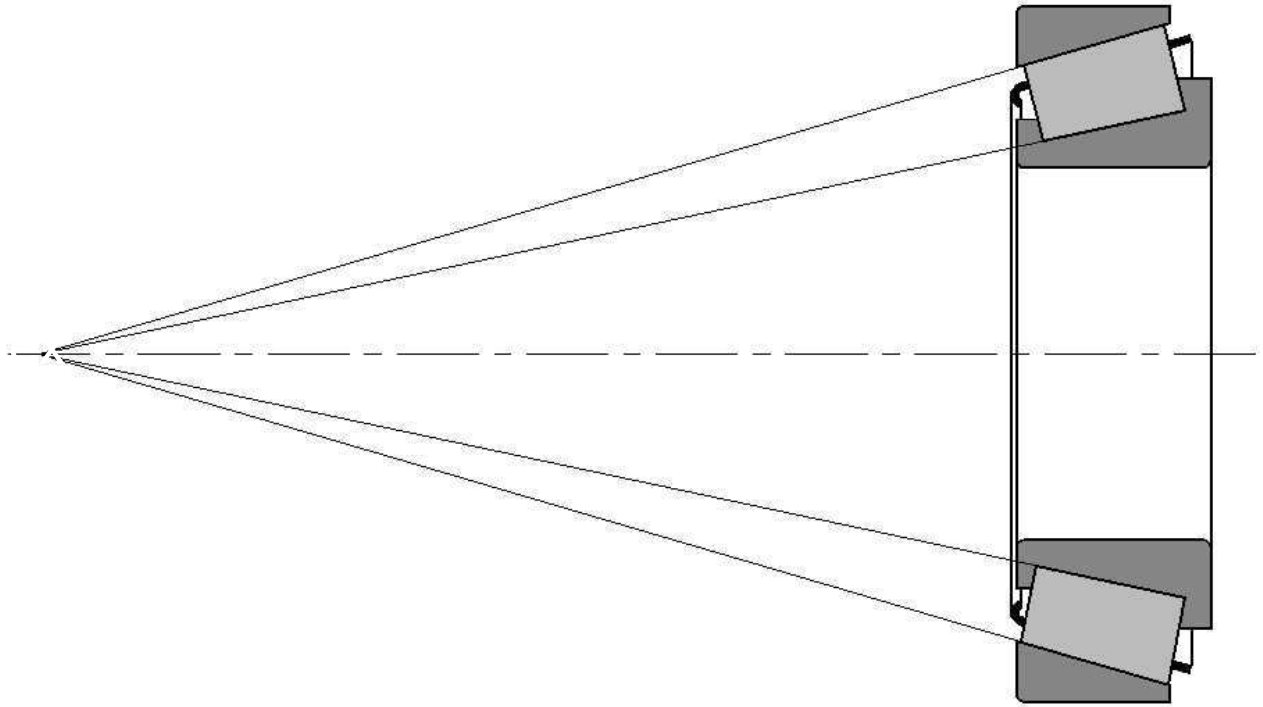
True Rolling Motion



On apex design provides true rolling motion along race

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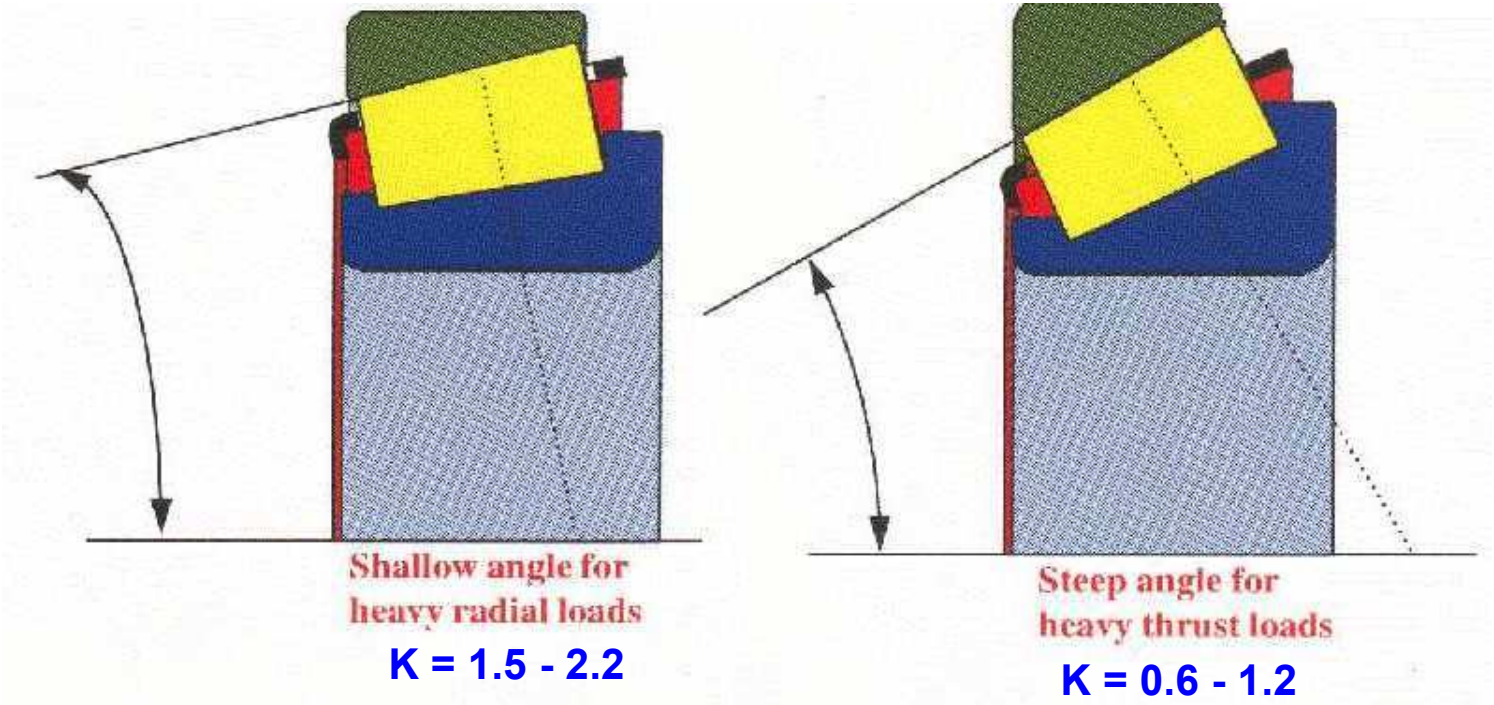
Combined Radial & Thrust



