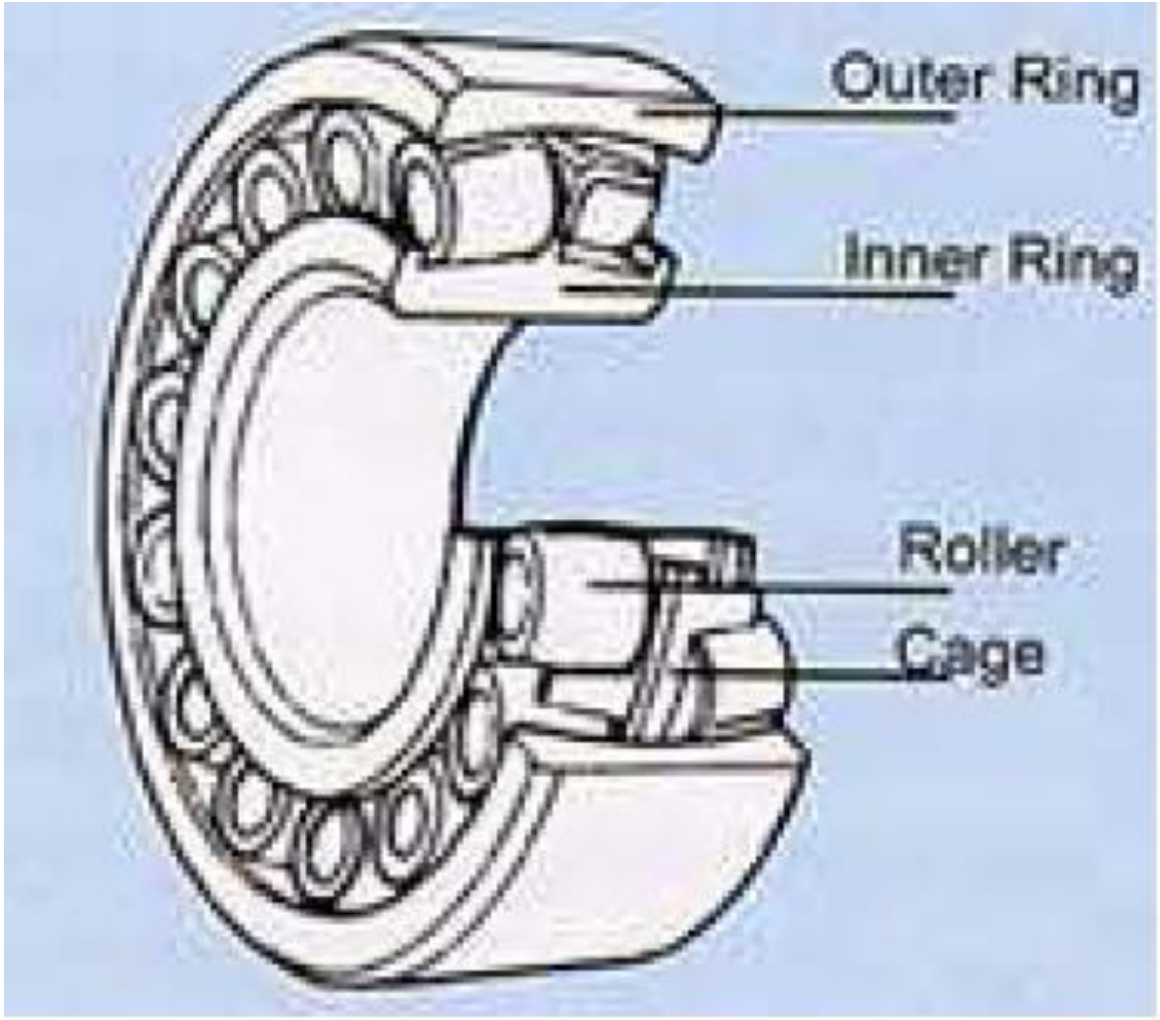
Bearing Technology

- Constructions/Design
- Functions
- Bearing Types
- *Lubrication theory*
- Stribeck curve
- Bearing defects
- **Bearing maintenance, overhauling & inspections**

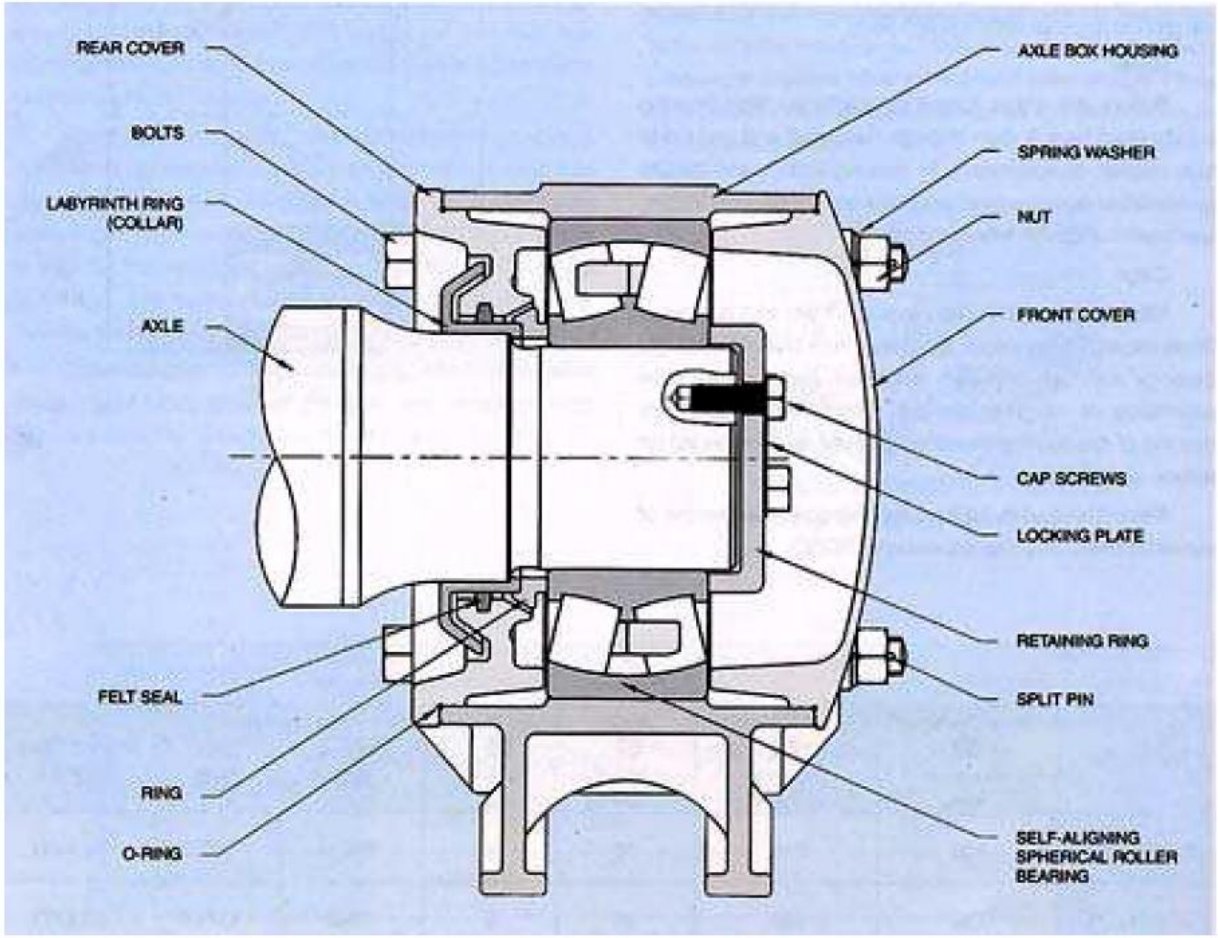
Constructionwise Spherical Roller Bearings {ICF}: Main Components -

- Outer Ring
- Inner Ring
- Spherical Roller
- Cage Separator/Retainer

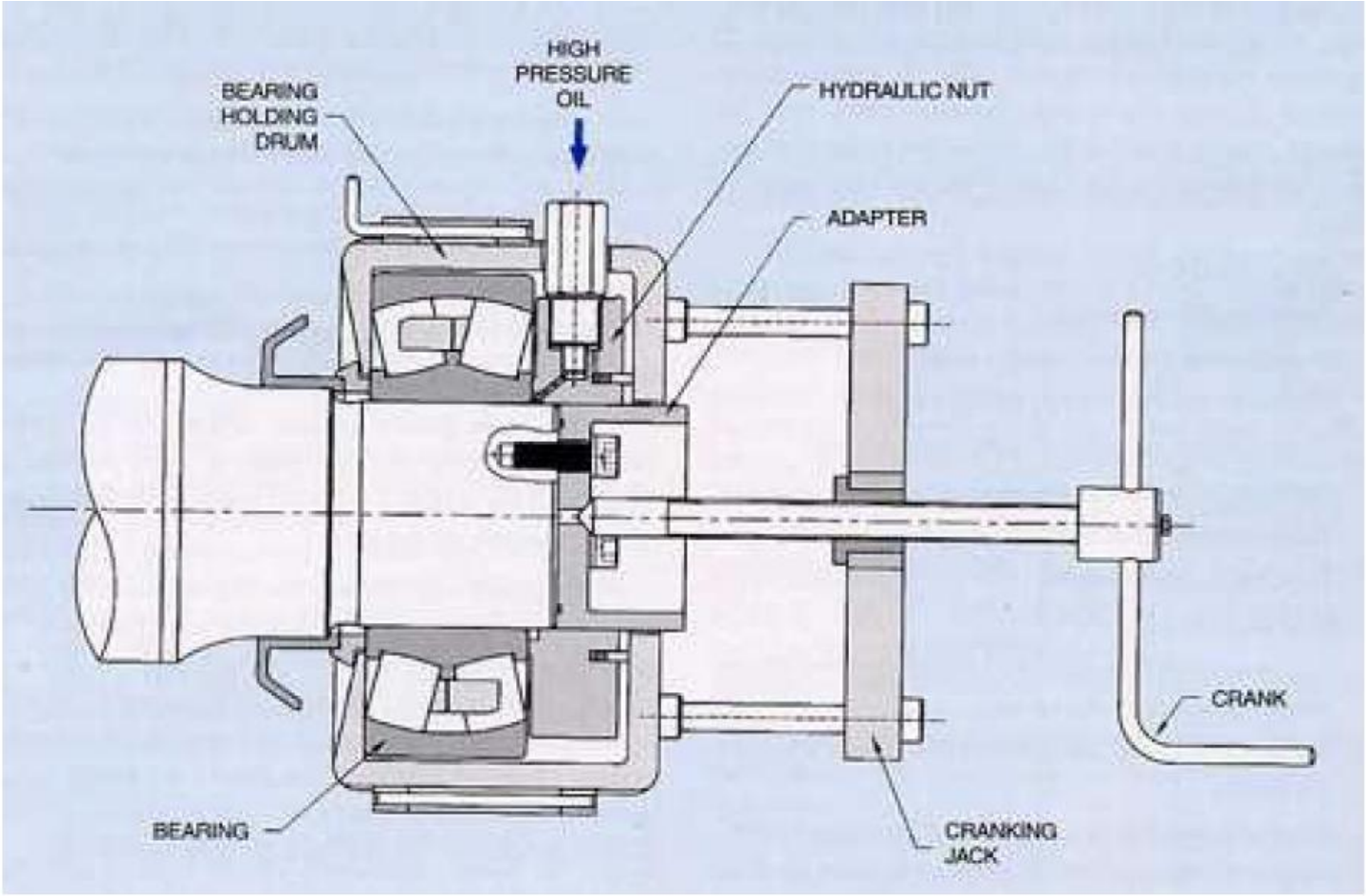
ICF self aligning Spherical Roller Bearings : Photo -



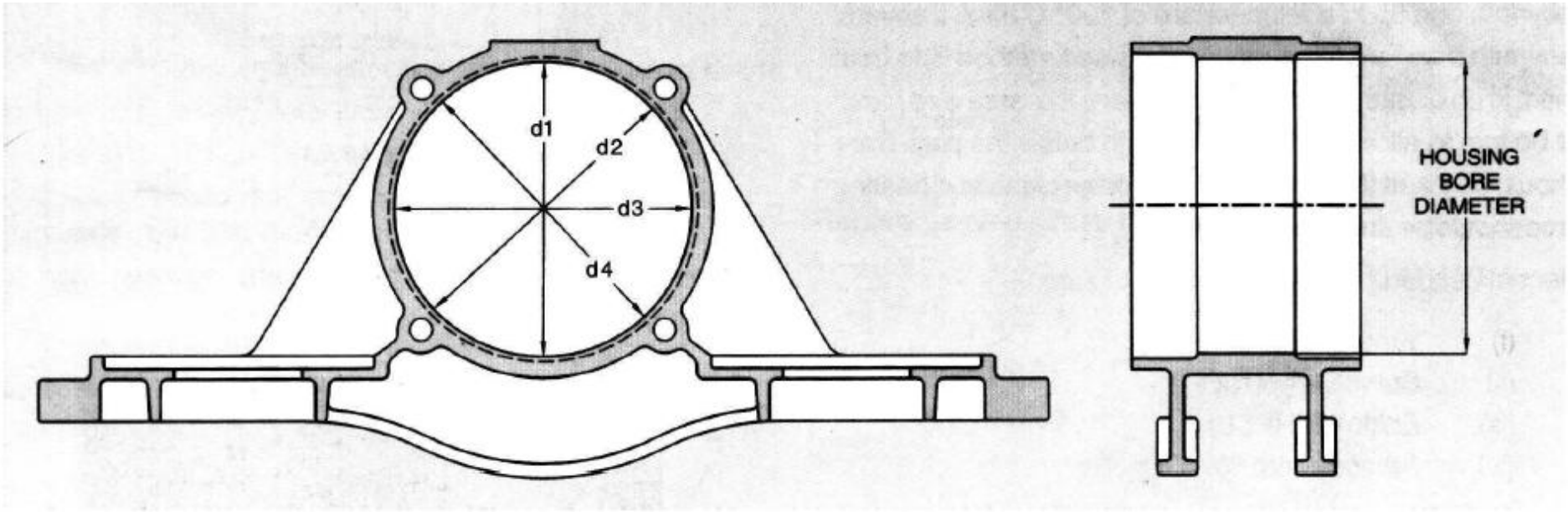
ICF self aligning Spherical Roller Bearings : Photo -



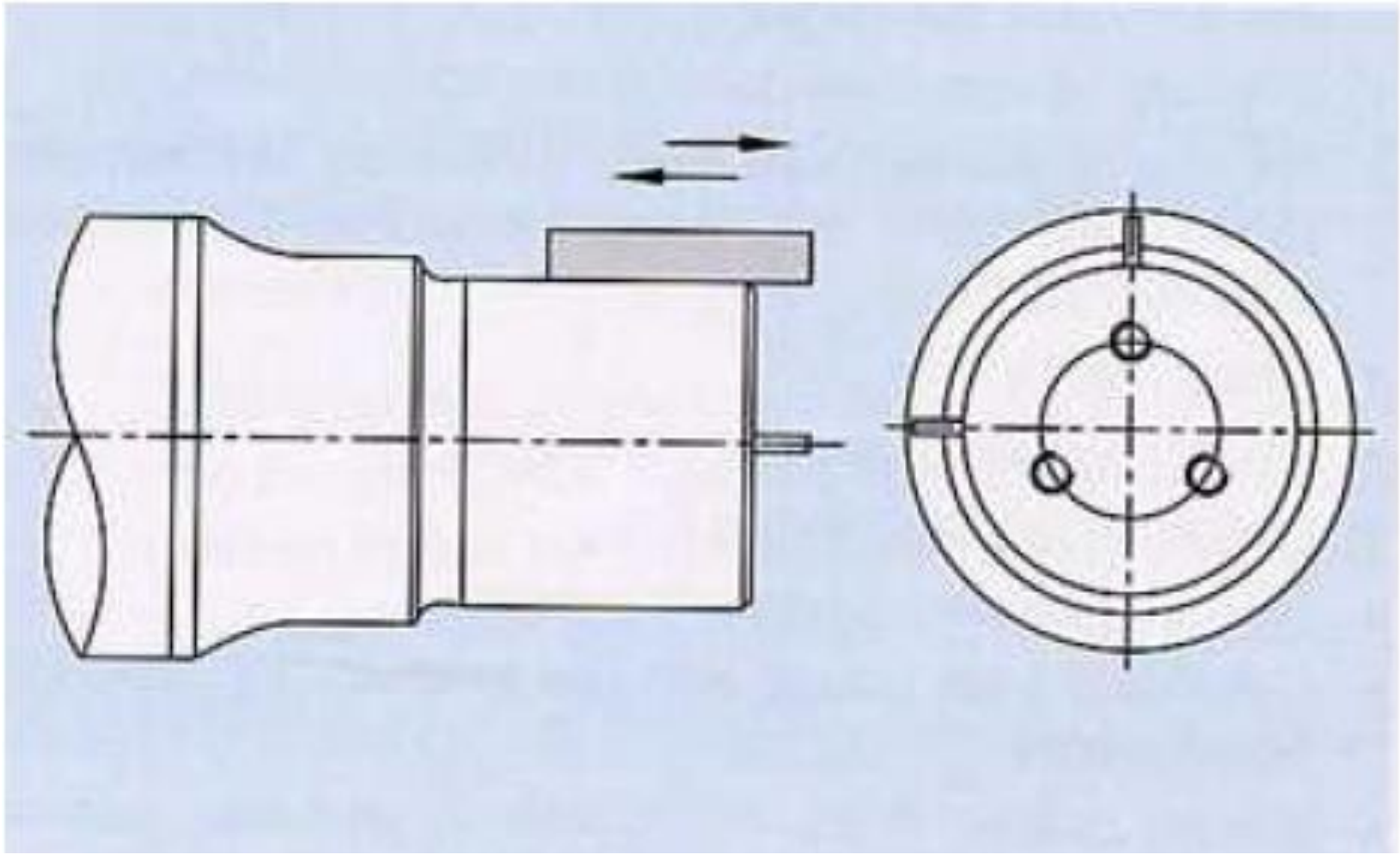
ICF self aligning Spherical Roller Bearings : Dismounting -



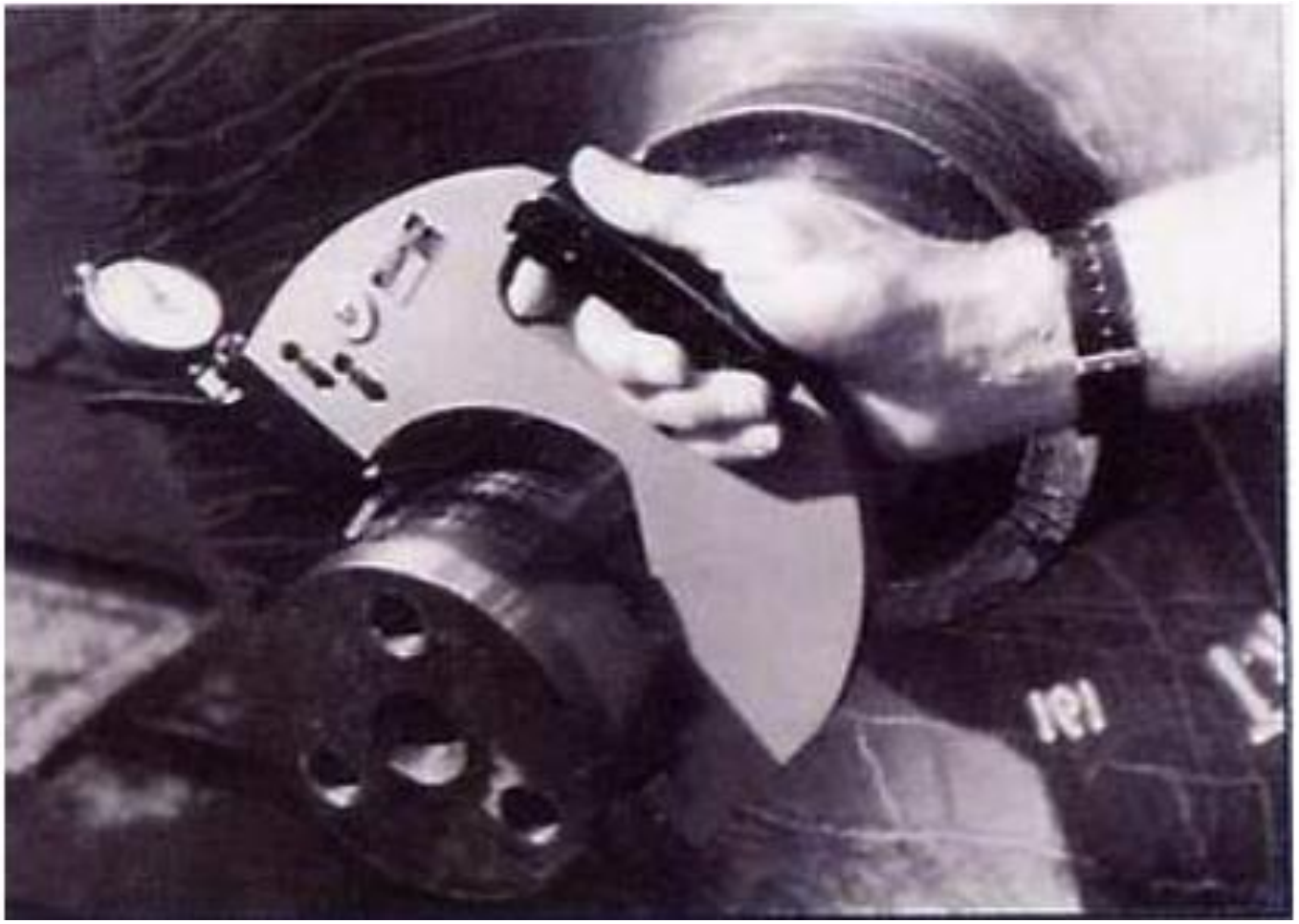
ICF self aligning Spherical Roller Bearings : Mounting housing image -