$$K = \frac{\text{dynamic radial load rating}}{\text{dynamic thrust load rating}}$$

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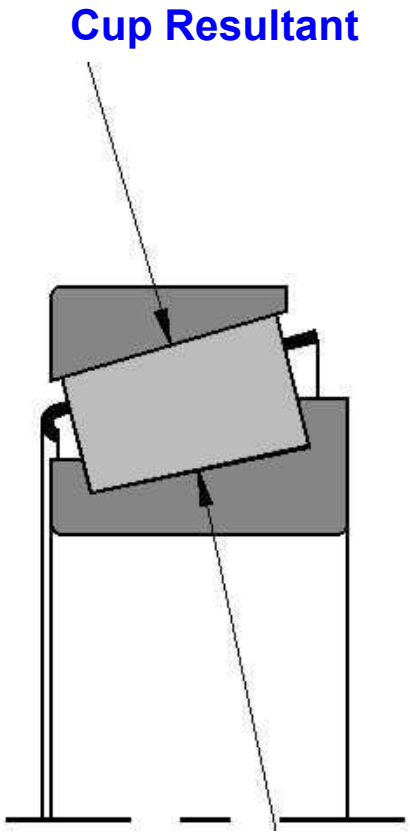
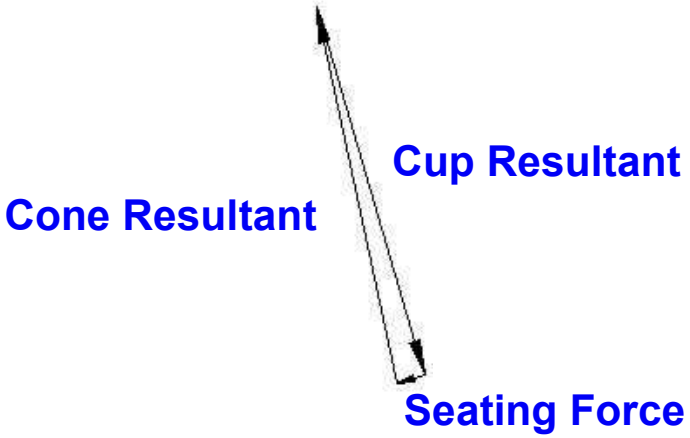
Positive Roller Alignment