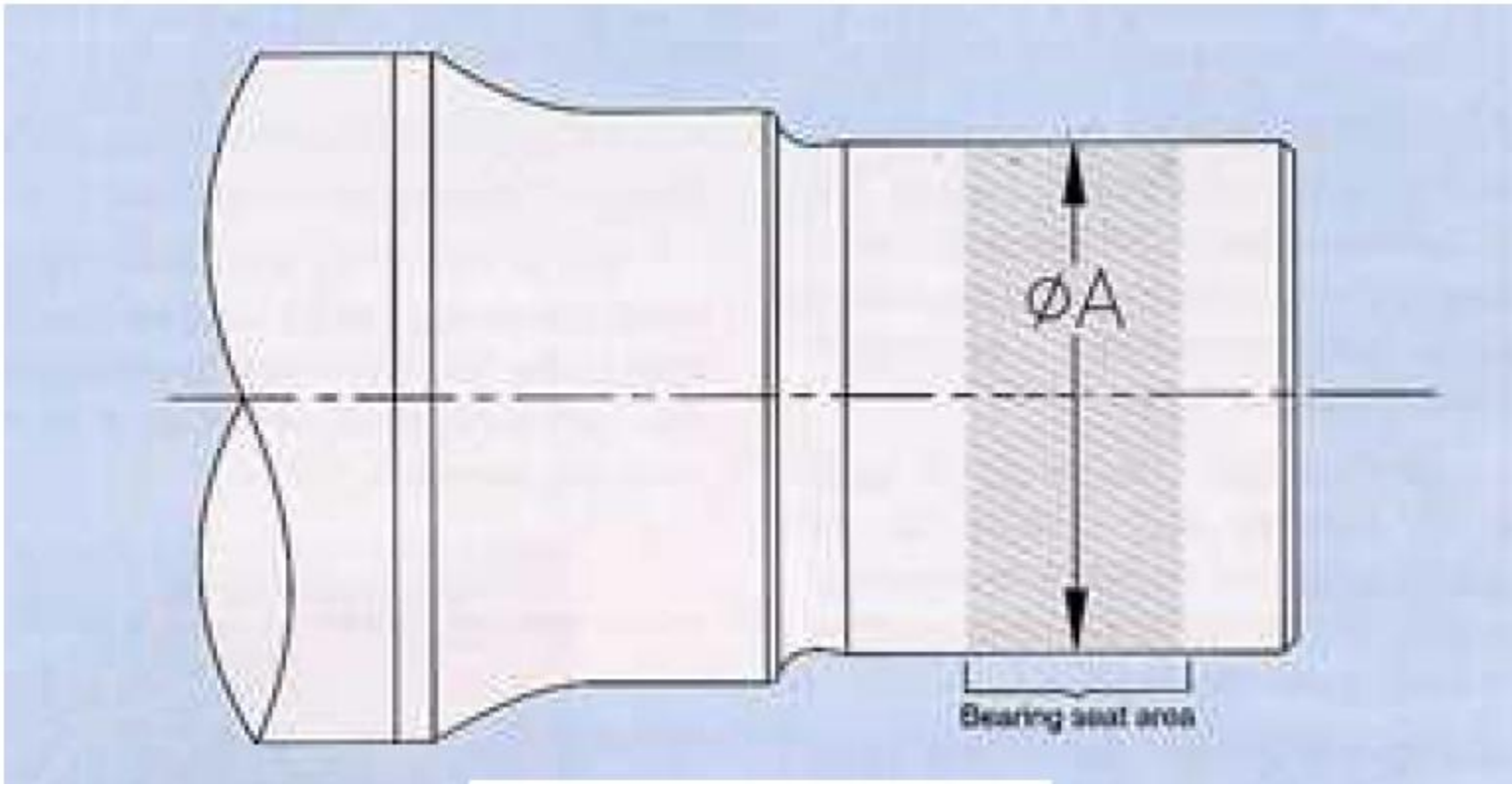
ICF self aligning Spherical Roller Bearings: Straight edge Journal checks-



ICF self aligning Spherical Roller Bearings: Dial Snap Gauge Journal Diameter checks-



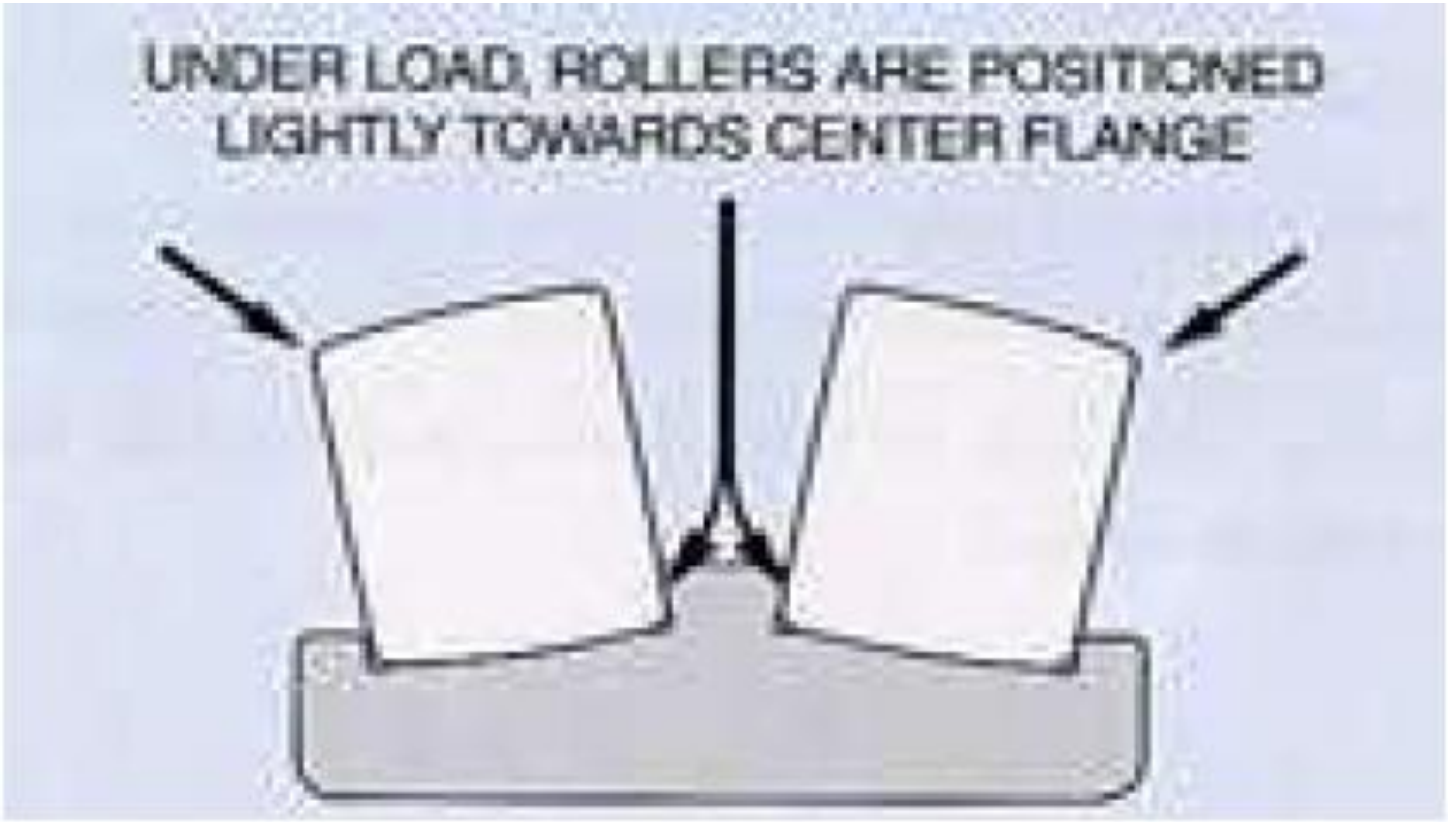
ICF self aligning Spherical Roller Bearings: Journal Diameter-



Journsl = Journal.

Journsl Diameter ØA(Max/Min)	Maximum permissible out of roundness (mm)	Maximum permissible taper (mm)
130.068 /130.043	0.015	0.015

ICF Spherical Roller Bearings : Functions -



ICF Spherical Roller Bearings : Inspections -



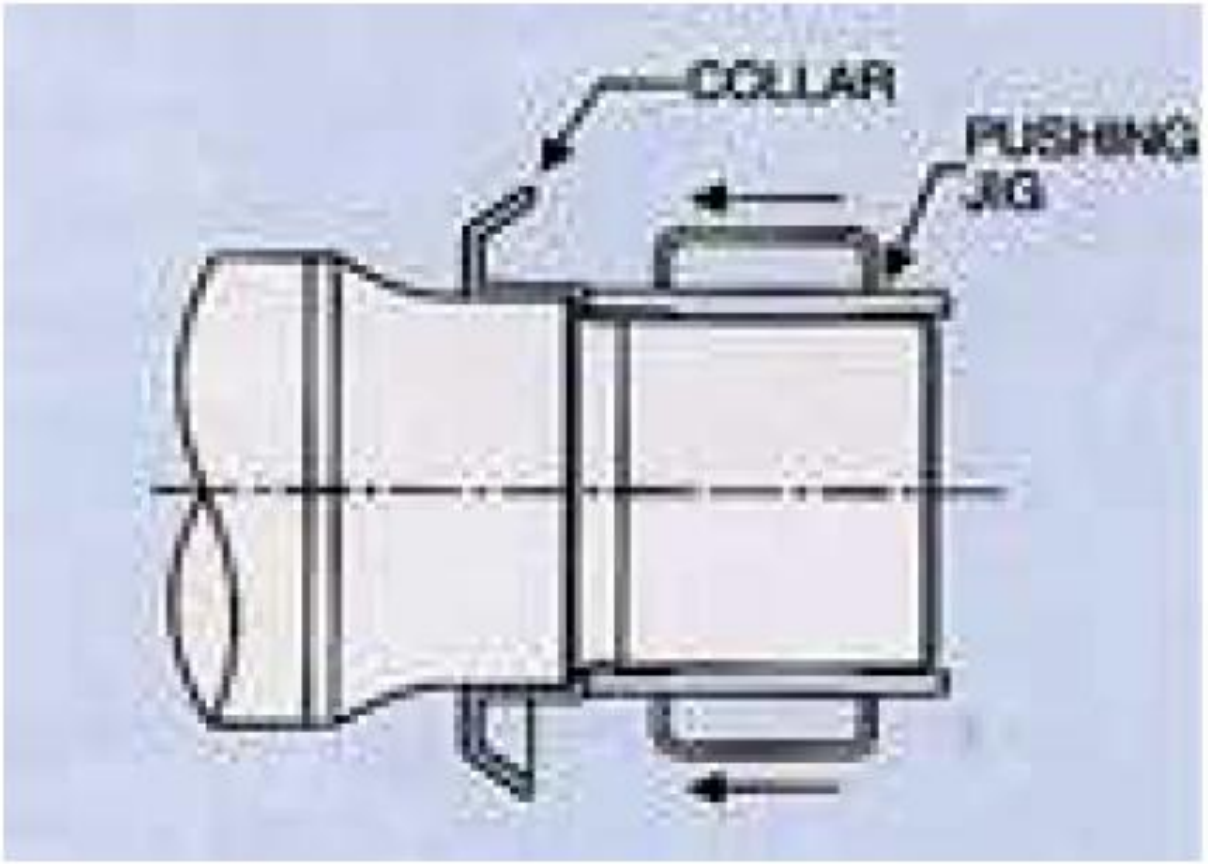
ICF Spherical Roller Bearings : Clearances -



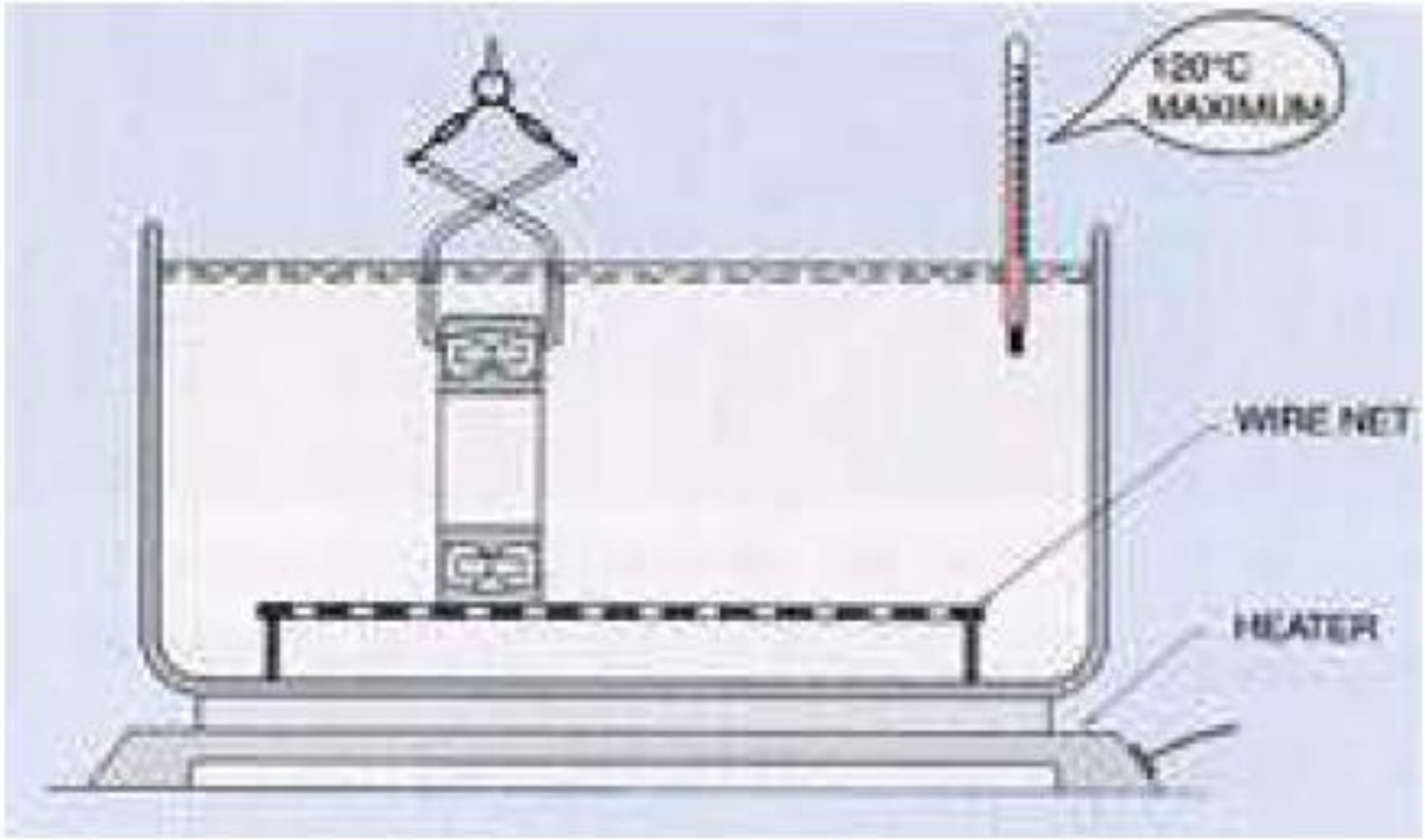
ICF Spherical Roller Bearings : Clearances -



ICF Spherical Roller Bearings : Mounting -



ICF Spherical Roller Bearing : Oil bath Heating during mounting -



ICF Spherical Roller Bearing : Induction heating during bearing mounting -



ICF Spherical Roller Bearing : 120 Deg. Cel. Induction heater's equipments -

Temperature and cycle time controllers

Auto demagnetizer

Temperature and cycle time indicator

Audio alarm to indicate completion of cycle

ICF Spherical Roller Bearing : Radial clearance checks on mounting -



M = mtr.s {Endcap bolts}

Bolt Size	Torque Value
M16	12 Kg-M
M20	16 Kg-M

ICF Spherical Roller Bearings : Radial Clearances in mounted bearings -

Bearing make	Radial clearance in mounted condition (in mm)	
	New Bearings	In service bearings
FAG/NORMA	0.080-0.160	0.220 max.
NEI/NBC	0.080-0.160	0.245 max.

ICF Spherical Roller Bearing : Incorrect mounting failures – Effects & Reasons.

Damage during mounting	Possible Cause
Score marks on rings	Bearing inner ring not properly aligned with axle during mounting. Forcible entry on axle box during mounting.
Surface cracks	Rapid or excessive heating of bearing (temperature more than 120 ^{O}C)
Discolorated surface	Excessive heating temperature (more than 120^{O}C)
Axial cramping of bearing	Faces of bearing and associated part not flush with one other.
Radial cramping of bearing	Oversize or undersize journal diameter.
Excessive fretting of outer race	Oversize housing bore
Grease oozing from rear cover	Used or poor quality of felt seal

ICF Spherical Roller Bearings : Peak Operating temperature – 80 deg. Cel. {Li based grease filled/Axlebox = 1.75 Kg}

HOT AXLES

IN CORRECT FIT

IMPROPER MOUNTING

IMPROPER HANDLING

POOR LUBRICATION

CONTAMINATION

EXCESSIVE HEATING

EXCESSIVE LOAD

Hot Axles : Reasons & Effects -

Defect	Effect on Bearing
Felt ring perished	1. Grease may ooze out from rear cover 2. Dust and water may enter the axle box
Rubber 'O' rings of cover perished	Dust and water may enter the axle box

ICF Spherical Roller Bearings : Hot Axles Continued -

'V' grooves on rear cover, front cover and axle box faces not filled with grease.	Dust and water may enter the axle box.
Improper and/or excessive / inadequate grease.	Excessive temperature, seizing or complete failure of Roller Bearing.
Bearing clearance not within prescribed limits.	Excessive wear of rollers and races leading to bearing failure.

ICF Spherical Roller Bearings : Hot Axles Continued -

End locking screws not tightened properly.	End locking arrangement may fail.
Journal finish and Diameter not as prescribed in the drawing.	Bearing may become loose/inner ring cracks causing serious damage to the bearing leading to bearing failure.
Excessive or inadequate lateral clearance between axle box covers and bearings.	1.Excessive clearance may damage roller bearings or covers. 2.Inadequate clearance may result in gap between axle box housing and bearings.

ICF Spherical Roller Bearings : Hot Axles Concluded -

Fitment of substandard/ improper size end locking bolts/ screws.	Bolt may fail in service cause damage to front cover and bearings
Improper locking of end locking screws.	Screw may get loose in service and cause damage to front cover and bearings
End locking screws not tightened properly.	End locking arrangement may fail.

ICF Spherical Roller Bearings : Damages -

Rust and corrosion  Surface becomes partially or fully rusted. Sometimes rusted at spacing equal to distances between rolling element	• Improper storage • Improper packaging • Insufficient rust preventative oil • Invasion of moisture, acid etc. • Handling with bare hands

ICF Spherical Roller Bearings : Damages -

Fretting  Fretting Surfaces wear producing red coloured particles that form hollows.	• Over size housing bore. • Insufficient interference • Insufficient lubrication • Fluctuating load • Vibration during transport or when not operating Conditions

ICF Spherical Roller Bearings : Damages -

Flaking/ Spalling  Flakes form on the surfaces of the raceway and roller elements. When the flakes fall off, the surface becomes rough and uneven.	• Excessive loads, metal fatigue, improper handling. • Improper mounting. • Insufficient precision of journal or housing. • Insufficient clearance • Contamination. • Rusting. • Passing of electric current through bearing. • Softening due to abnormal temperature rise.

ICF Spherical Roller Bearings : Damages -

Seizure  Bearing heats up, becomes discolored and eventually seizes up.	• Insufficient clearance (including clearances made smaller by local deformation) • Insufficient Grease. • Bad quality of grease. • Excessive load. • Roller Skewing. • Softening due to abnormal temperature rise. • Slippage of inner ring over journal due to failure of clamping arrangement.

ICF Spherical Roller Bearings : Damages -

Cracking  Splits and cracks in bearing rings and rollers	• Rapid heating during mounting. • Excessive shock load. • Improper handling, use of steel hammer and ingress of large foreign particles. • Surface deformation due to improper lubrication. • Excessive interference. • Over size housing bore and excessive ovality. • Large flaking. • Overheating due to creeping.

ICF Spherical Roller Bearings : Damages -

Cage damage  Breaking or wear of cage.	• Excessive moment load. • Excessive fluctuation of speed. • Trapping of foreign objects. • Excessive vibration. • Improper mounting (misalignment)

ICF Spherical Roller Bearings : Damages -

Rolling Path Skewing  Roller contact path in raceway surface strays or skews.	• Deformation or tilt of bearing due to insufficient precision of journal or housing. • Improper mounting. • Insufficient rigidity of journal and housing.

ICF Spherical Roller Bearings : Damages -

Smearing and scuffing  Surface becomes rough with small deposits. "Scuffing" generally refers to roughness of the bearing ring ribs and roller end faces.	• Improper lubrication. • Ingress of foreign matter. • Rollers skew due to excessive misalignment. • Excessive surface roughness. • Excessive sliding of rolling elements.

ICF Spherical Roller Bearings : Damages -

Indentations  Hollows in raceway surface produced by solid foreign objects trapped or impacts (False brinelling)	• Ingress of small solid foreign objects such as dirt, dust. • Trapping of flaked particles. • Impacts due to careless handling.

ICF Spherical Roller Bearings : Damages -

Electric Current Damages  Pits form on raceway and develop into ripples. Further development leads to corrugated surface. Some times spot or localized burns are also noticed.	• Electric current flowing through raceway.

ICF Spherical Roller Bearings : Damages -

Discoloration  Change of raceways / roller colour	• Temper color by overheating. • Deposition of deteriorated grease on surface. • Improper lubrication.

ICF Spherical Roller Bearings : Damages -

Peeling  Peeling is a cluster of very small spalls. Peeling can also include very small cracks which develop in to spalls.	• Ingress of foreign matter. • Improper lubrication.

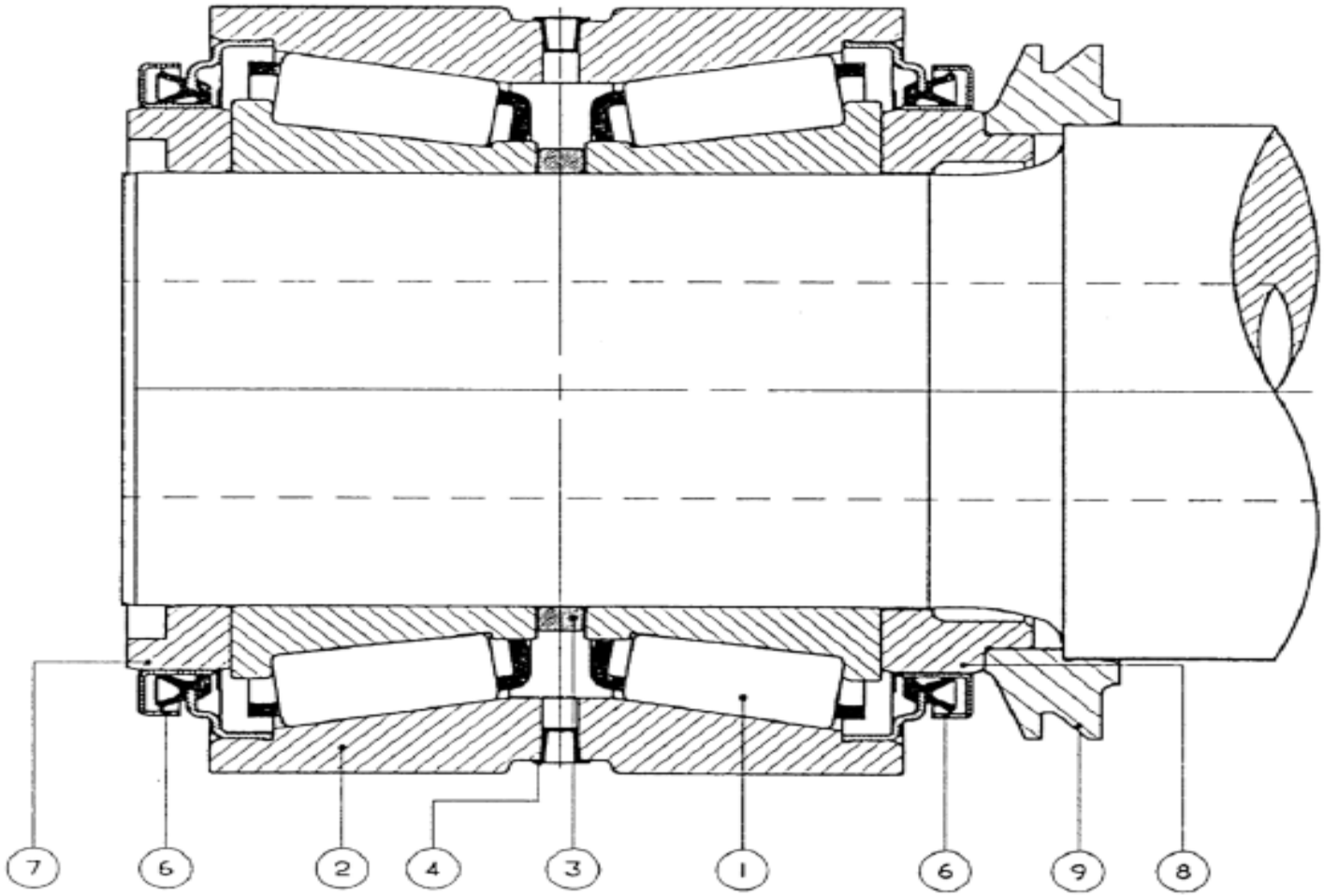
FIAT CTRB Specifications : RDSO LKO October 2014 -

BG IR Axle load = 18 tons
Wheel centre speed = 200 Kmph
Prototypes = 40
12 lakh Km run = 60 months = 5 yr.s

TBU in LHB coaches

- UIC 130 standard
- Pre sealed bearing
- Pre set bearing
- Pre lubricated bearing
- Post commissioning lubrication discontinuous
- Accurate angular alignment must be there
- NBL {no bearing lubrication} type

CTRBU/TBU Constructions : Components -



Timken bearing unit sectional view

CTRBU/TBU Constructions : Components -

S NO	DESCRIPTION	QTY	PART NO	WEIGHT (KG)
1	CONE ASSEMBLY	2	H127746	5.812
2	DOUBLE CAP	1	NP499858	14.306
3	CONE SPACER	1	H127748XA	0.274
5	GREASE	1	GR 241	0.280
6	HDL$_{TM}$SEAL	2	K152139	0.500
7	BACKING SPACER	1	K153064	1.393
8	SEALING RING	1	K153063	0.910
9	BACKING RING	1	K160115	3.012
TOTAL WEIGHT				**32.799**

Lubricant Details

GR represents 280 Grams of MOBLITH SHC220.

CTRB/TBU maintenance & overhauling : Mounting & dismounting -



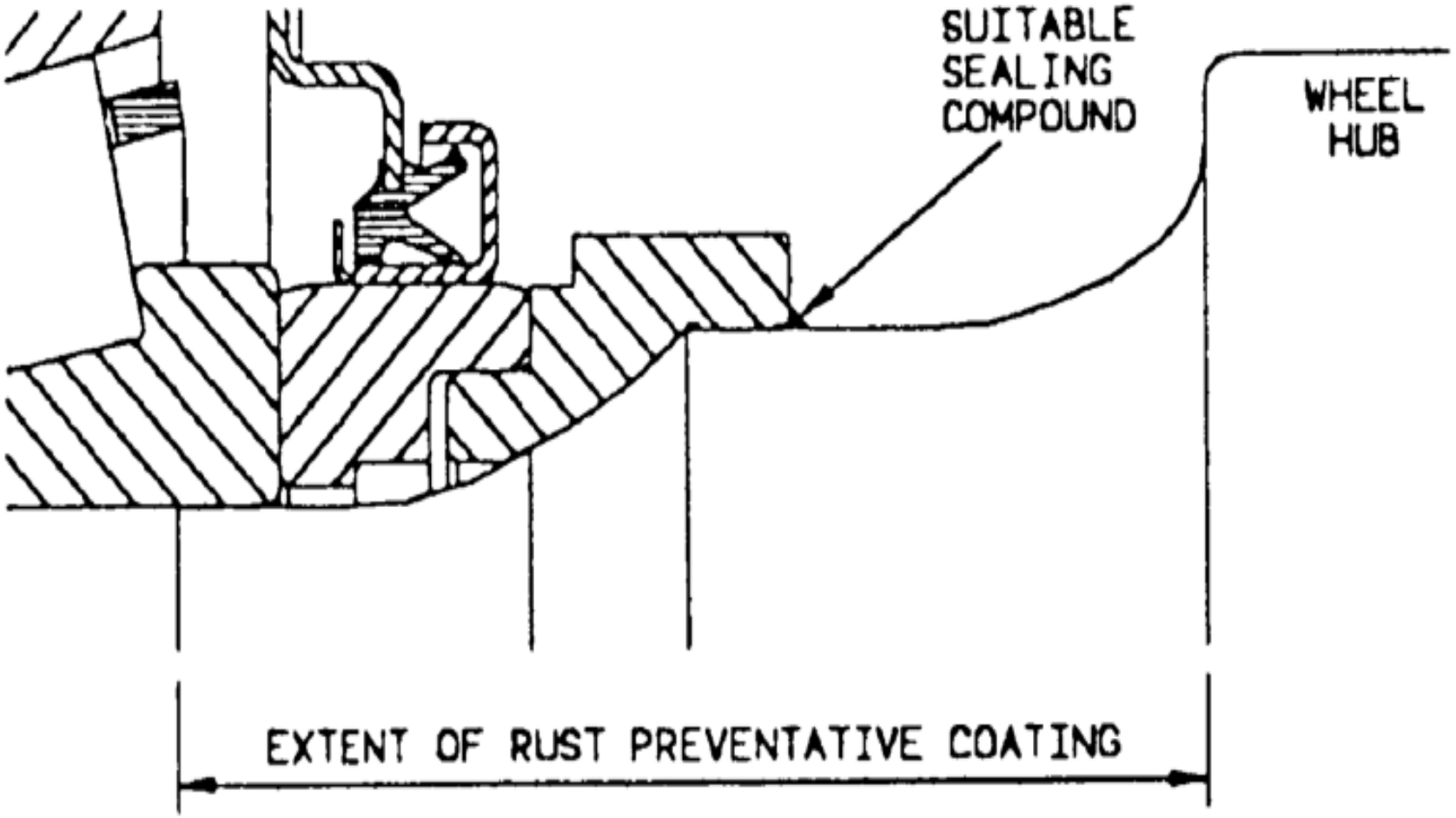
CTRB/TBU maintenance & overhauling : Mounting & dismounting forces 28-32 Tons.



CTRB : Double cone cup form -

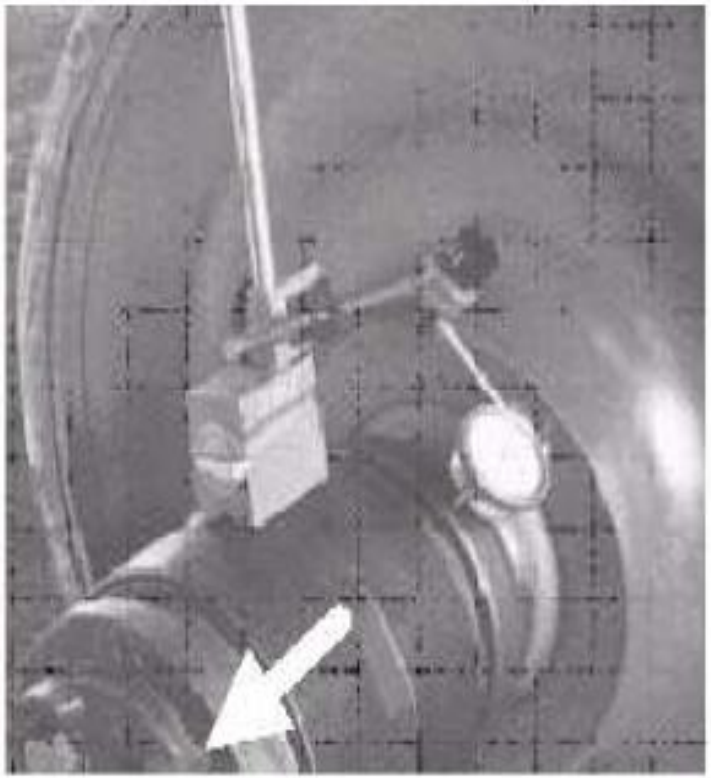
- Cone assembly/Inner race set
- Cup assembly/Outer race set
- Cone spacer
- Conical rollers
- Polymer cage
- Seal sleeve
- Backing ring
- Seals
- Polymer Distance rings

FIAT : Seals of CTRB for LHB carriage -

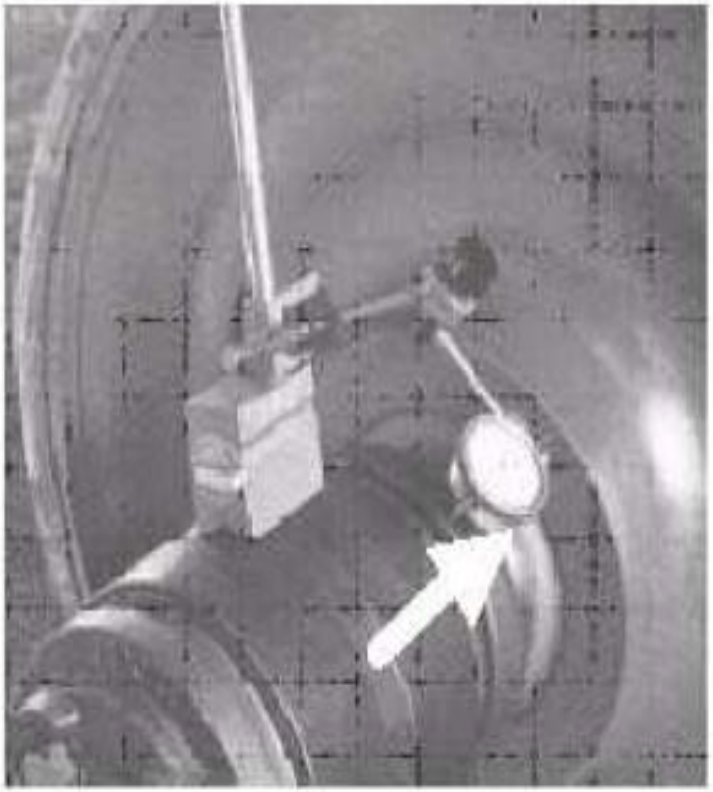


LHB CTRB Axial clearances :

0.10 mm - 0.40 mm.



Pulling the TBU



Pushing the TBU

FIAT : Journal & CTRB inspections -

Check the bearing seating. The journal diameters should be **130.043 mm to 130.068 mm** and taper of dia must not exceed 0.02 mm over length of journal. Shoulder dia should be **160.174 to 160.134 mm** must be measured in 2 planes at 90^0 (maximum different value between 2 points = 0.012 mm) in 3 points.

Measure and record the inner dia of TBU. It should be **130.0 mm - 0.000 to - 0.025 mm (for SKF)**. Mount the pilot sleeve onto the journal with the bolts, in order to sustain and guide the TBU during the mounting, and tightening the screws with the tightening torque **21.5 kg-m**.

Bench End Play (mm)	Mounted End Play at installation (mm)
0.58 - 0.64	0.025 - 0.500

Ensure that cap screws are tightened with torque wrench. (Set at 18-22 Kg-m)

Put the bearing assembly on pilot sleeve and refit the bearing on journal with 20-25 tonne seating load (for Timken Makes bearings).

Tighten the security plate & security disc with M-20 cap screw at 18-22 Kg-m torque with the help of torque wrench

Check mounting lateral play with the help of magnetic base dial indicator. It should be 0.025 mm to 0.33 mm for new bearing and 0.025 mm to 0.500 mm for in-service bearings

FIAT CTRB clearance inspection



FIAT : Journal & CTRB inspections – Pressure is actually Force ; Pickups = Pickup.

Journal dia should be **130.043 mm to 130.068 mm.** Taper of dia must not exceed **0.02** mm over length of journal
Shoulder dia should be **160.174 mm to 160.134 mm.**

To ensure that the bearing is firmly seated against the axle fillet, the pressure indicated on, the gauge during pressing on should be increased by 50%. This seating load pressure should be within the limits 20-30 tonnes.

Peeling is just a metal pickups. Peeling up to 0.025 mm deep is allowable.

As per Railway Board's instruction bearings should be refurbished by OEMs or manufacture after every 3 years or 12 Lakhs Kms of running, whichever is earlier. If the bearings are removed from axle prior to the above mentioned period, it should also be refurbished.

RDSO references regarding CTRB : -

- EN 12080
- EN 12081
- EN 12082
- UIC : 515 – 1
- UIC : 515 – 5
- UIC 814
- ISO 281
- ISO 492
- ISO 2639
- IS 3073 {reg. Brg. Surface Finish}
- LHB {ALSTOM FIATSIG} 17.565 : 100 - 103

FIAT CTRB Specifications :

Designing model criteria –

1. Axle load = 18 metric tonnes
2. BG Wheelset speed = from 220 Kmph to 180 Kmph value ranges
3. Carriage CG height = 2000 mm {2 metres} over rail level {peak acceleration = 3.0g}
4. Vertical Load on wheel = 110 kN
5. Wheel side thrust = 80 kN {horizontal}
6. Regreasing time/Service Life=12/30 Lakh Km run

Environmental criteria : LHB CTRB -

- Sandstorm/flying ballast exposure
- Rainwater/Snow
- Relative Humidity ranges : { 30 – 100 } %
- Temperatures : [(-10) – (+ 70)] degrees Celsius
- Cleaning frequency : every { 2 – 5 } days
- Pressurised jet water cleaning @ 50 deg. C
- Grease seal change periodicity = IOH/POH

Acceptance Sampling : CTRB -

- For Lots of {0-100} : 2 samples are checked
- For Lots of {101-250} : 3 samples are checked
- In Lots over 250, 4 samples are inspected
- Zero Defective {hypothesis} sample
- Hypergeometric distribution
- Both rings are checked for defects till depth of 4 mm beneath the raceways is reached
- VHN must exceed 550
- Residual magnetism not exceeding 0.5 milli Tesla

Quality Controls : CTRB -

- Axle box housing bore diameters [(F8) Lower Control Arm] = ranging from 230.122 mm to 230.050 mm only
- Axle box housing bore diameters [(F8) Upper Control Arm] = ranging from 230.150 mm to 230.050 mm only
- Journal diameters {p6} = ranging from 130.068 mm to 130.043 mm strictly ensured by IR
- Allowable mean roller diameter difference/CTRB = 0.003 mm
- Tapered Roller length tolerances/CTRB = [from (+0.102) mm to (-0.254) mm]
- Cup, Cone + roller hardness = {from 57 to 66} HRC
- Allowable Hardness variation/CTRB = 4 HRC
- Case hardened steel rollers hardness by HV 30

CTRB warranty :

Earlier of the following clauses -

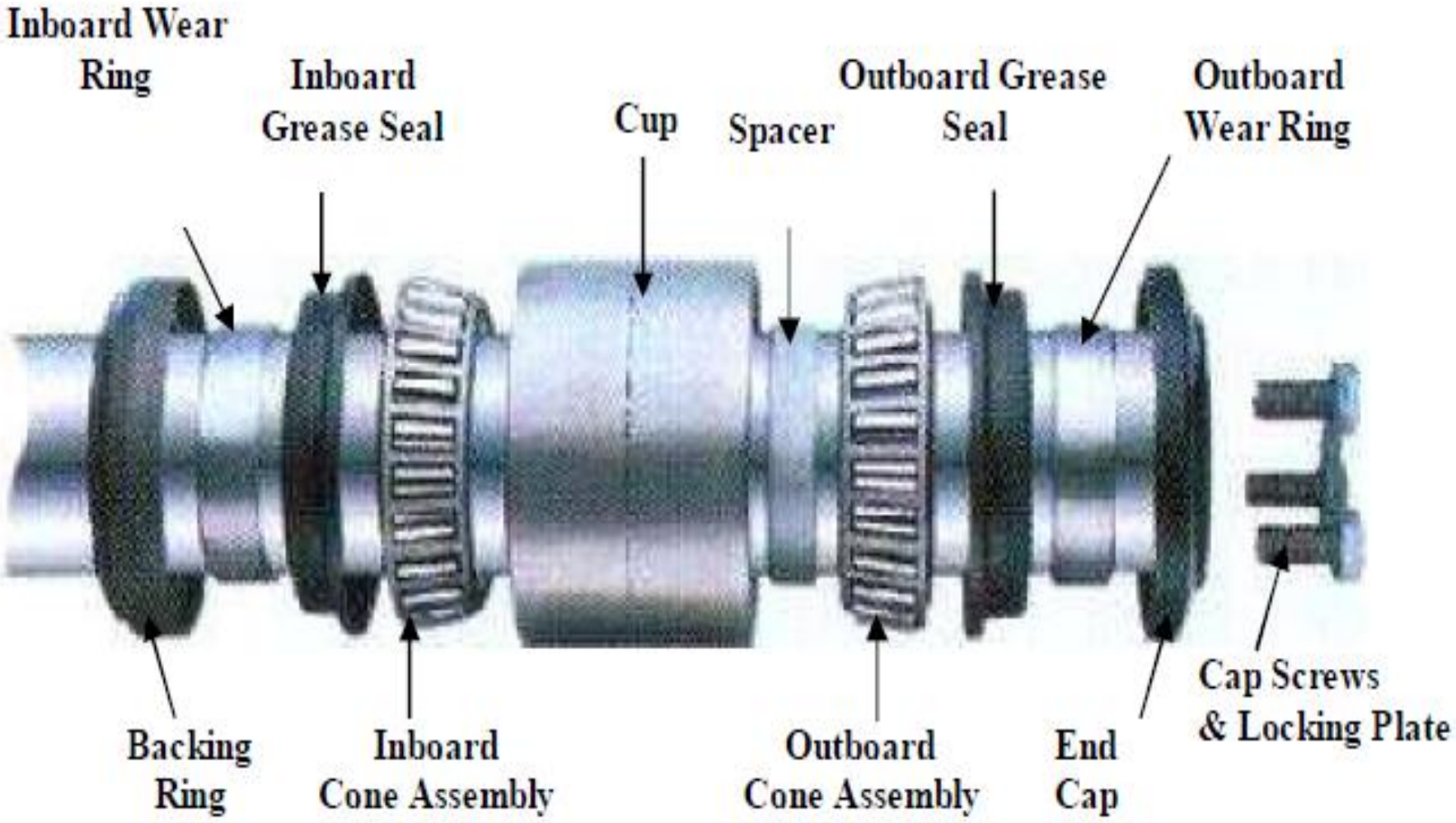
- 48 months following supply
- 36 months following commissioning
- Later guarantee for improving terms

Wheel dia difference (Permitted)	
On the same axle	- 0.5 mm
On same bogie	- 5 mm
On bogie to bogie	- 13 mm

CTRB Overhauling : LHB -

- Training by firm at nominated Workshops on CTRB overhauling + reconditioning
- TXR’s CTRB troubleshooting pamphlet
- 5 Officers’/Supervisors’ Trg./WS
- 10 Artisans’/Subordinates’ Trg./WS

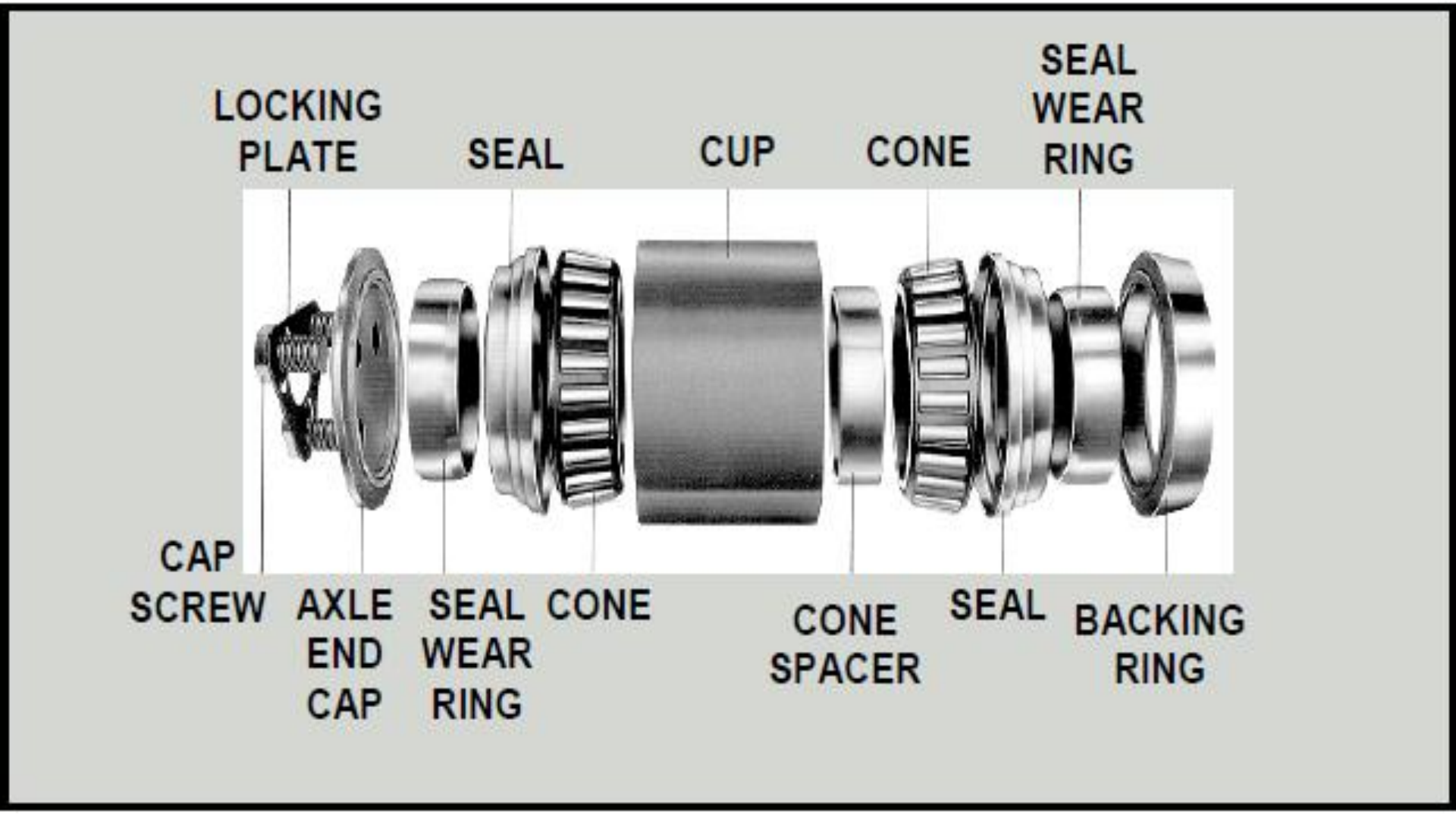
CASNUB Bogie CTRB : Components -



AP Bearing series : TIMKEN -



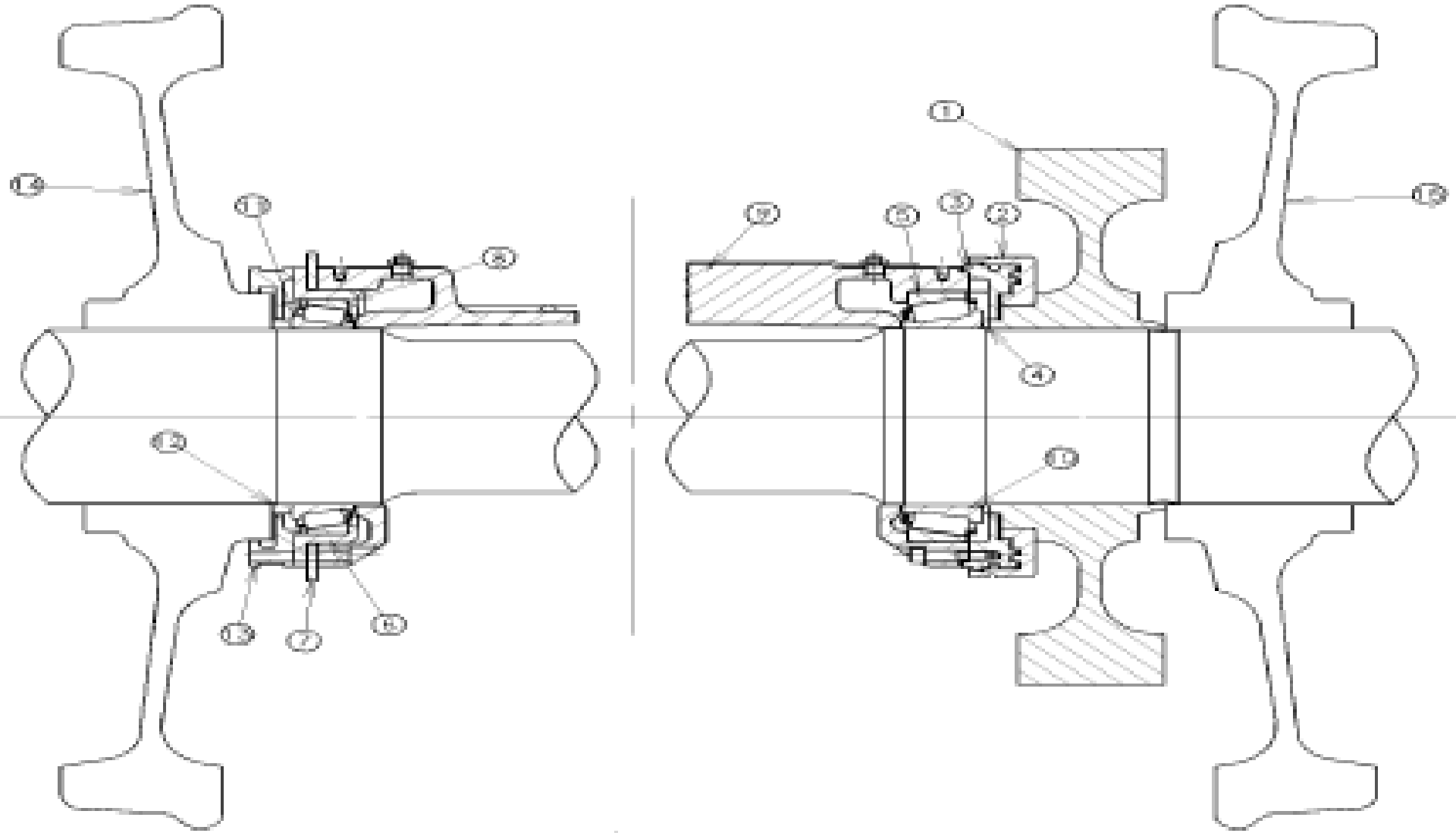
TBU : TIMKEN – structural details .