The small seating force ensures positive roller alignment



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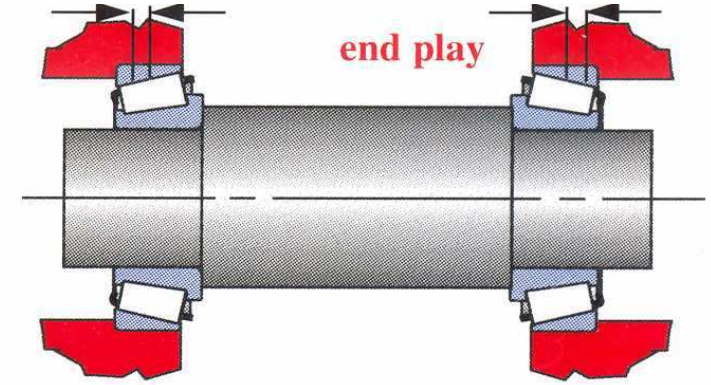
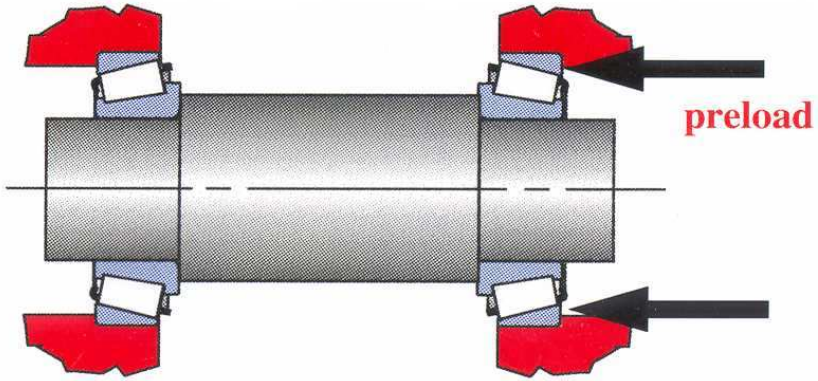
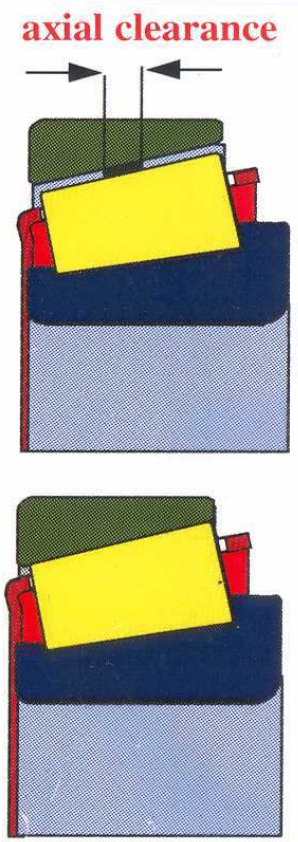
Setting = Axial Clearance



Endplay provides axial clearance



Preload is a compression force measured as axial overlap



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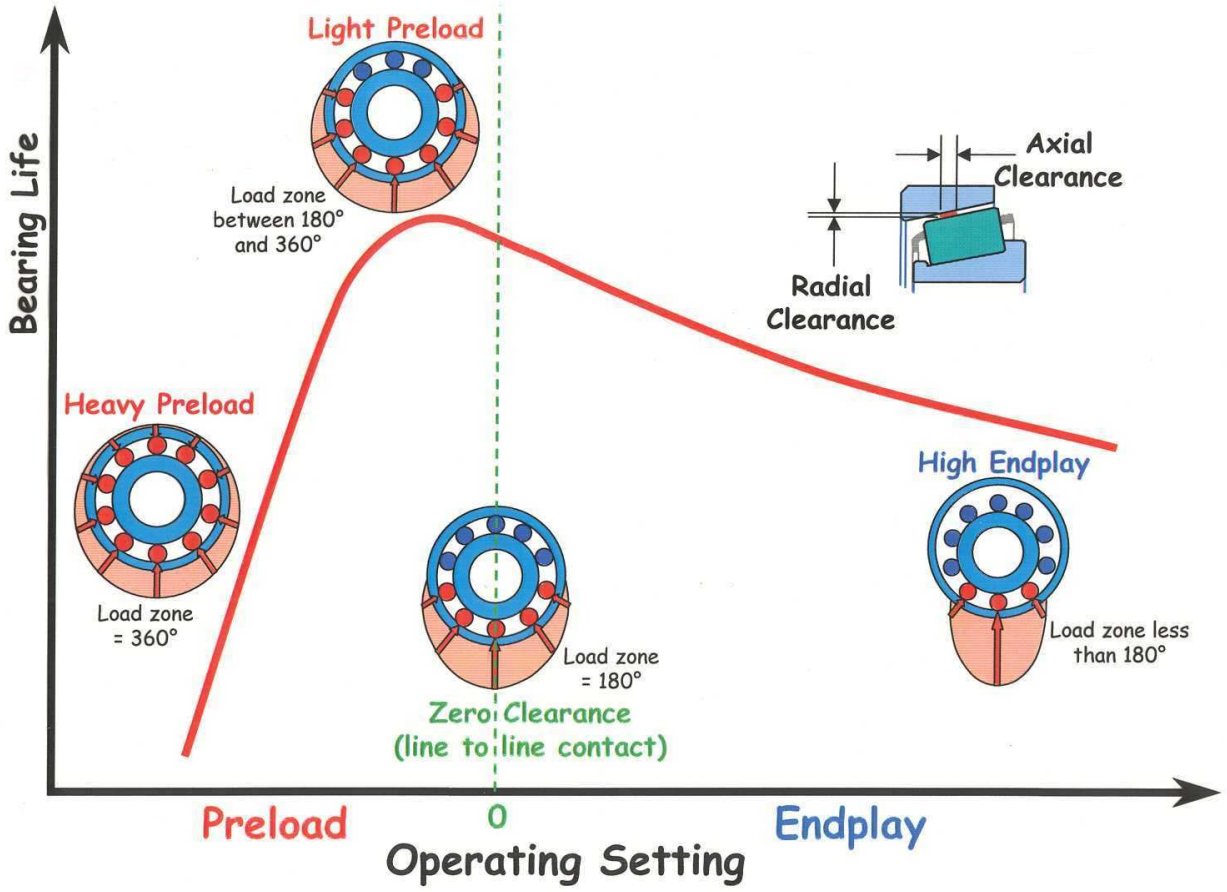
TRB Setting