Motor Suspensions

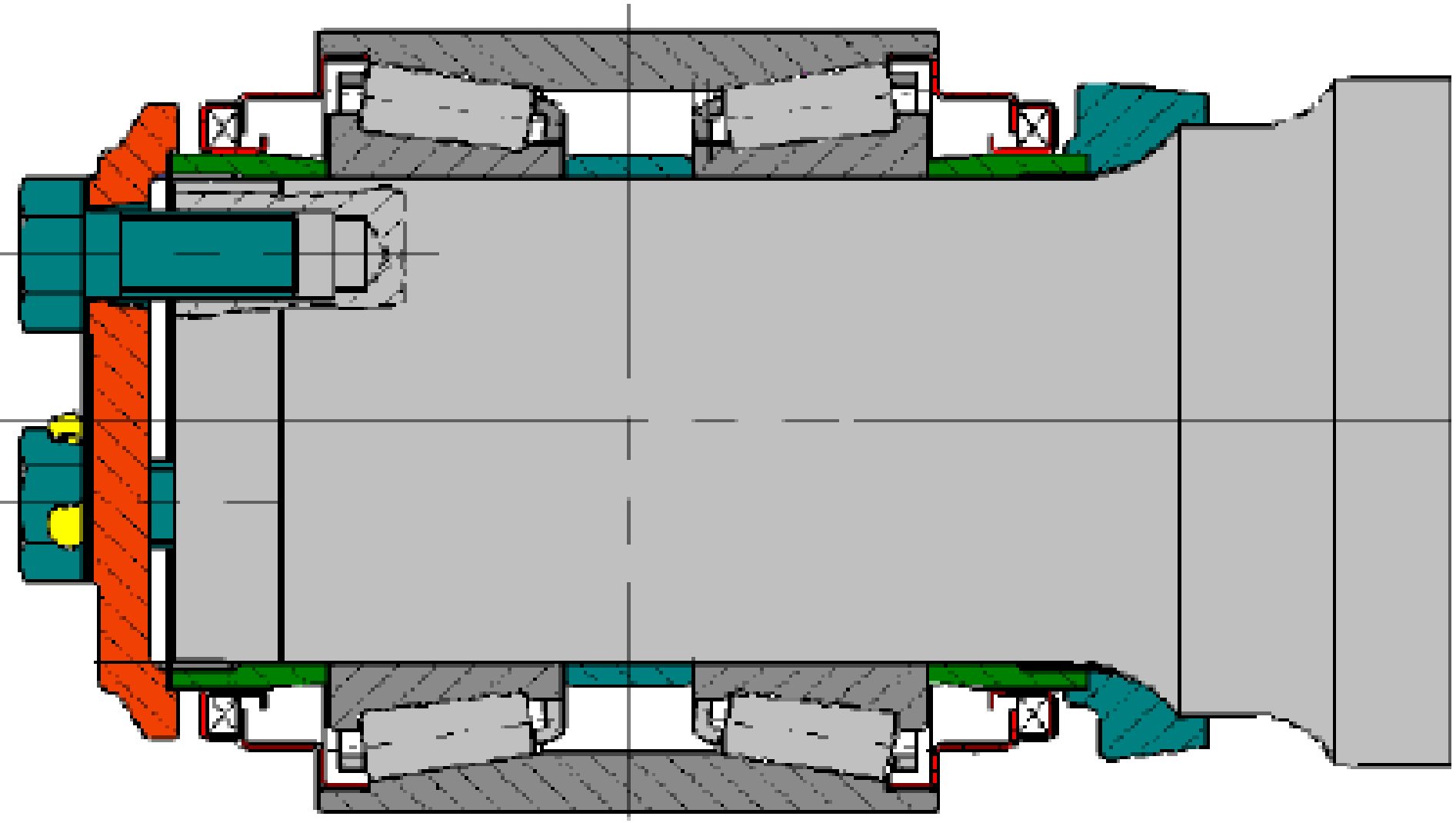


Basic MSU Design

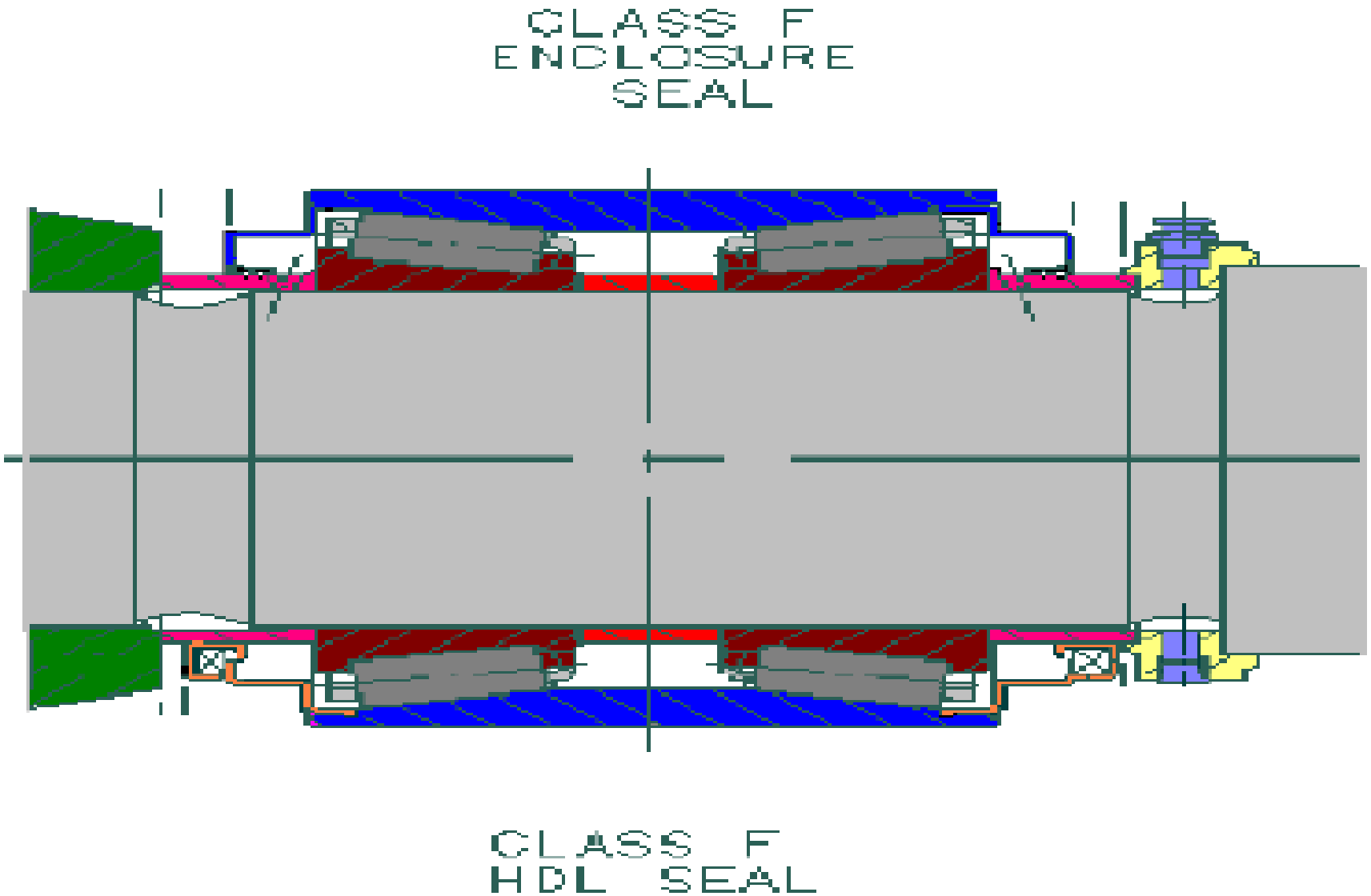


Basic MSU Design

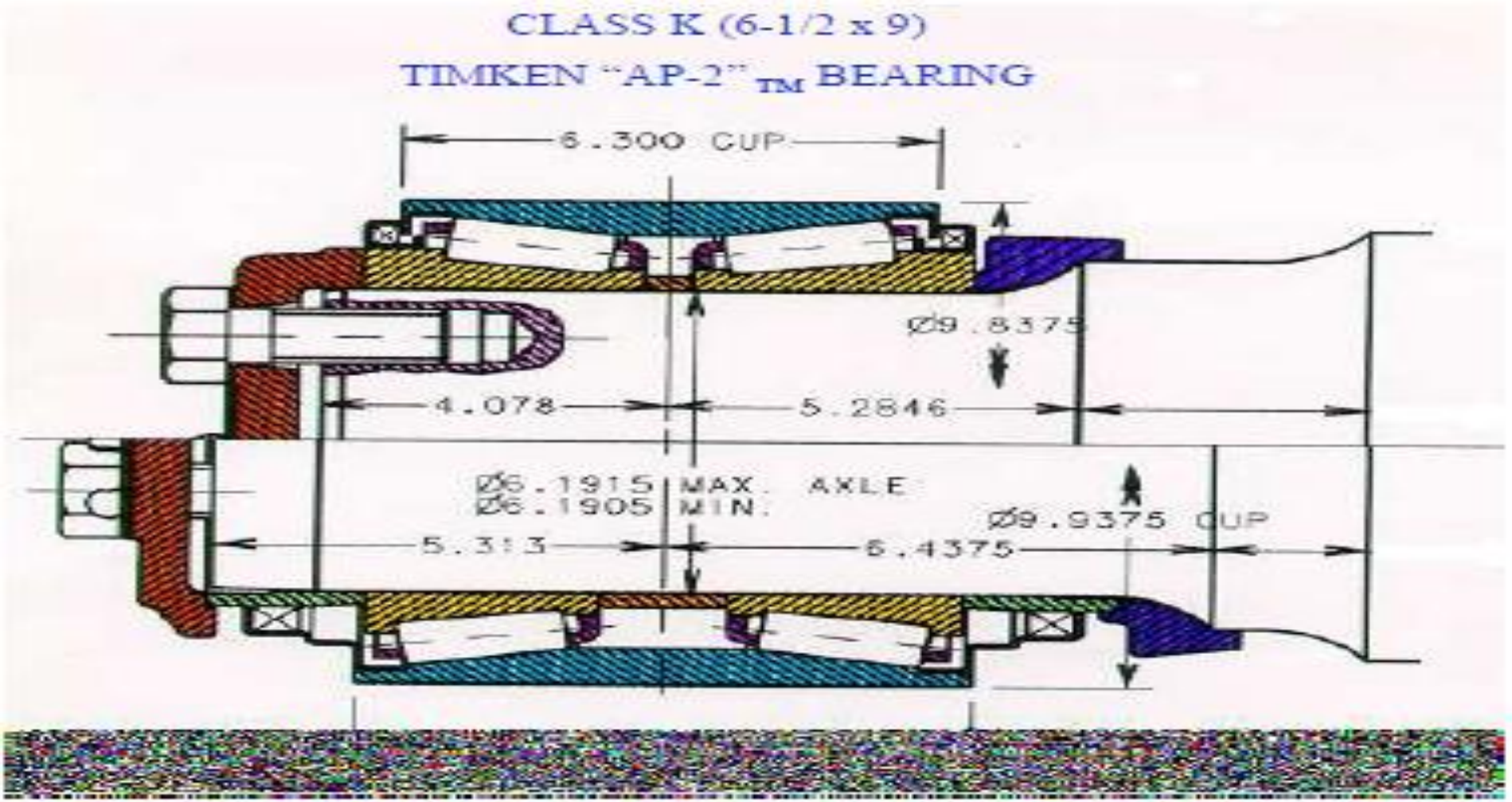
TIMKEN TBU Sectional Drawing



TIMKEN TBU Section Development



TIMKEN AP TBU



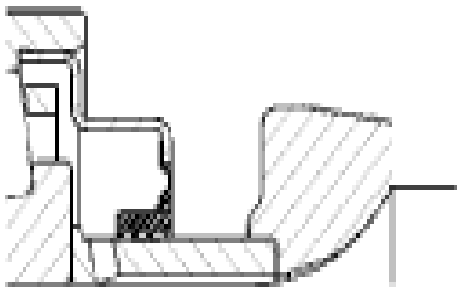
TBU : TIMKEN - AAR

AAR FREIGHT CAR DESIGNATIONS

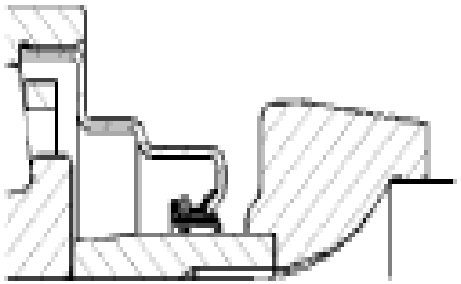
CLASS	SIZE	CAR CAPACITY (TONS)	WEIGHT ON RAILS
A	3.75 X 7	20	66,000
B	4.25 X 8	30	103,000
C	5.00 X 9	40	142,000
D	5.50 X 10	50	177,000
E	6.00 X 11	70	220,000
L	6.00 X 8	70	220,000
F	6.50 X 12	100	263,000
K	6.50 X 9	100	286,000
G	7.00 X 12	125	315,000
M	7.00 X 9	125	315,000

TIMKEN TBU

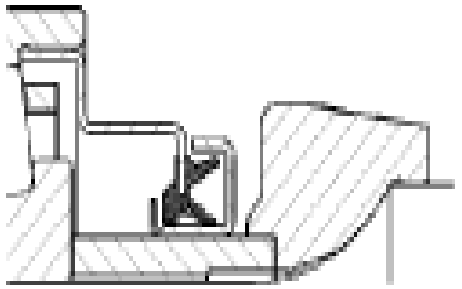
SEAL TYPES



LABYRINTH SEAL



RUBBING TYPE SEAL

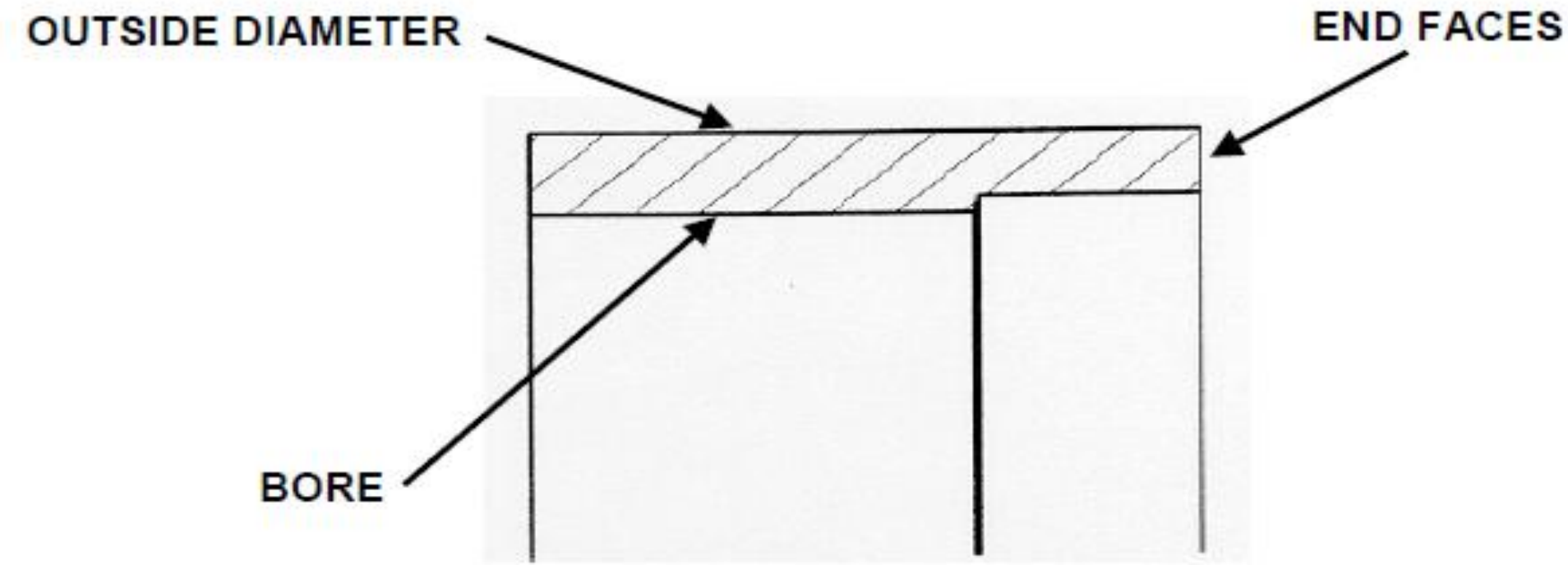


HDL SEAL

TIMKEN TBU

HDL SLEEVE

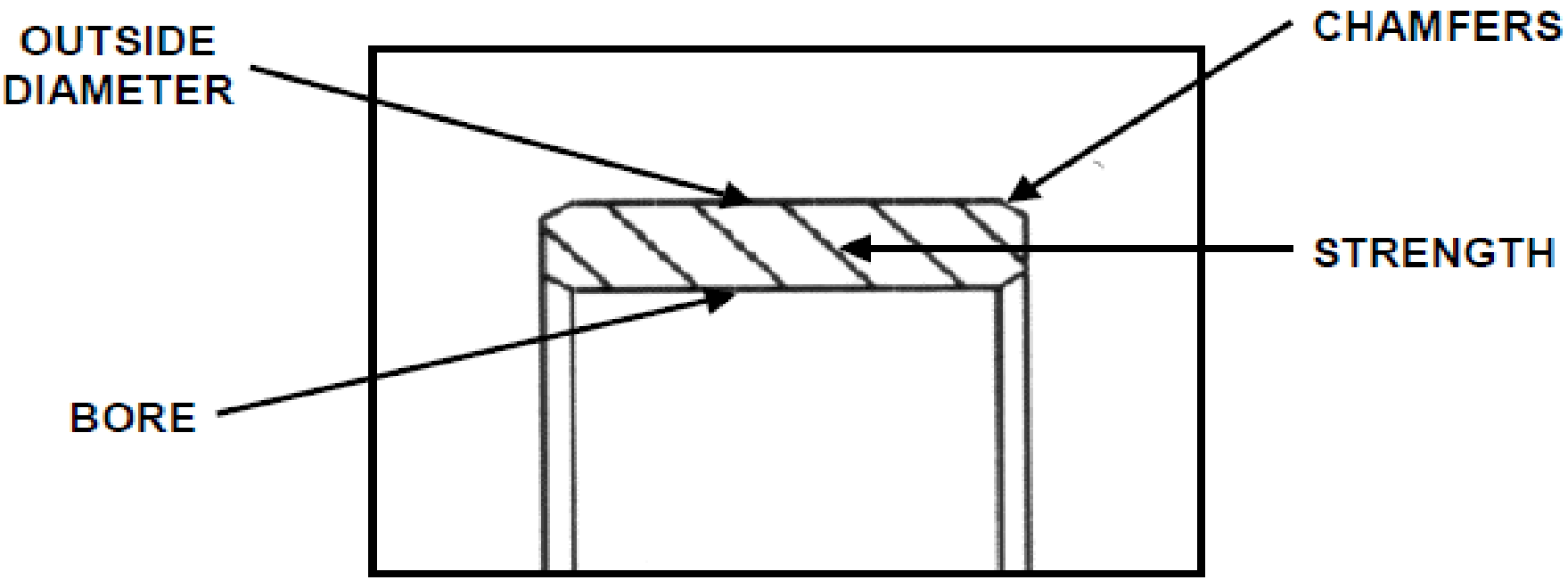
- **Transmits axial loads**



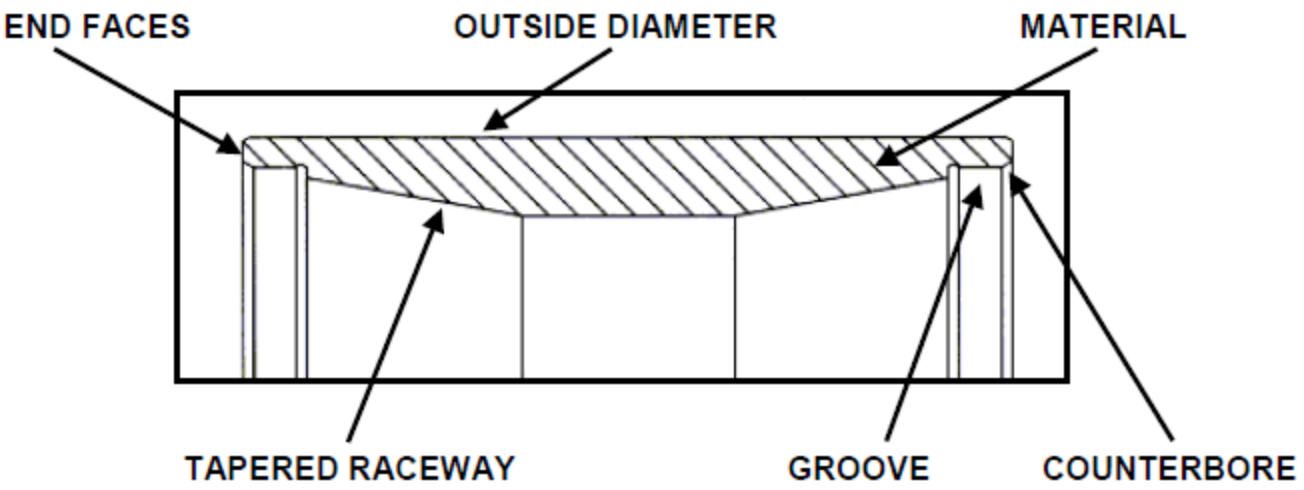
TIMKEN CTRB component functions

SPACER

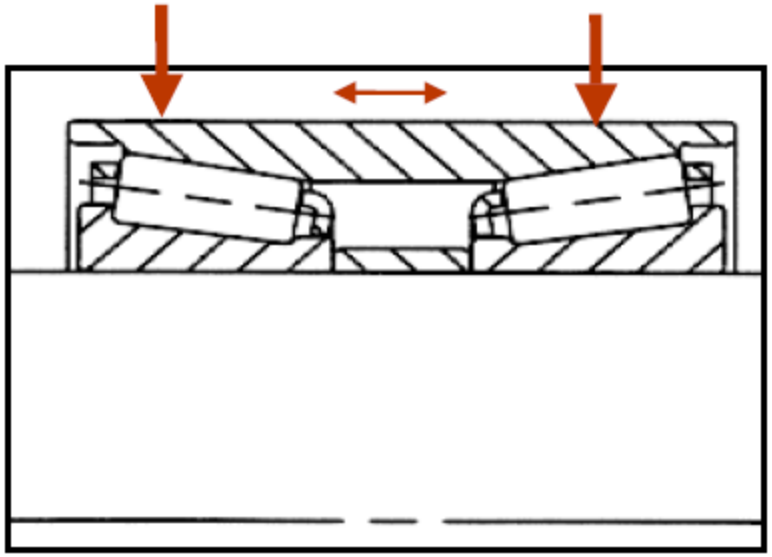
- **Separates cones**
- **Provides adjustment of internal bearing clearance**
- **Transmits seating, clamp, and removal loads**

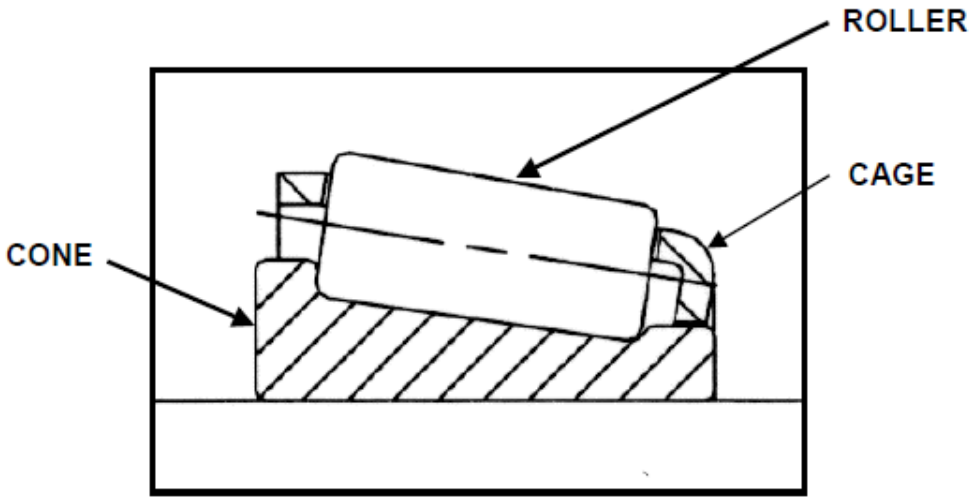


TIMKEN TBU Cup & Cone



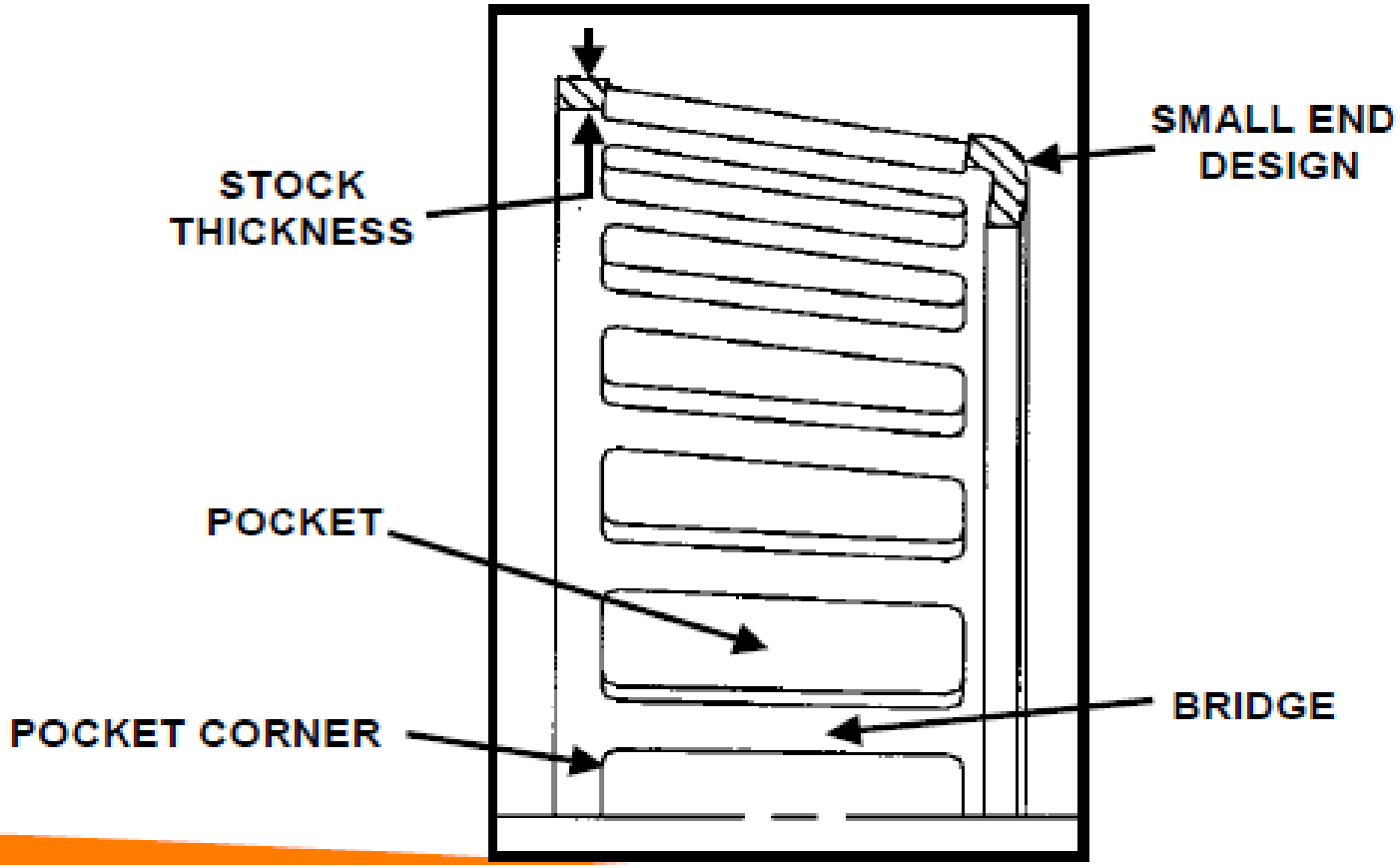
Carry static and dynamic radial and thrust loads





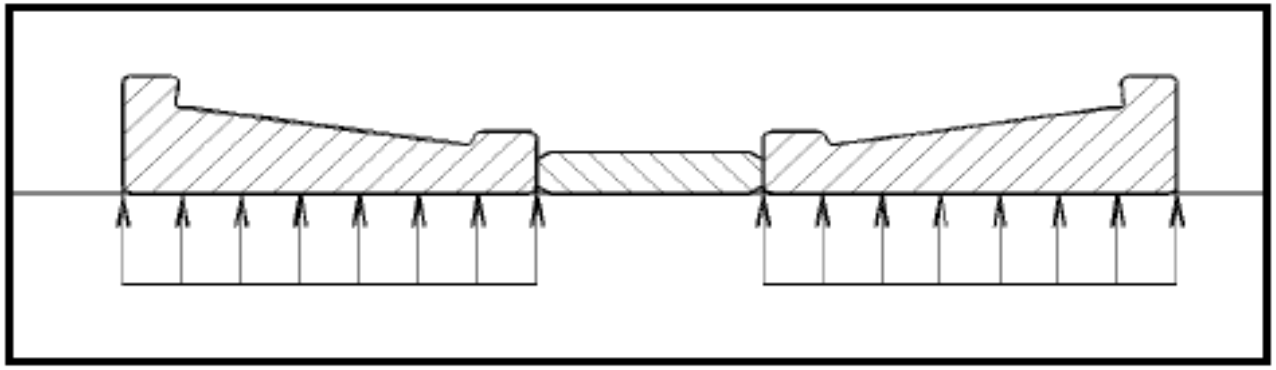
Cage Separator

- **Spaces/separates rollers evenly around circumference**
- **Helps align unloaded rollers**
- **Keeps rollers assembled to cone**



TIMKEN TBU

BEARING RETENTION FIT



CONTACT PRESSURE

CONTACT PRESSURE

Example (Class F, 2 Cones)

Fit	μ	F (pounds)
0.002	0.20	22,300 (11 tons)
0.005	0.17	65,600 (33 tons)

CASNUB Bearing adapters, Axle End Capscrew & Locking



Figure 2

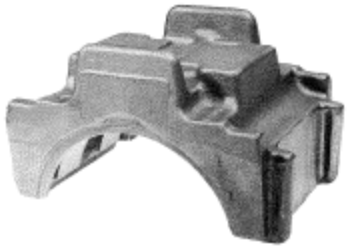
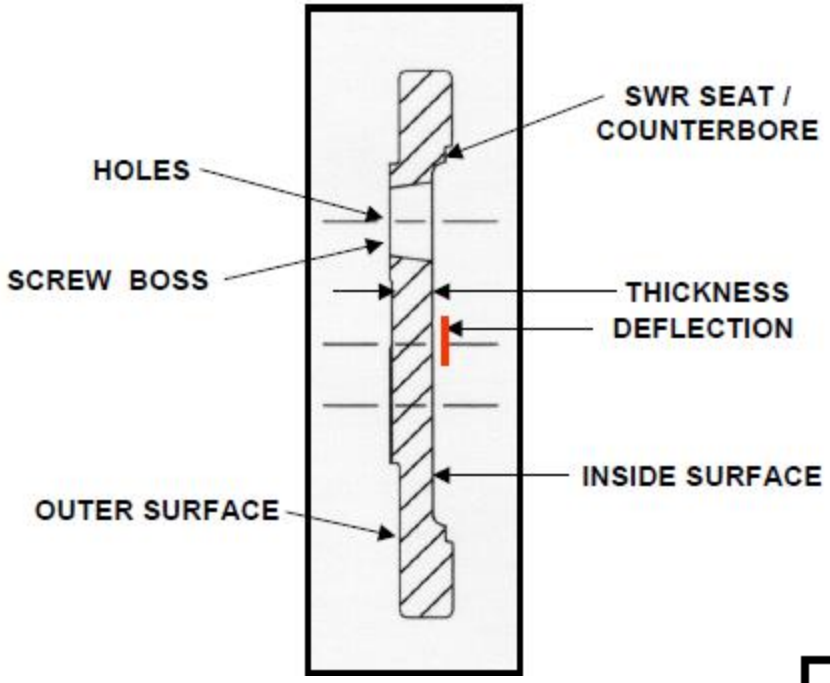
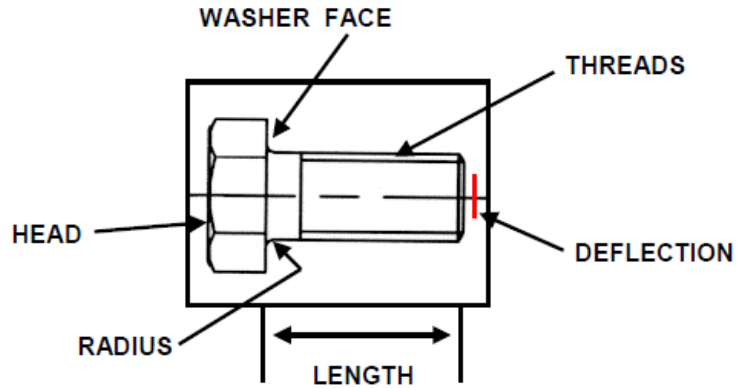
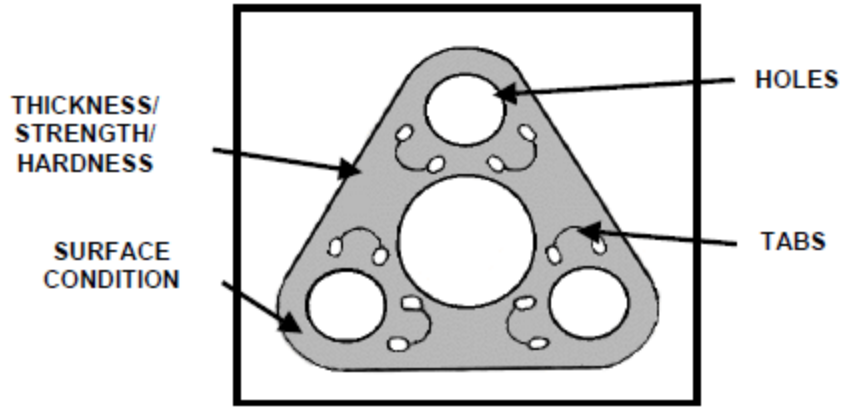


Figure 3

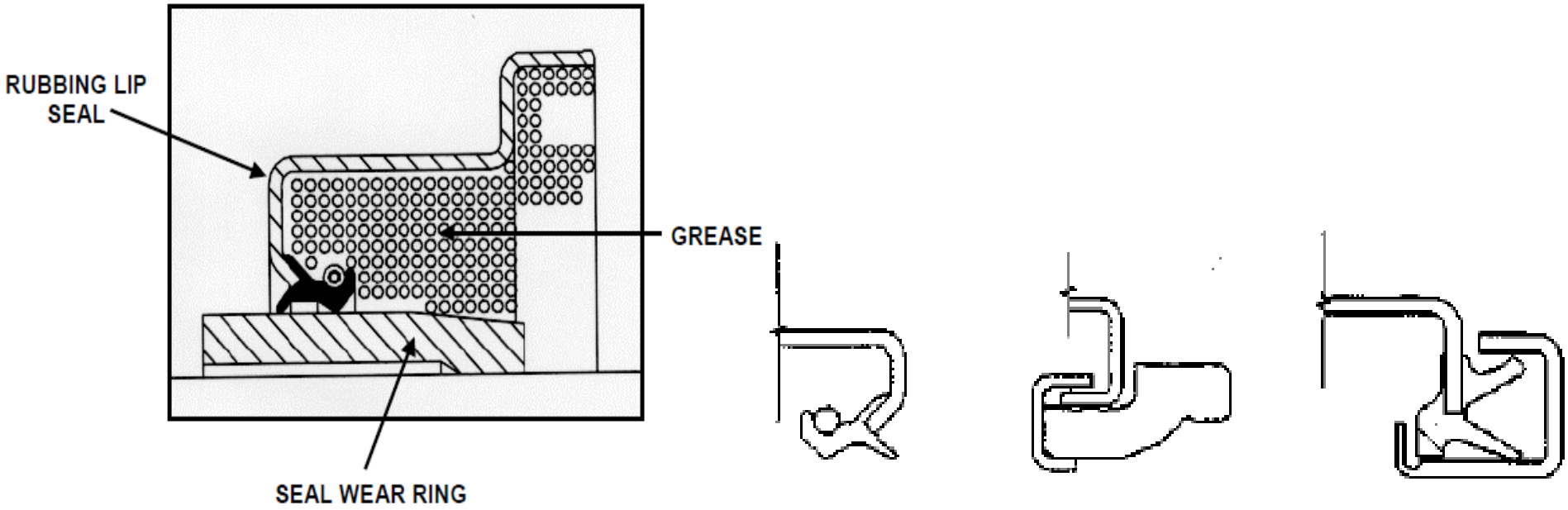






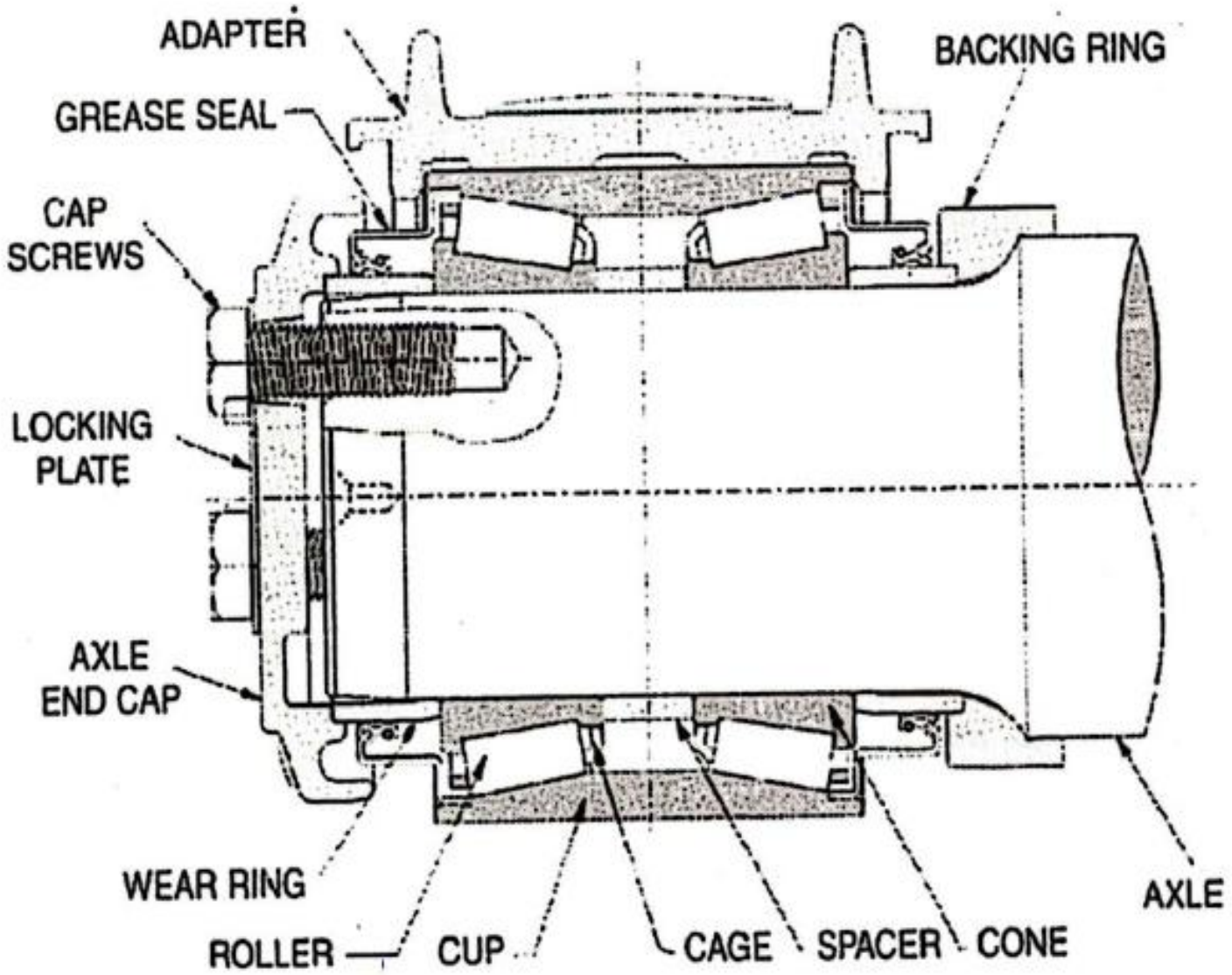
Seal comparisons : TIMKEN TBU -

- **Lubricates basic bearing for service life cycle**

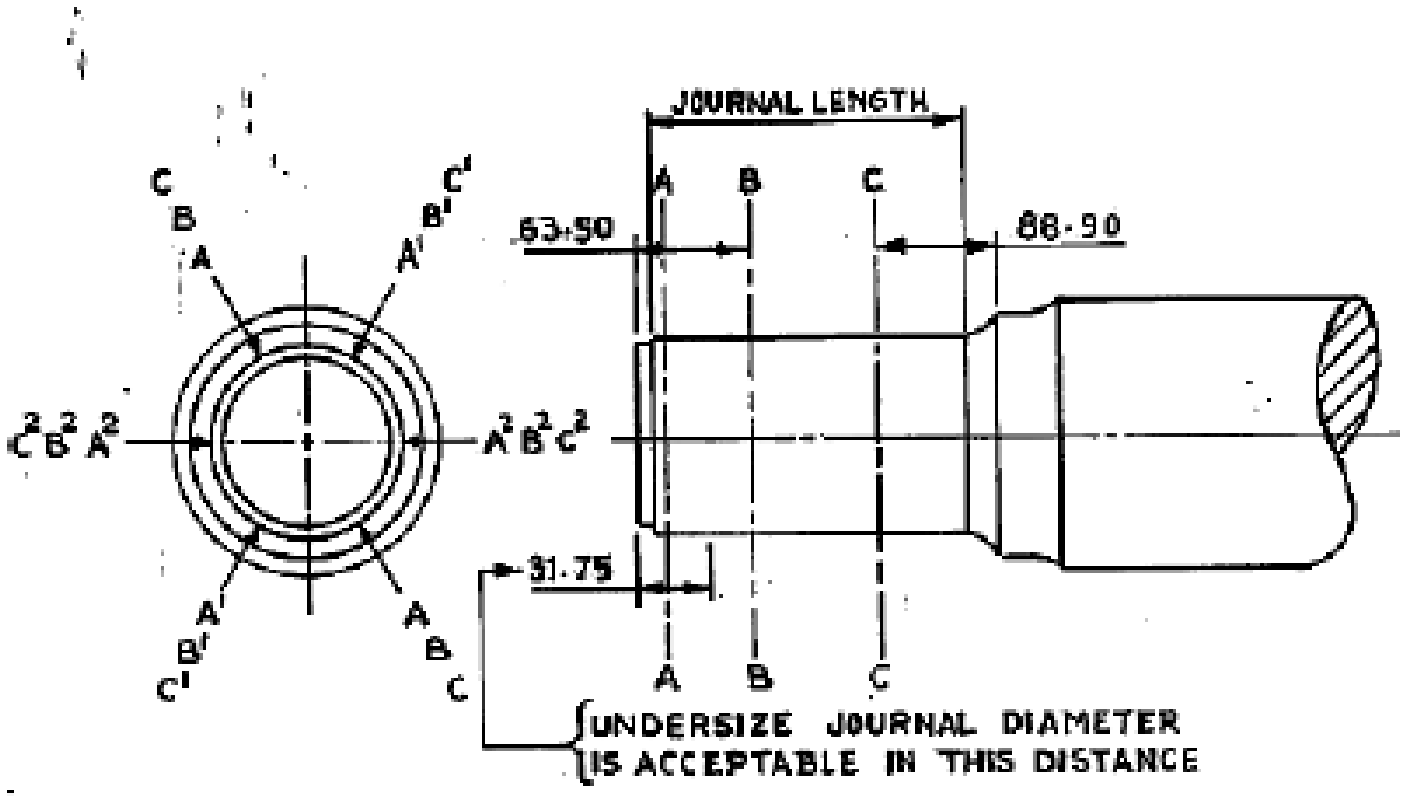


SEAL DESIGN	2 LIP	LABYRINTH	HDL
Grease Retention	Good	Fair	Excellent
Dirt Exclusion	Good	Fair	Excellent
Water Exclusion	Fair	Poor	Excellent
Operating Temperature	Poor	Excellent	Excellent
Operating Torque	Poor	Excellent	Excellent
Venting Capability	Poor	Good	Excellent