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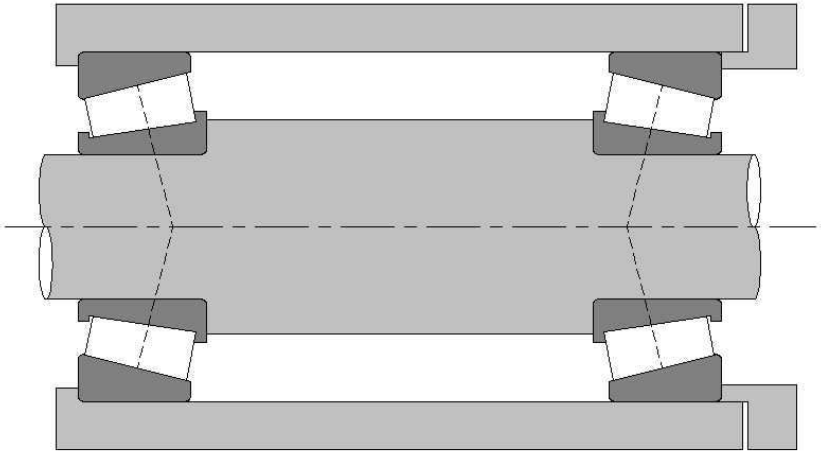
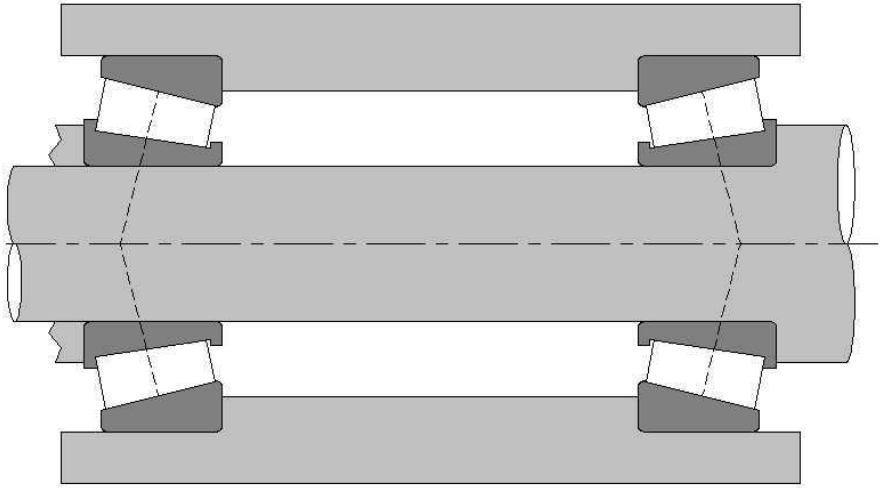
TRB Mounting Arrangements





- Direct mount is less sensitive to misalignment
- Adjustment through cups
- Prevalent for centered loads

- Indirect mount provides more rigidity
- Adjustment through cones
- Prevalent for overhung loads

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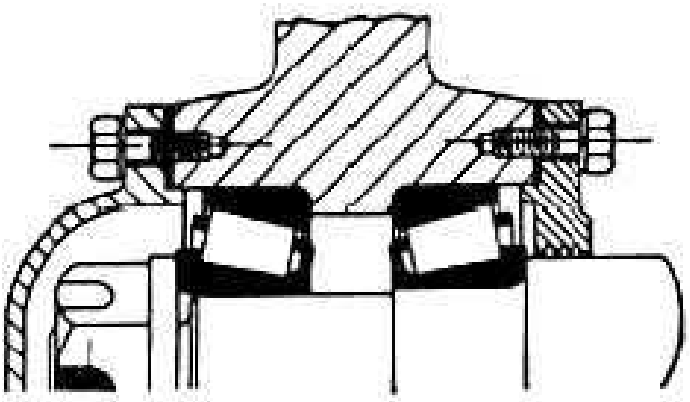
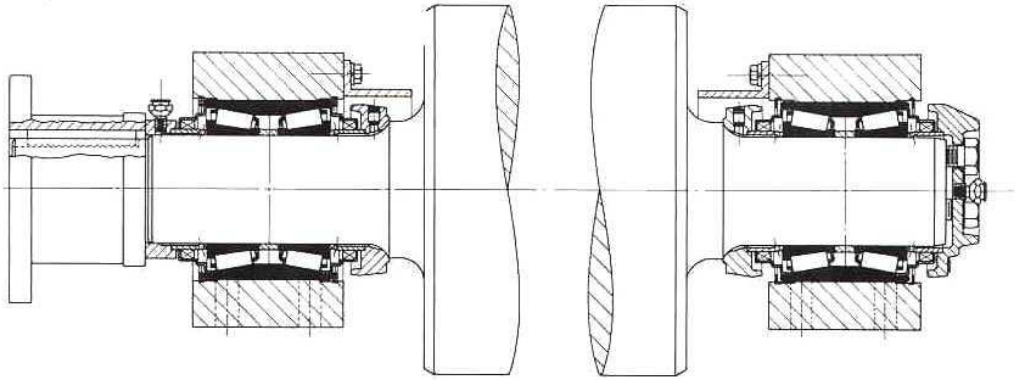
Single Row vs. Two Row

- Single row mounting requires adjustment



- Two row mounting is typically non-adjustable



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Bearing Material & Metallurgy

- Steel quality is a major factor in bearing life
- Quality is determined by cleanness
- Alloy / Chemistry affects properties of steel