CASNUB No Field Lubrications CTRB: Components-



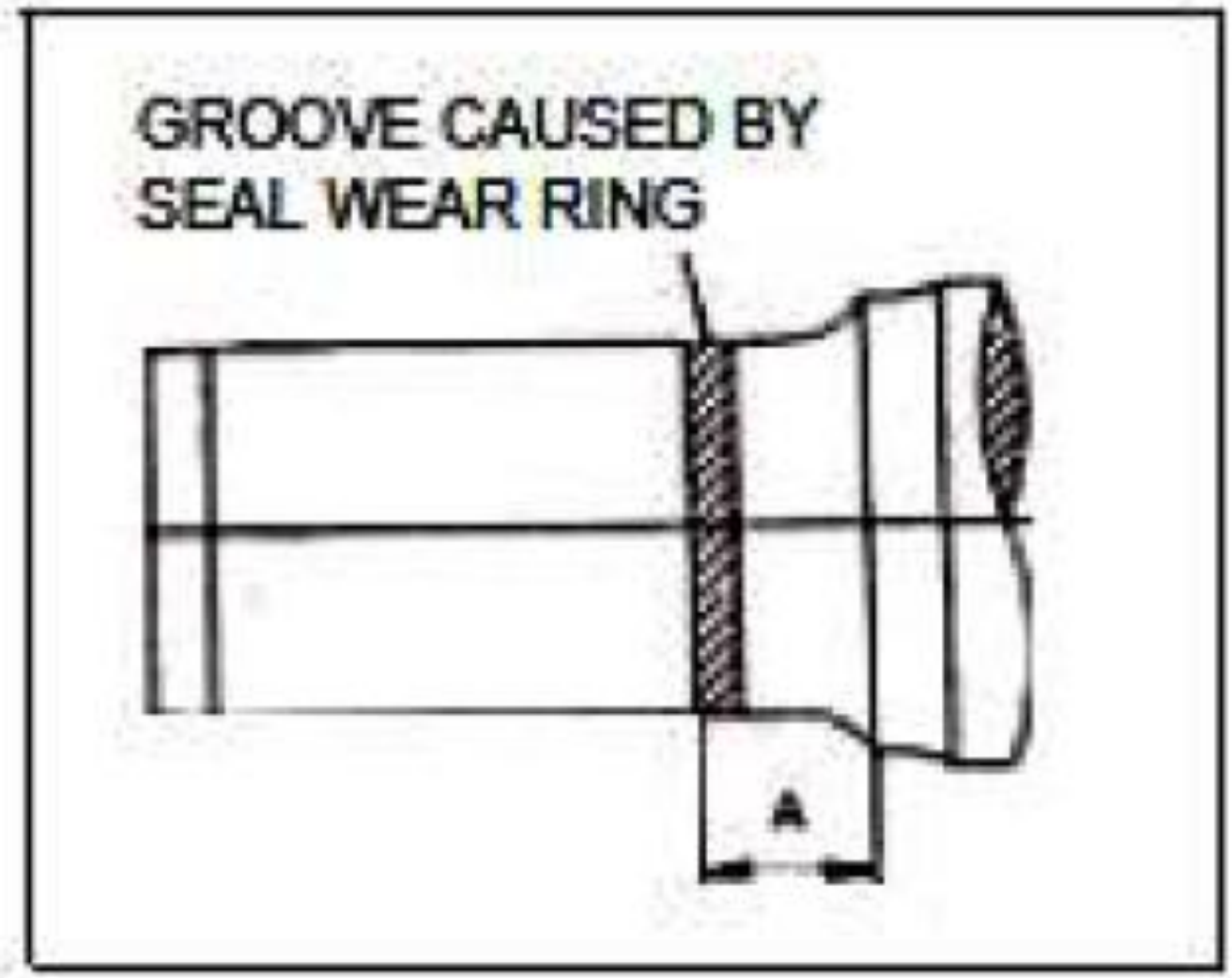
CASNUB CTRB : Bearing Seat -



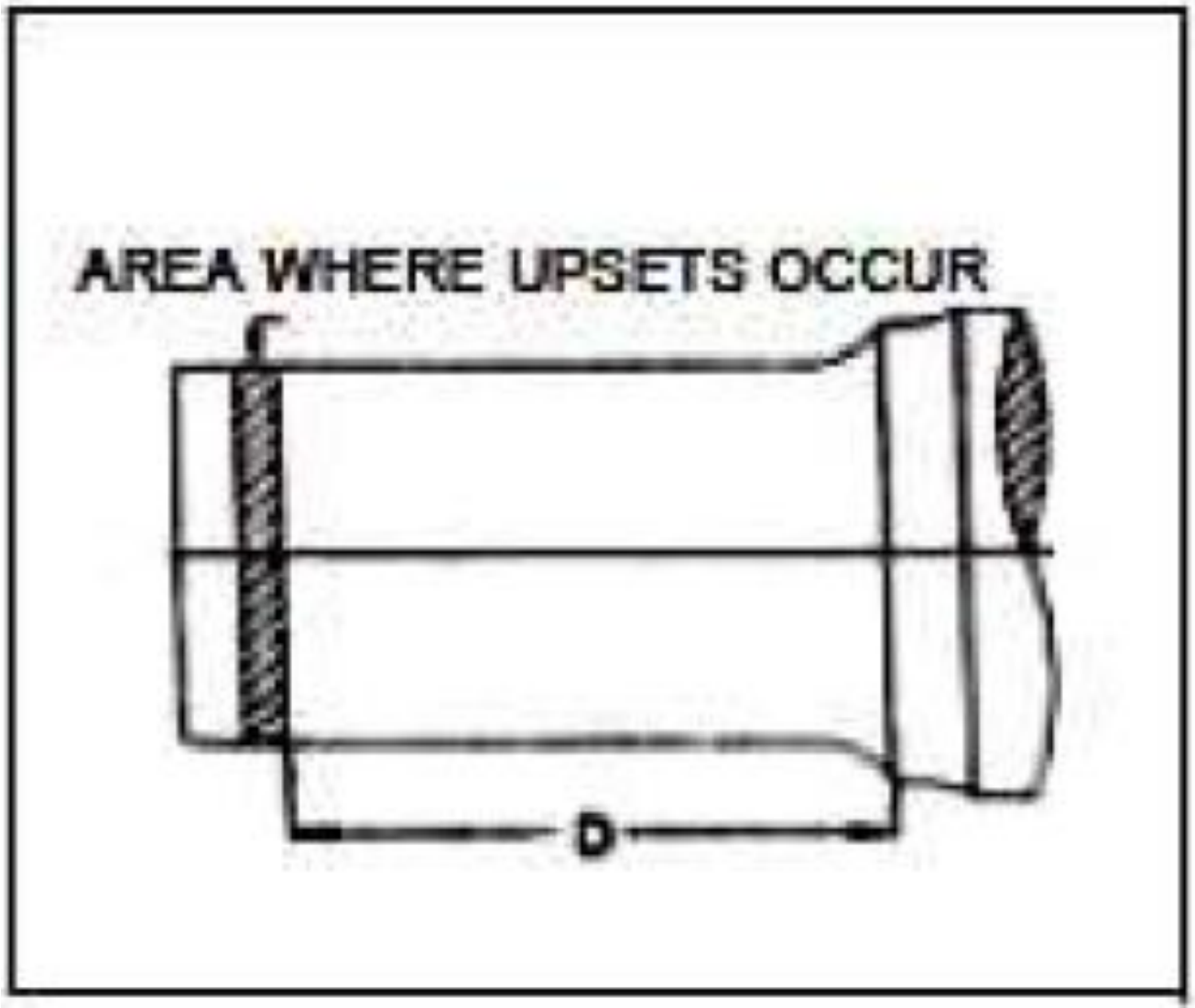
CASNUB CTRB

JOURNAL CLASS (Size)	ACCEPTABLE TOLERANCES FOR JOURNAL DIAMETER		BEARING SEAT LOCATIONS			
	MAXIMUM	MINIMUM	A	B	C	D
E (6"x11")	144.564 mm (5.6915")	144.539 mm (5.6905")	73.0 mm (2.88")	132.2 mm (5.20")	166.7 mm (6.56")	236.5 mm (9.31")

CASNUB CTRB journal groove's radial depth permitted = 0.05 mm.



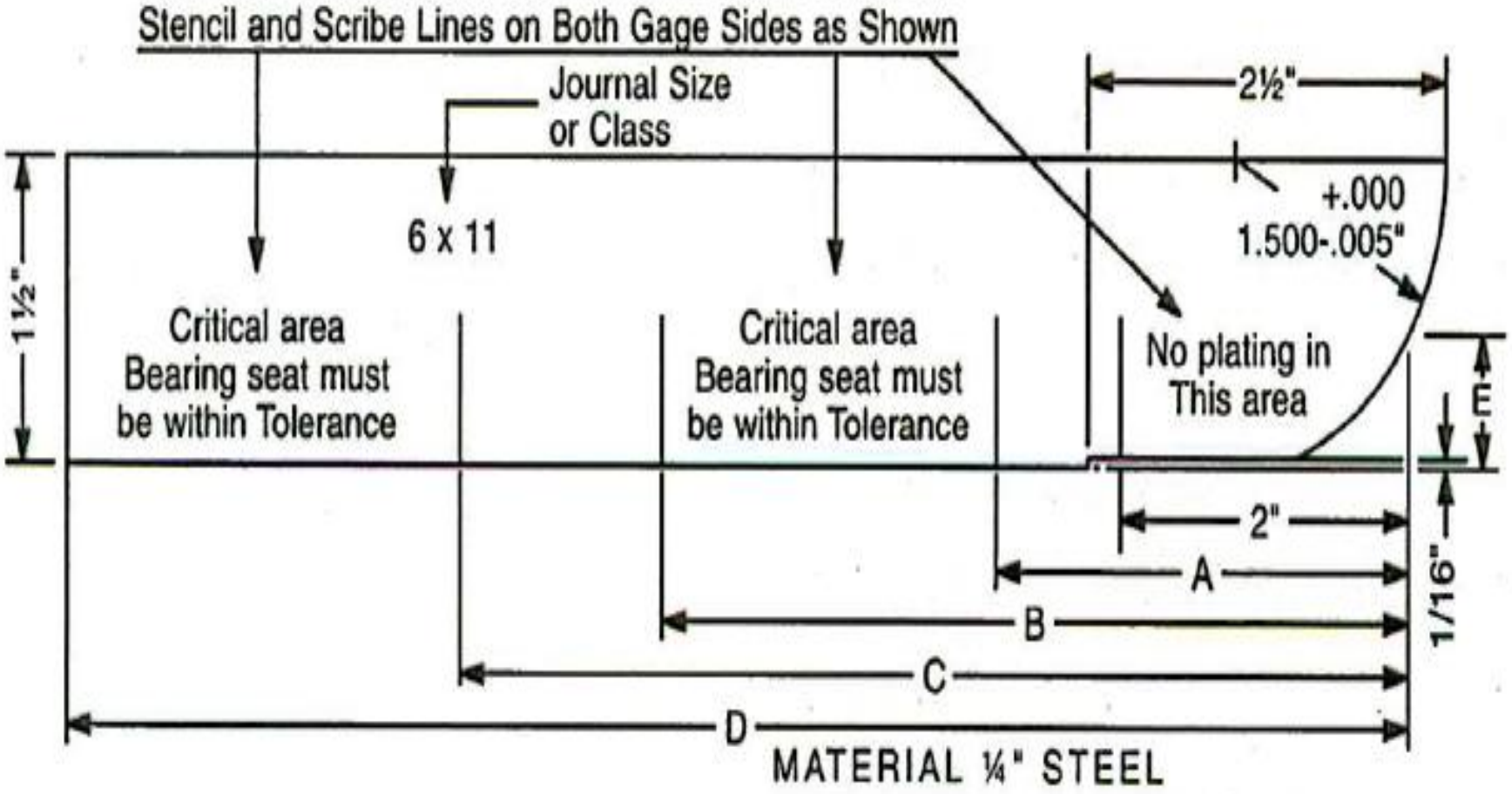
CASNUB CTRB journal's axial upset height permitted = 0.080 mm.



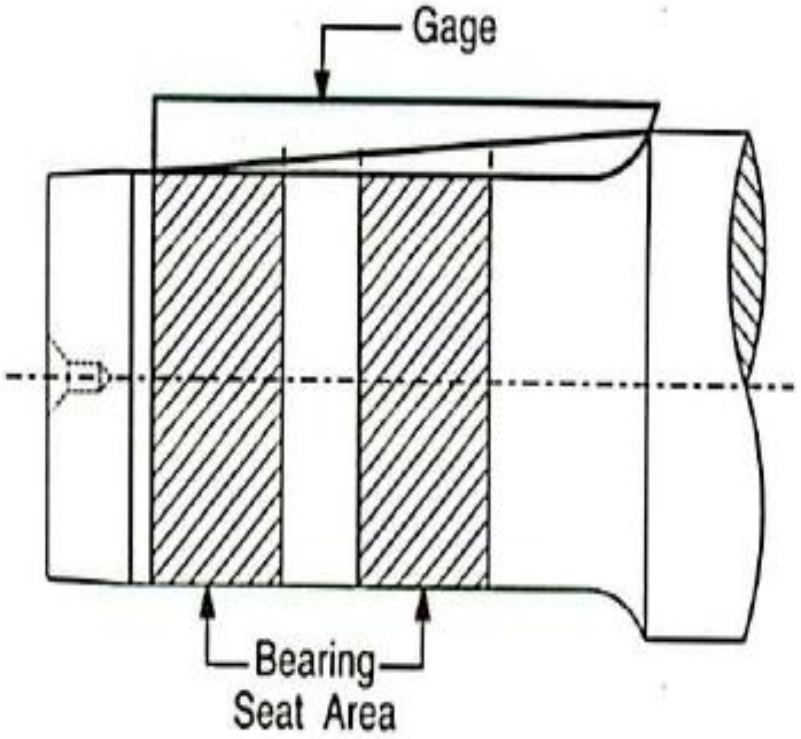
CASNUB CTRB: AAR/UIC Inspection Clauses- Wagon Journals.

FREIGHT (WAGON) AXLES					
JOURNAL CLASS	DIMENSIONS				
	A	B	C	D	E
E (6x11)	2.88" (73.0 mm)	5.20" (132.2 mm)	6.56" (168.7 mm)	9.31" (236.5 mm)	0.67" (17.0 mm)

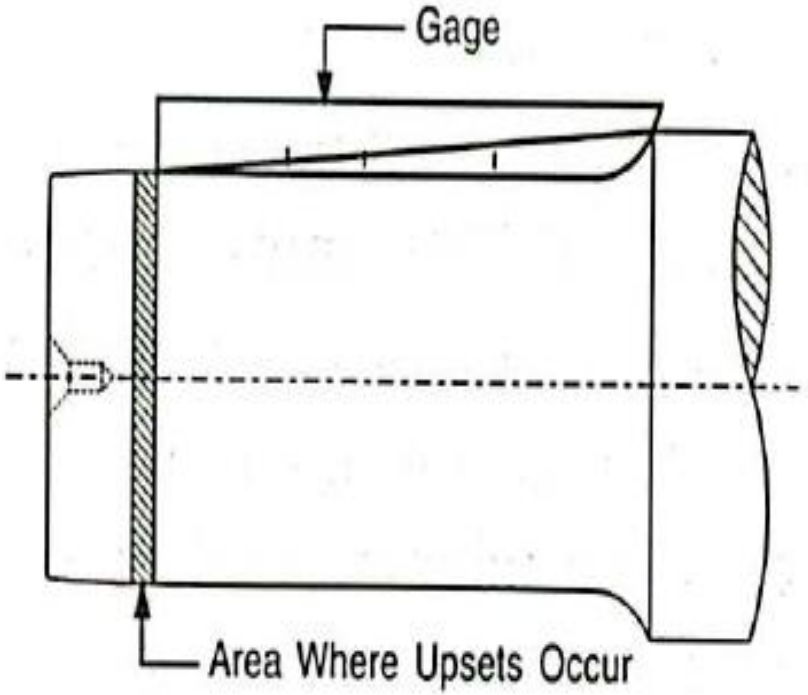
CASNUB CTRB Seat location gauges



CASNUB CTRB Journal seat inspections: Gage = Gauge.

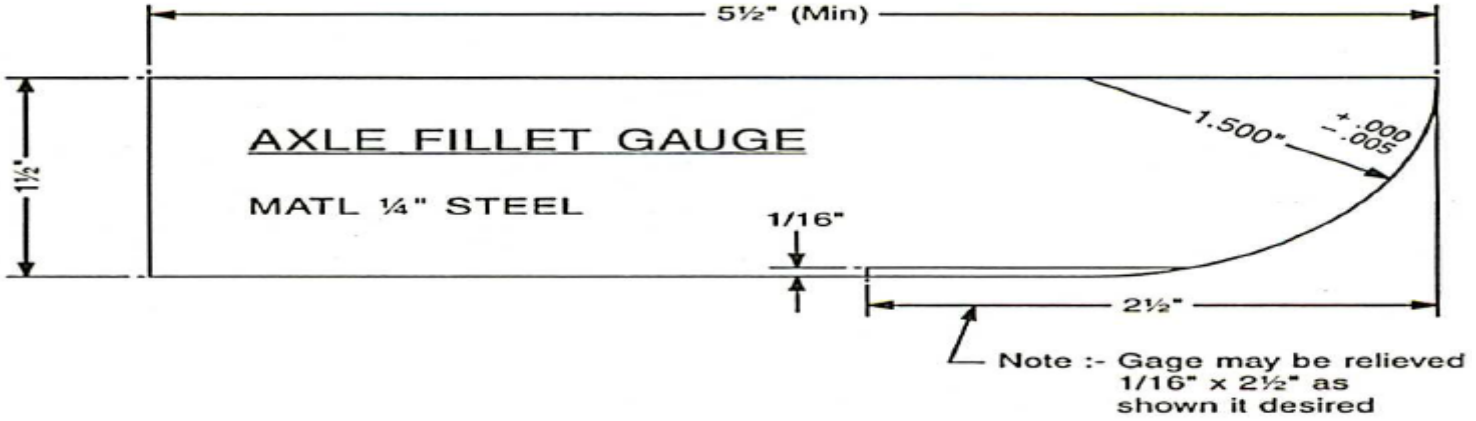


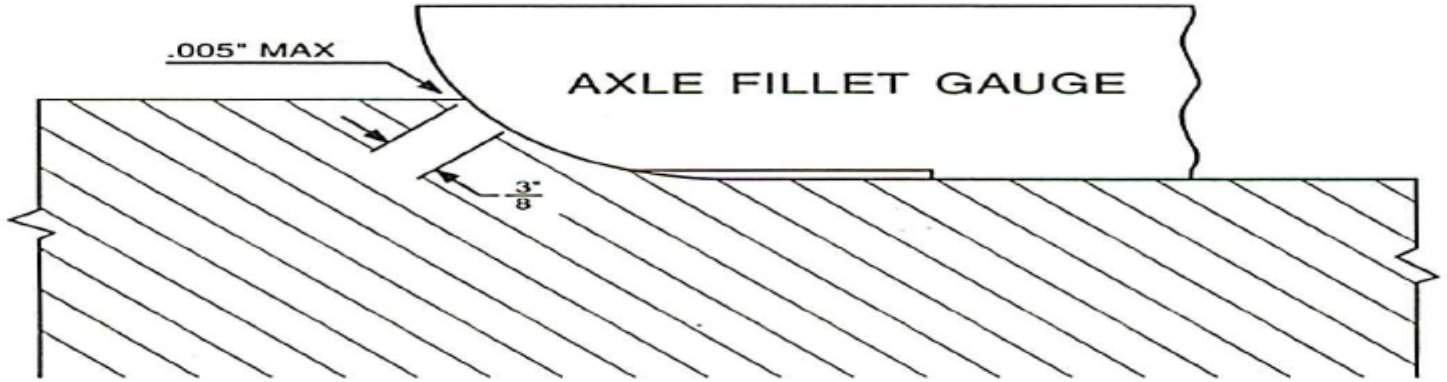
Method of using gage for locating bearing seat areas



Method of using gage when reworking

CASNUB CTRB journal fillet radius inspections





The journal fillet area of a roller bearing axle is critical. To ensure proper fit and proper seating of the backing ring on the axle fillet, the journal fillet gauge must be used to check the fillet radius. If a 0.005" feeler gauge can be inserted more than 3/8" (10 mm) down from the dust guard seat, at all points around the axle periphery, the axle fillet must be corrected.

CASNUB CTRB: Mounting & Dismounting– Pressure is Force only.

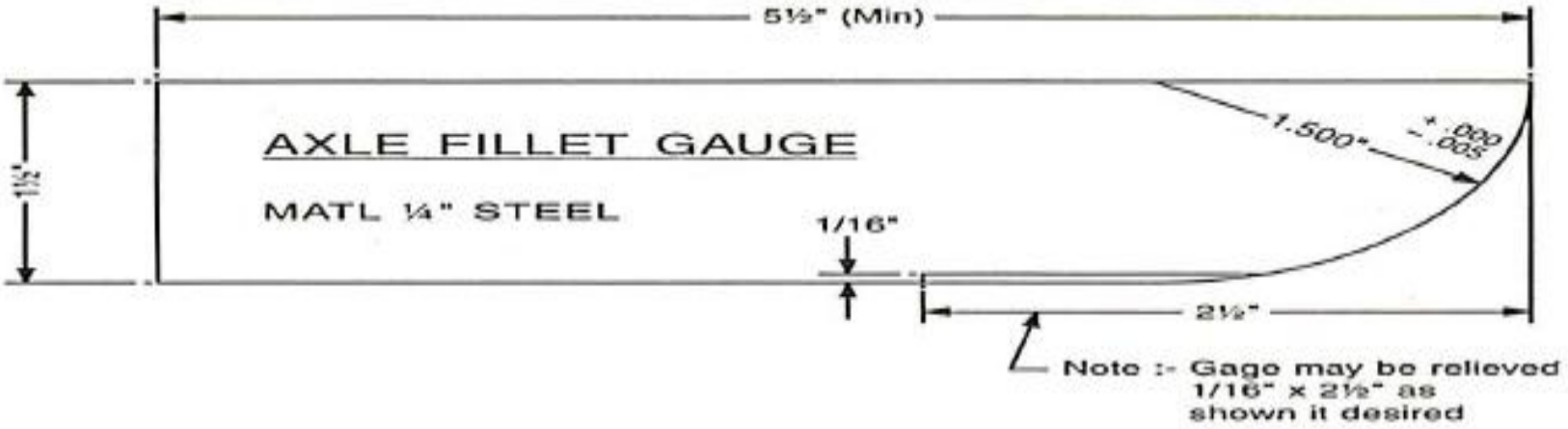
New recommended values of various mounting parameters for Cartridge Tapered Roller Bearing (6 x 11) Class "E" are as below:

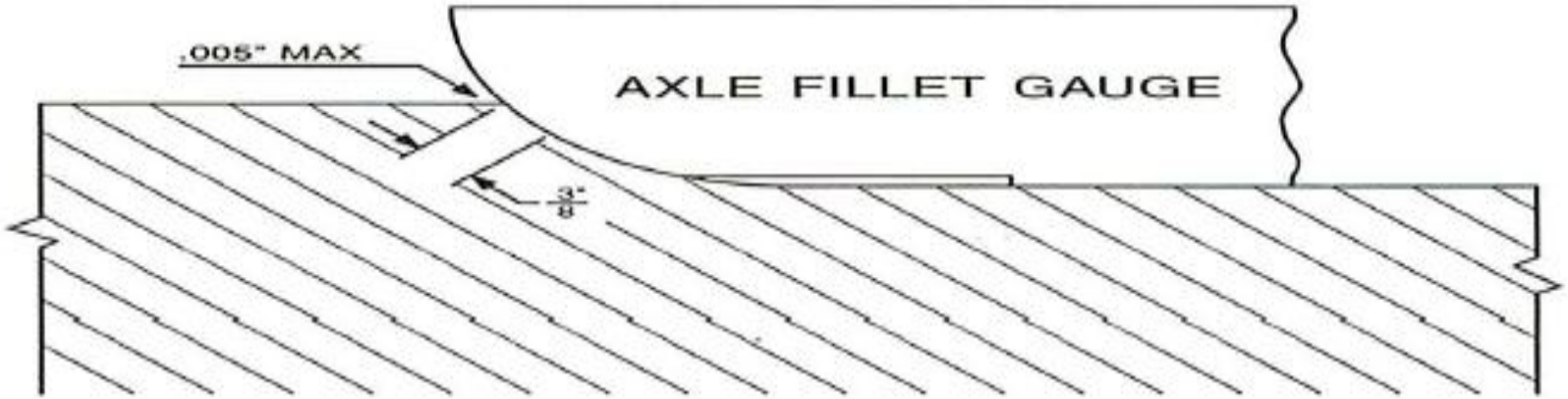
Final Seating Pressure (Hold for 5 seconds)	**50±5 tons**
Cap Screw size	**1"- 8 UNC**
Cap Screw Torque (Minimum 2 passes and maximum 5 passes)	**40 Kg-m** (290 foot-pound)
Torque Wrench Accuracy	± 4% Maximum
Mounted bearing lateral play (Apply hand pressure only)	(0.03 mm to 0.38 mm)

Amount of grease to be applied

To Single Roller Assembly (Each Cone Assembly)	**Between Roller Assembly (Around spacer)**	**Total $\pm^{30}$ gm**
115 gm	170 gm	400 gm

CASNUB CTRB: Workshop Inspections-



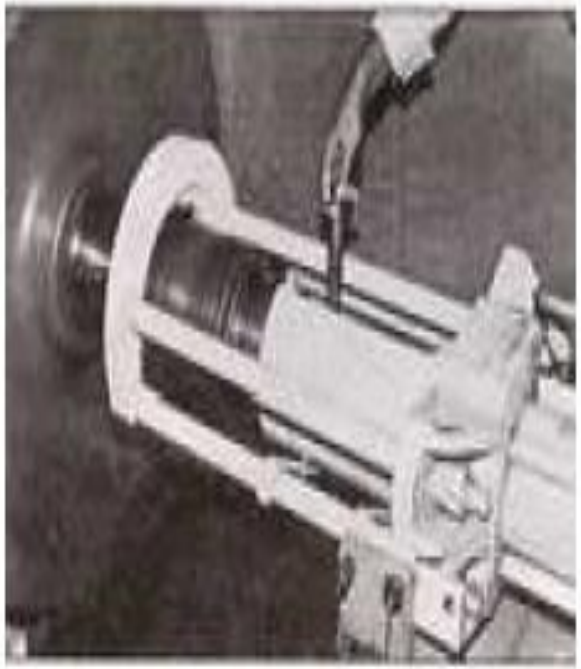


CASNUB CTRB : Dial gauges -



CASNUB CTRB : Extracting Tooling -







CASNUB CTRB : Adapter Inspection -

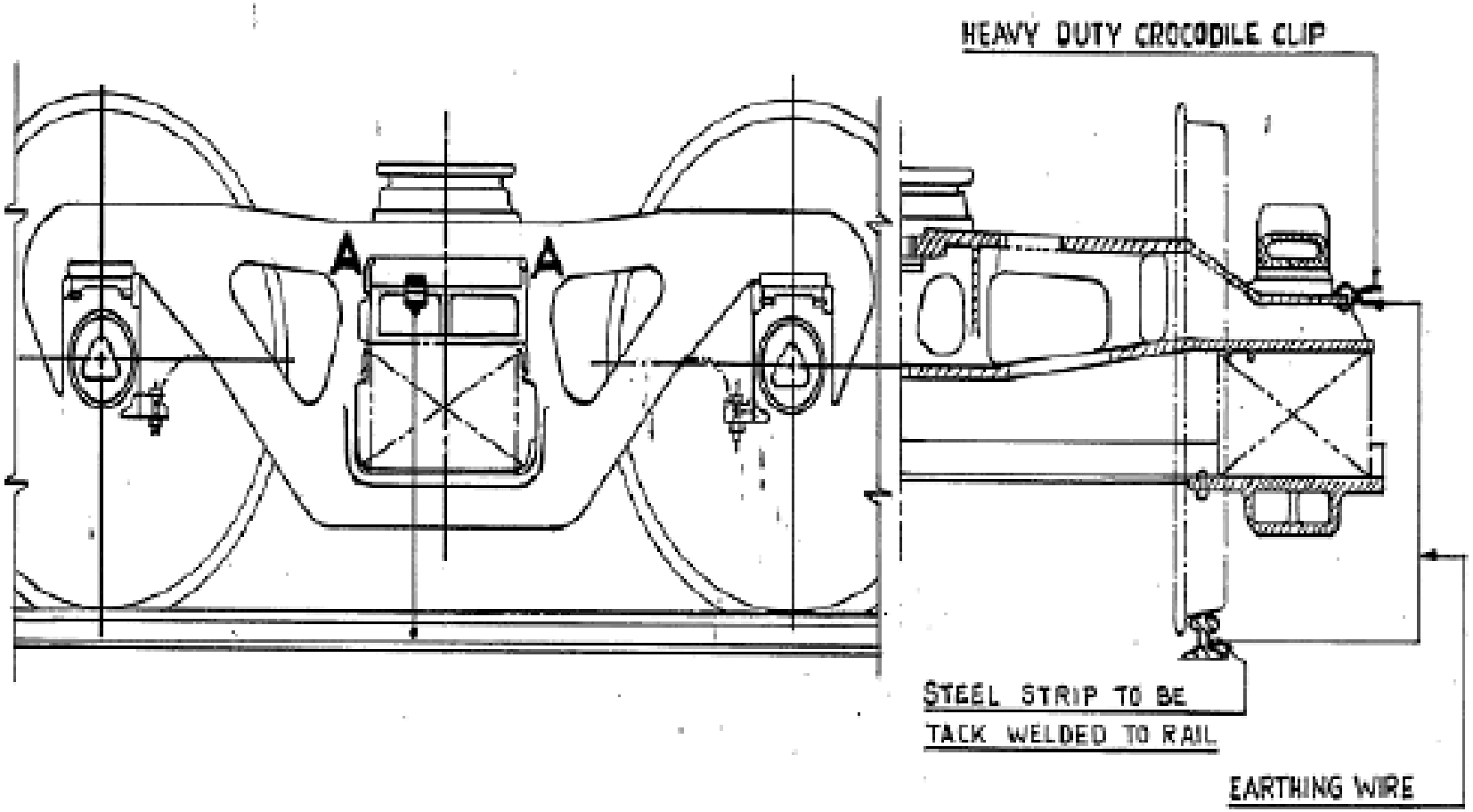




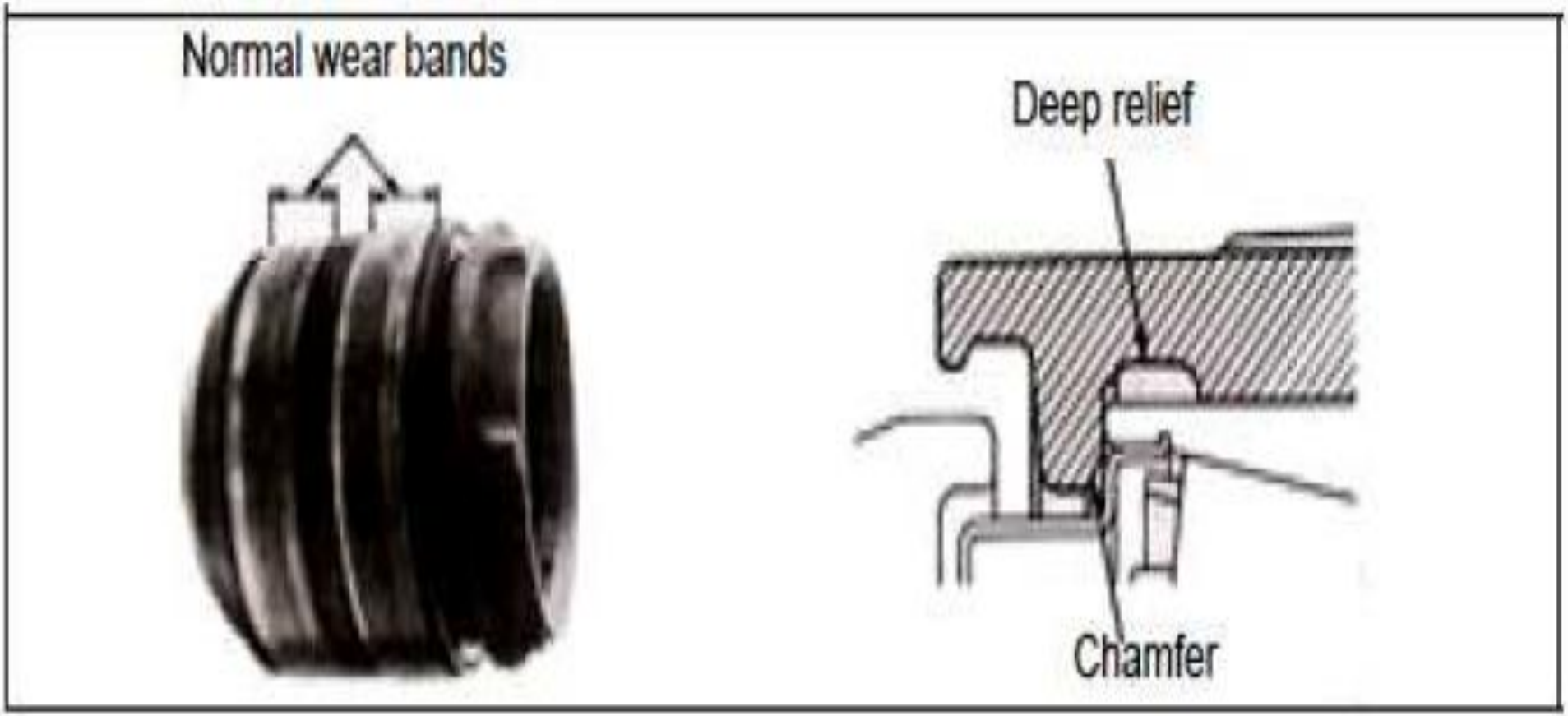
CASNUB CTRB : Dial Gauging -



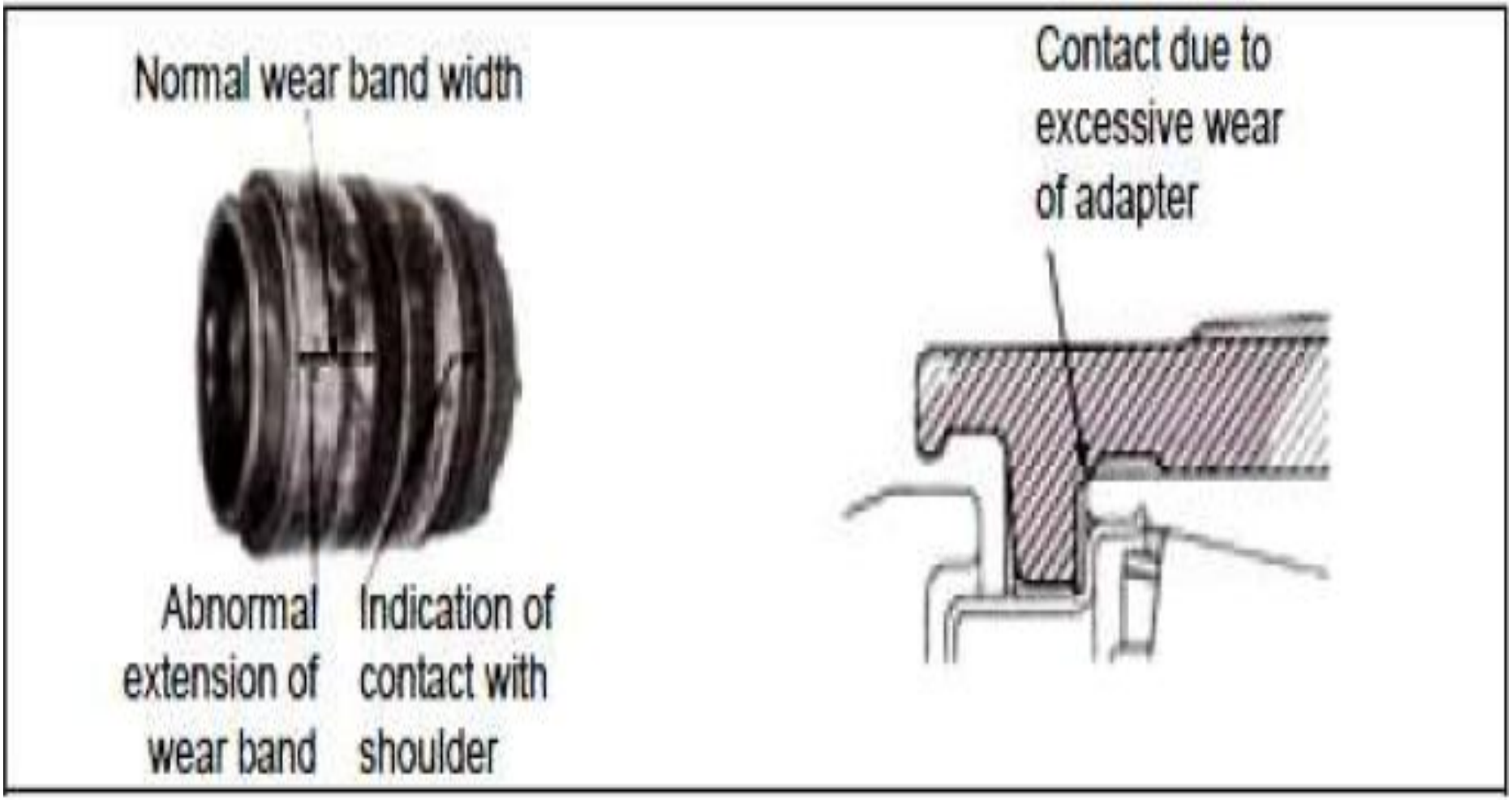
CASNUB CTRB : Arc protections -



CASNUB CTRB : Adapter Grooves -



CASNUB CTRB : Adapter thrusts -



CASNUB CTRB : Damaged Cups -



CASNUB CTRB : Loose backing rings -



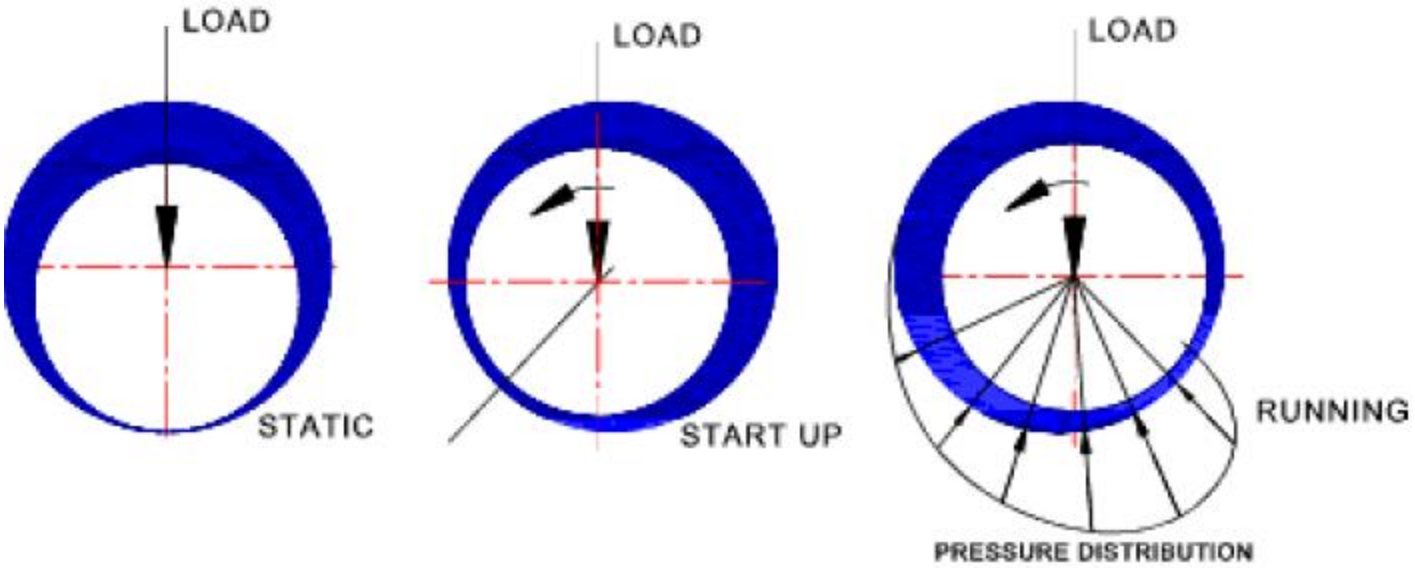
CASNUB CTRB: Hot axle temperatures– 90 degrees Celsius {limiting value}.

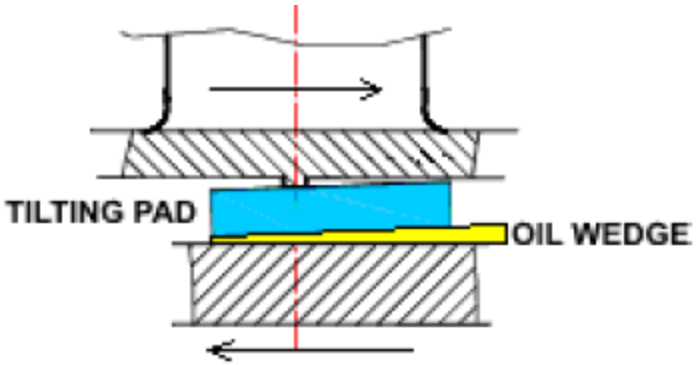


Hydrodynamic lubrications : Thickened wedgefilm – Spinning shafts

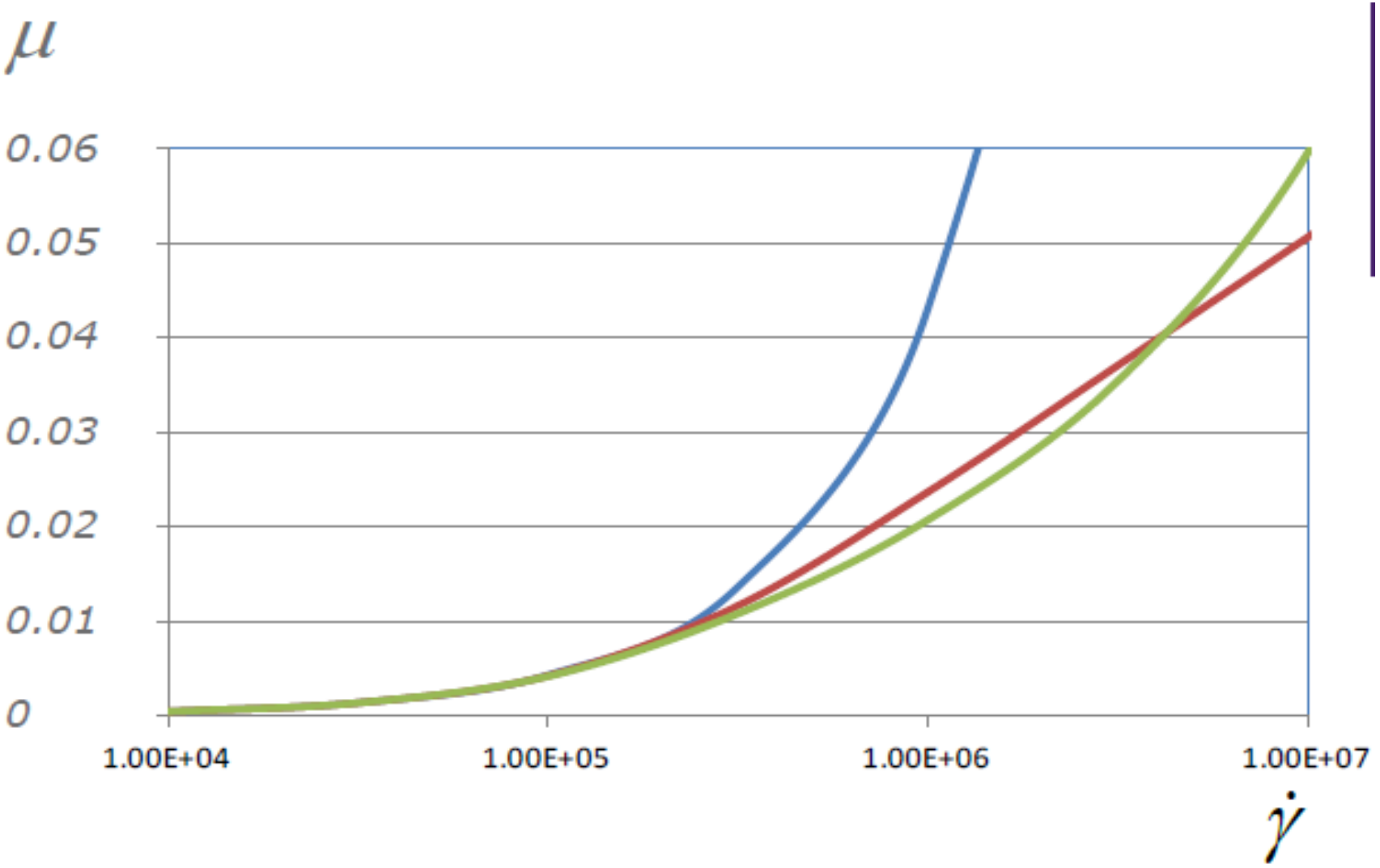
- Squeeze film lubrications : Reciprocation – Piston Rings & Cylinder liner.
- Stribeck Curve : Sommerfield – Petroff {Concentric long fast journals} & McKee’s equations.