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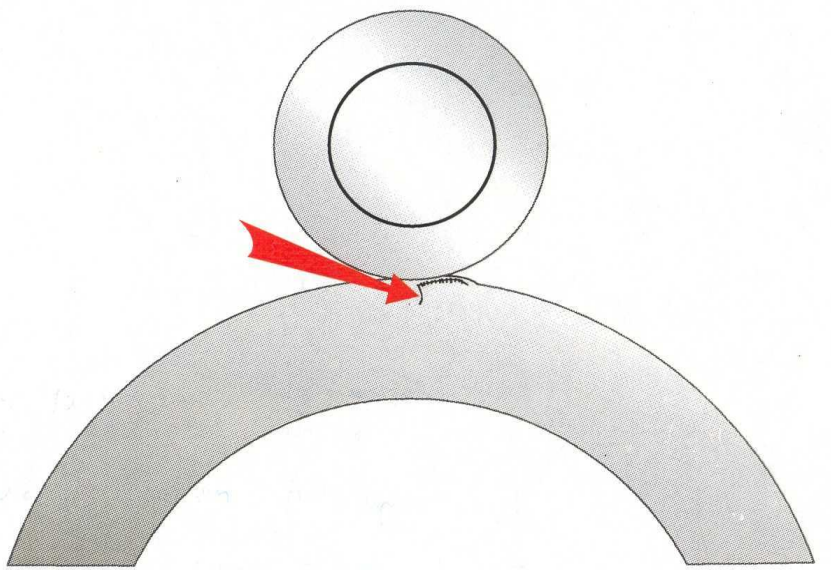
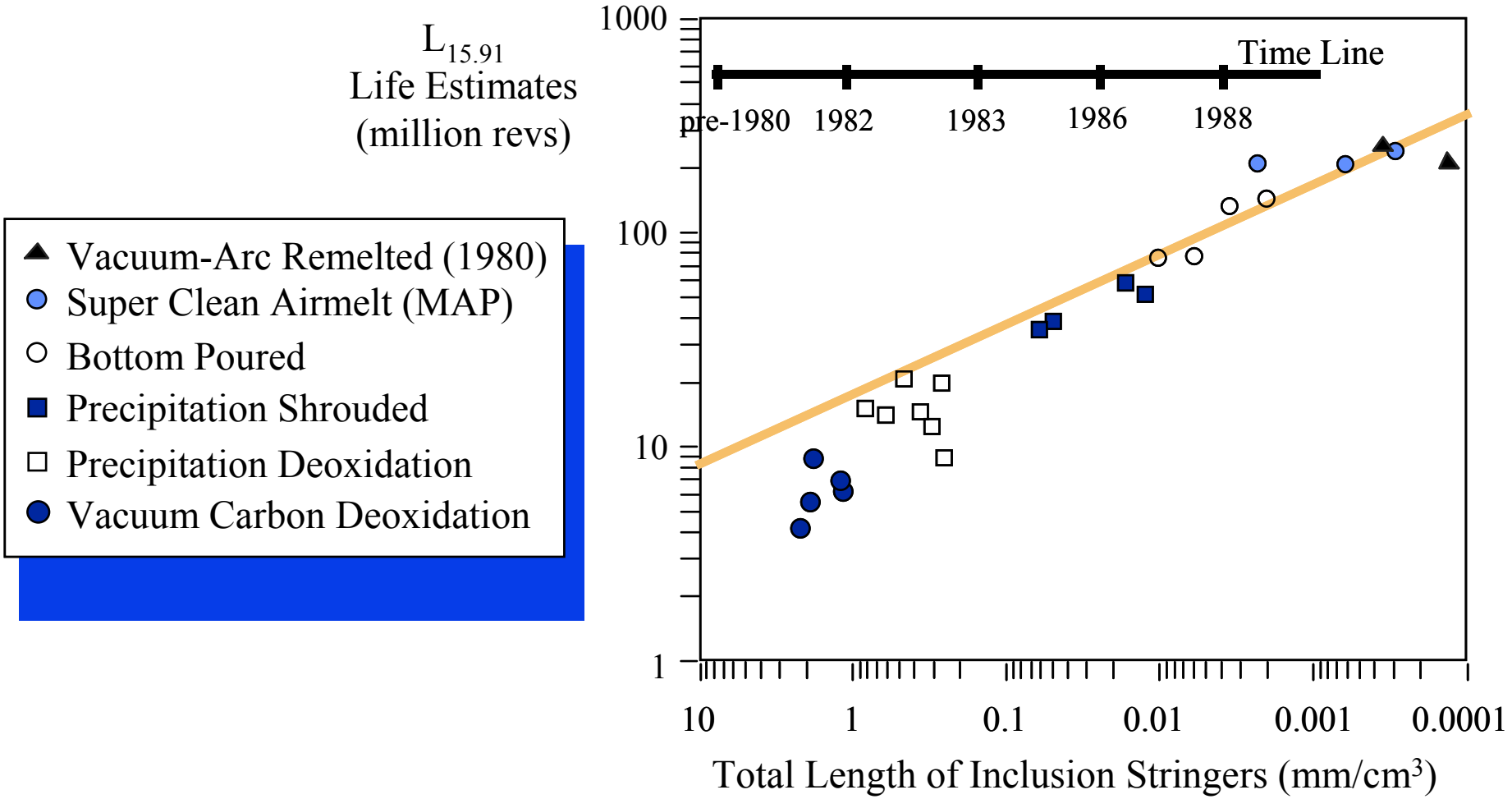
Cyclic Fatigue Mechanism

- Non-metallic inclusions can limit bearing life
- Spall will eventually occur over non-metallic inclusions
- Load ratings based on bearing life before spall occurs



Bearing Life Improvement



Fitting Practice

- Tight fits for rotating race
- Exceptions: low speed applications, TQO work and back-up rolls, keyed bores
- Heavy duty tight fits for heavy loads and high speed *(Limits for TH product)*
- Loose or split fits suggested when adjustment is necessary and for stationary races

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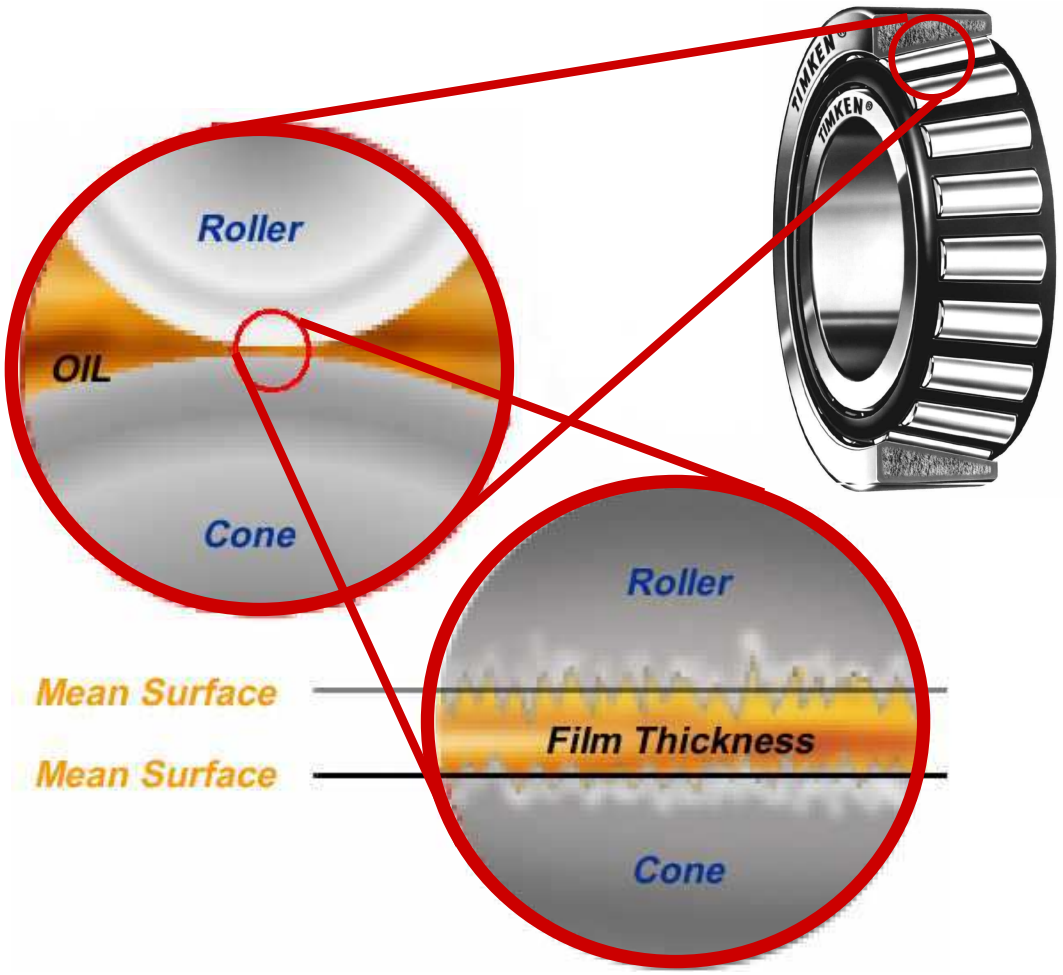
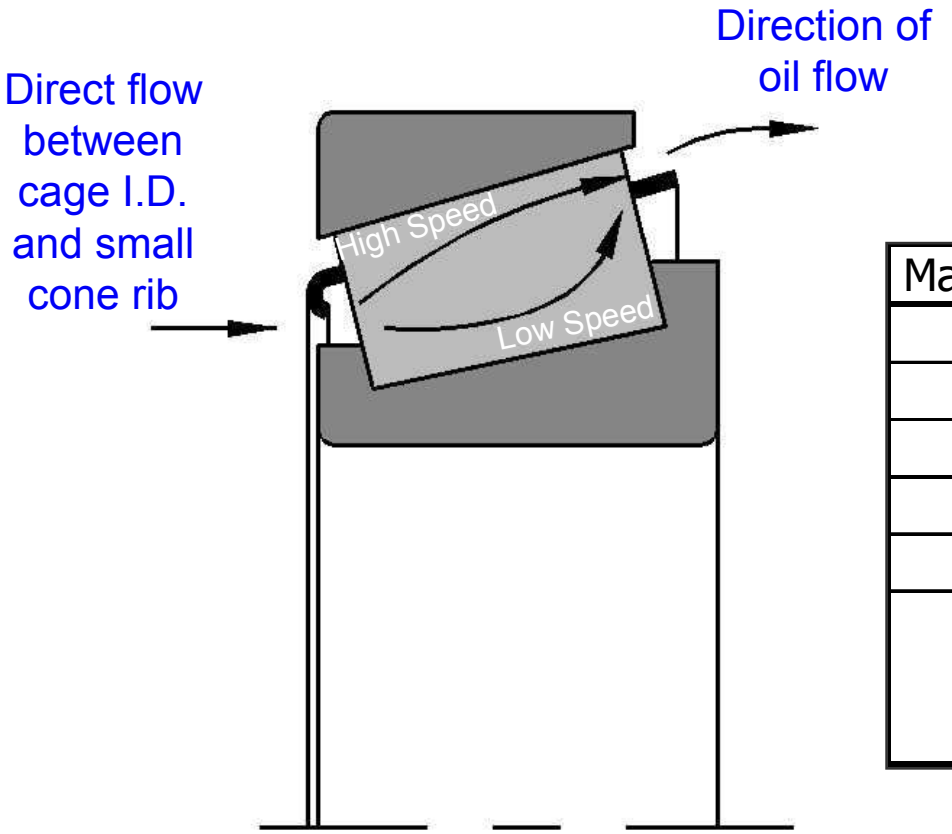
Purpose of Lubrication

- Reduction of friction, wear and fatigue
- Corrosion prevention
- Transfer of heat
- Remove debris



Oil Flow Through the Bearing



Rolling Mill Speed Guidelines

Max Rib Speed (FPM)	Min System Lube
1,500	Grease *
3,000	Oil Level
5,000	Ciculating Oil
5,500	Air/Oil or Oil Mist
6,000	Oil Jets
10,000	Special High Speed Bearings with Ciculating Oil

Rib Speed = $\frac{\pi \times \text{Cone Rib Dia.} \times \text{RPM}}{12 \text{ in/ft}}$

* Note: Work Roll Bearings are an exception to the rule

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