Hydrodynamic lubrications : Plummer Blocks – Plain Journals & Thrust Pads.

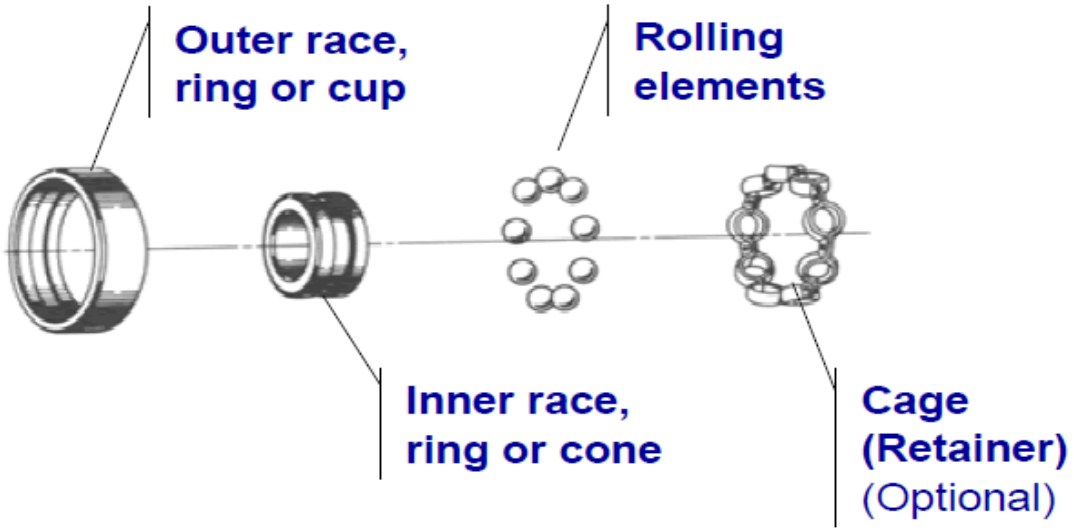




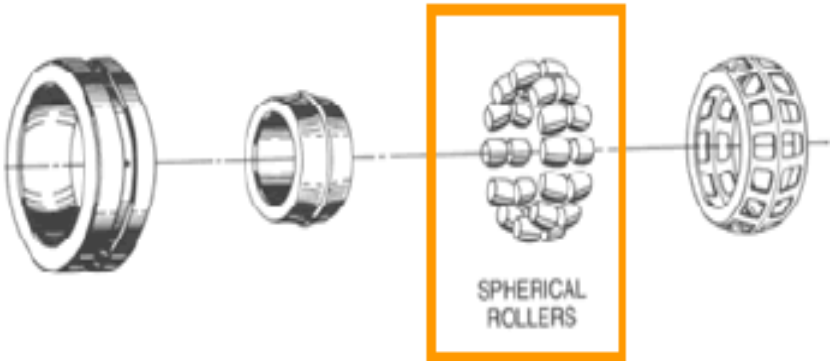
Antifriction Bearings : Elastohydrodynamic lubrications -



Ball Bearing Unit : Details -

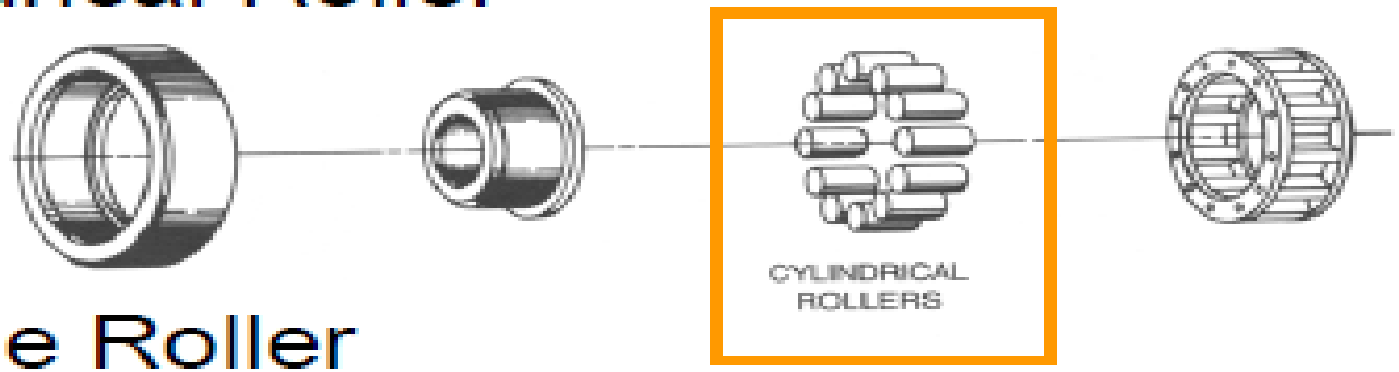


Spherical Roller

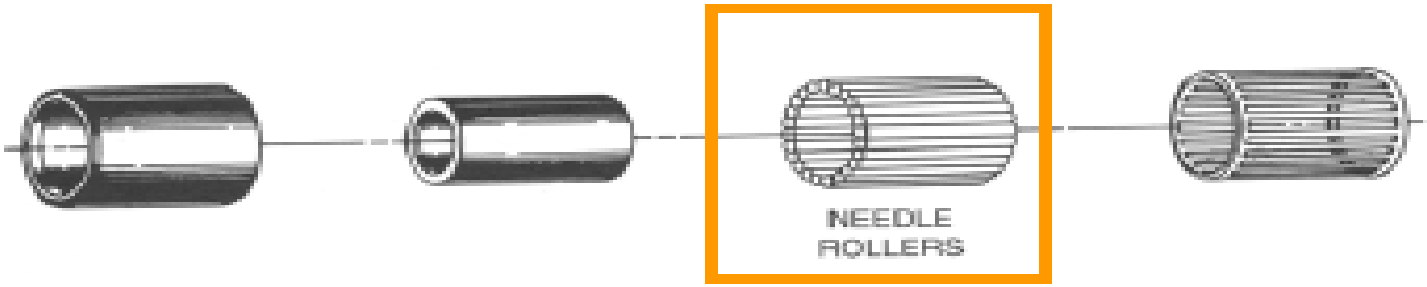


Antifriction Bearing Units : Details -

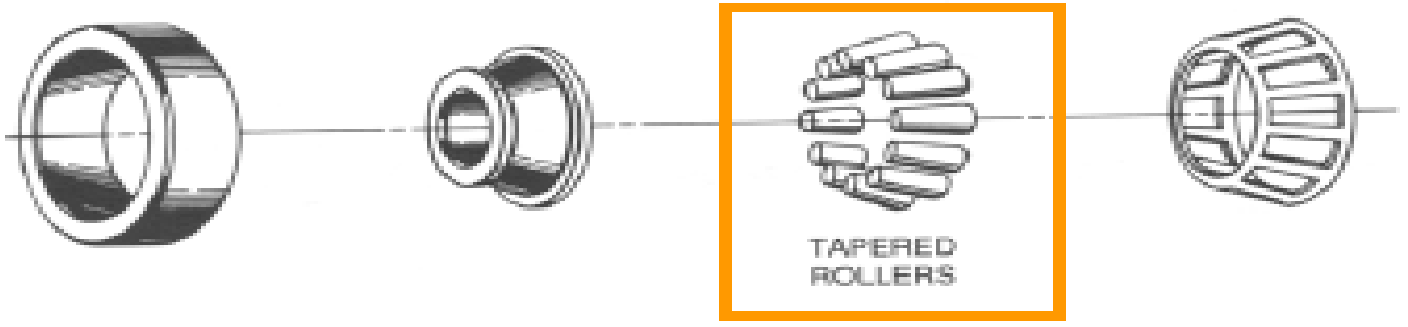
- Cylindrical Roller



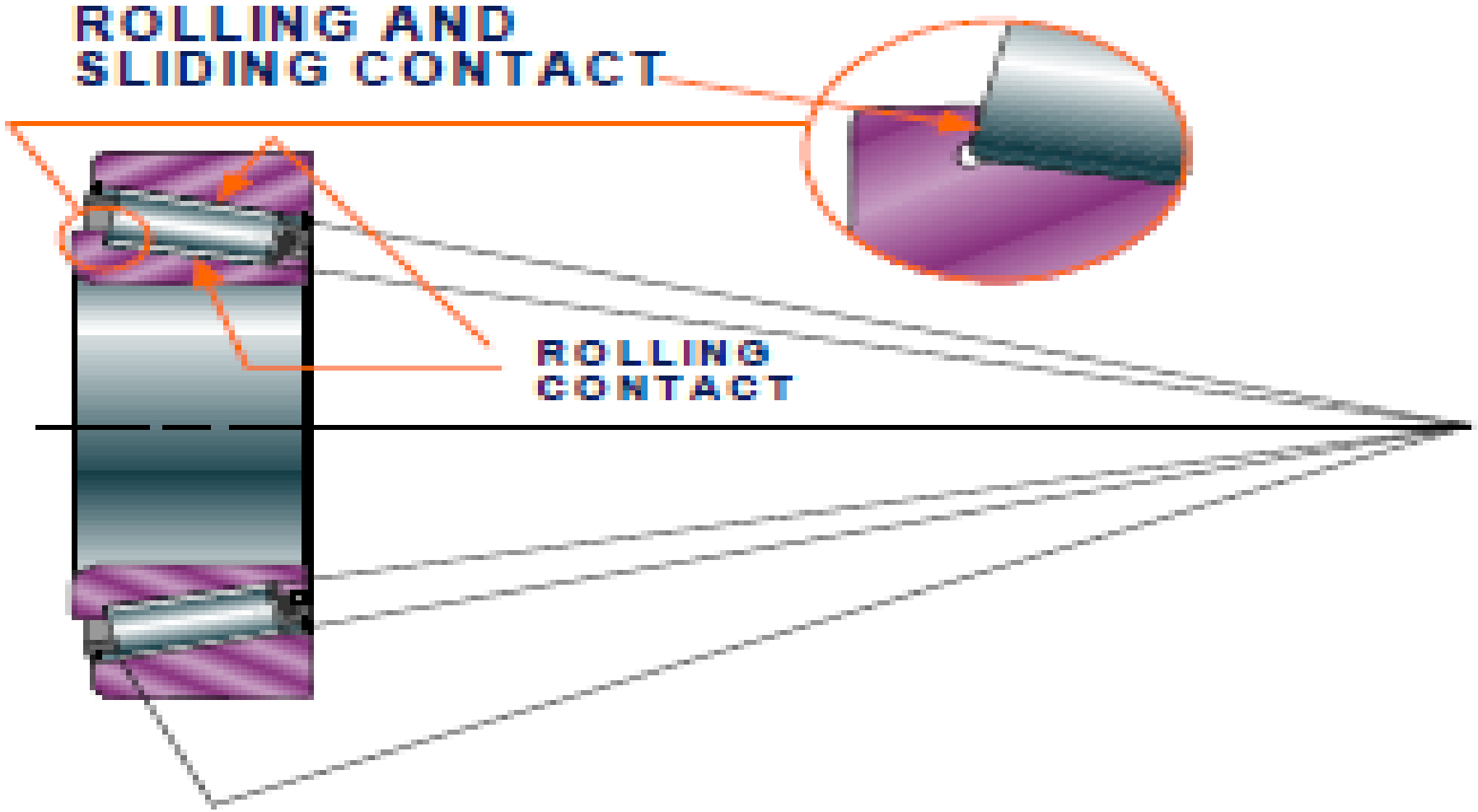
- Needle Roller



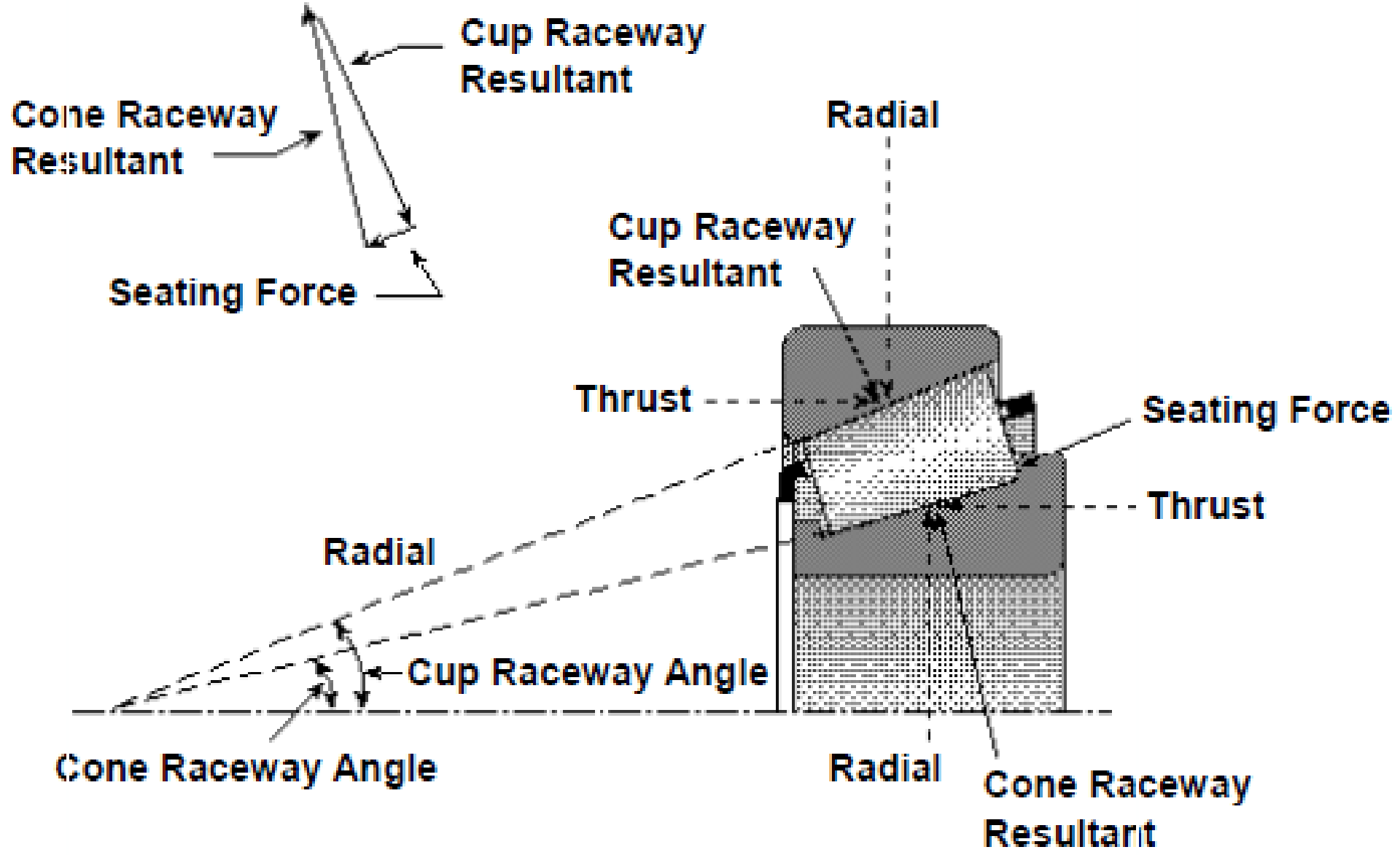
- Tapered Roller



Rolling Contacts



Rolling Contacts



3 basic lubrications

Hydrostatic lubrication:

- Pressure & film build-up by external forces

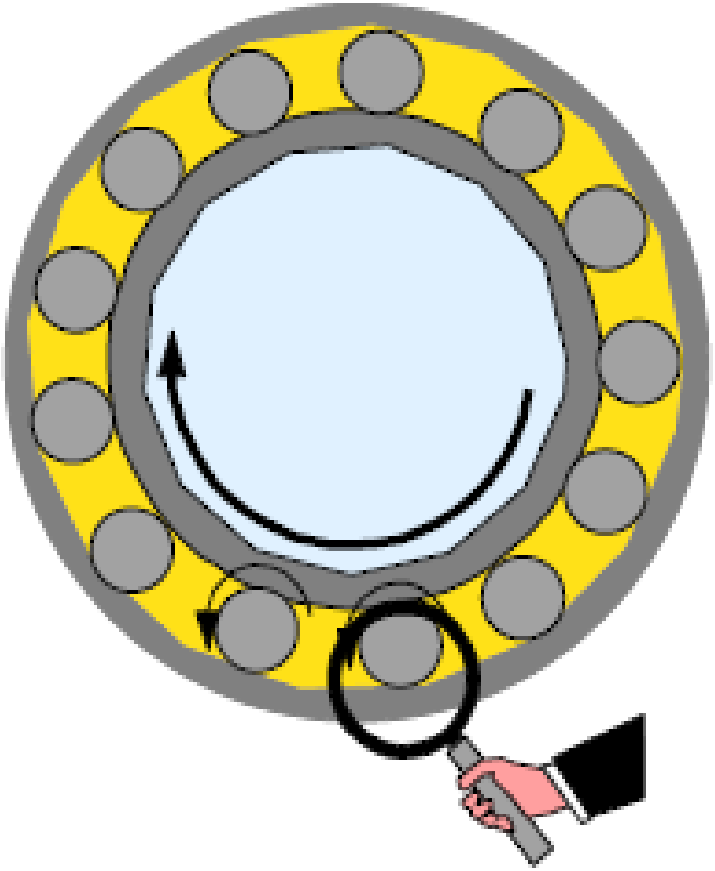
Hydrodynamic lubrication:

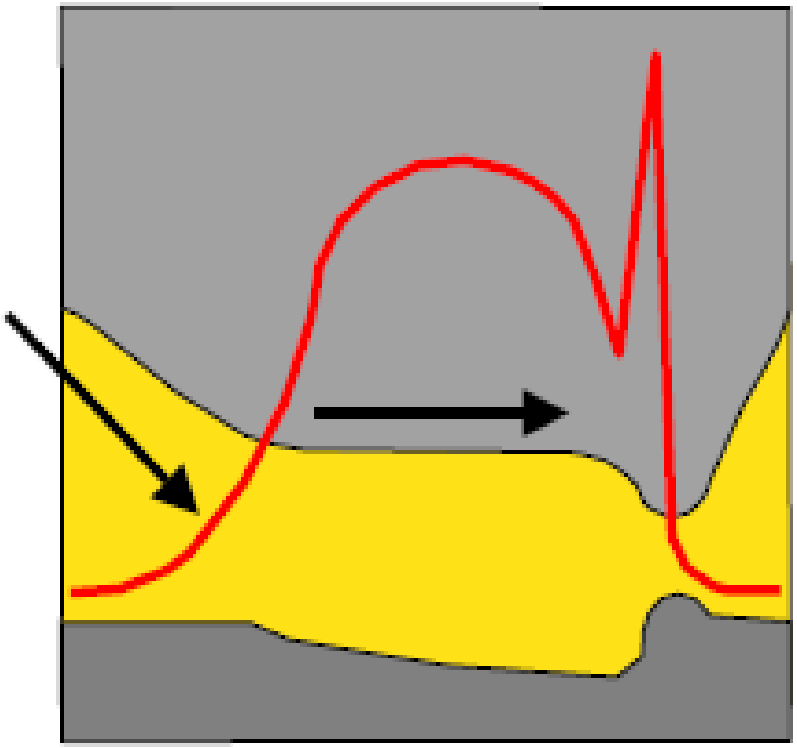
- Pressure & film build-up internally by surface movements and rigid surface geometry

Elasto-hydrodynamic lubrication:

- Pressure & film build-up by flexible surface geometry and surface movements

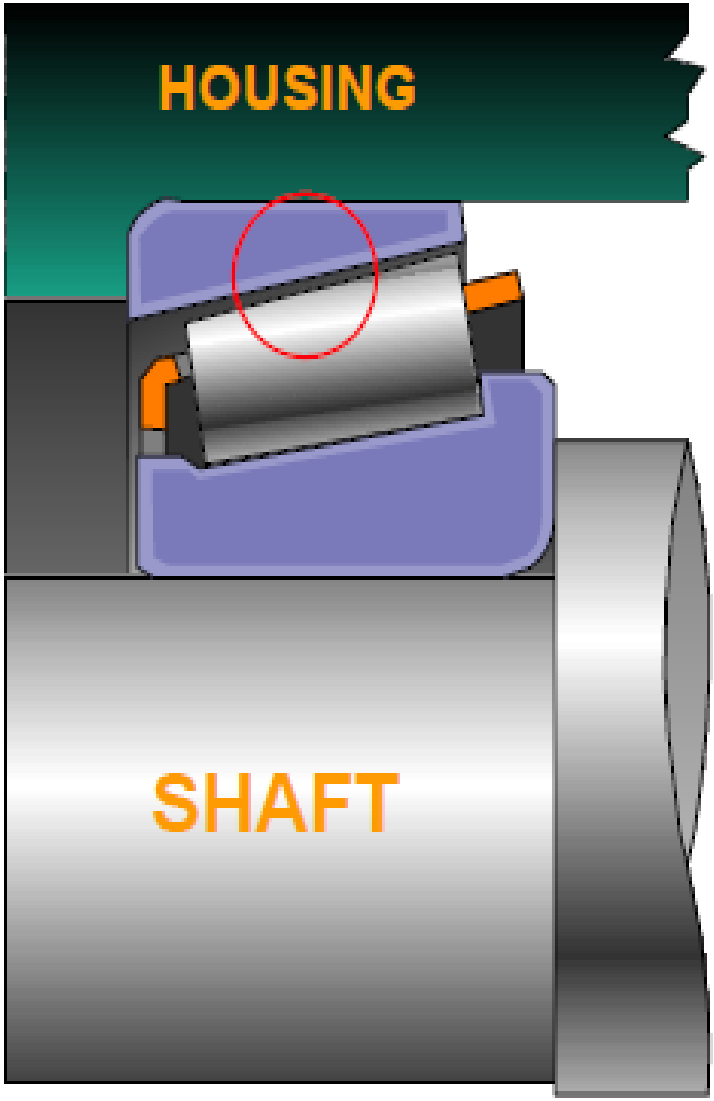
Antifriction bearings





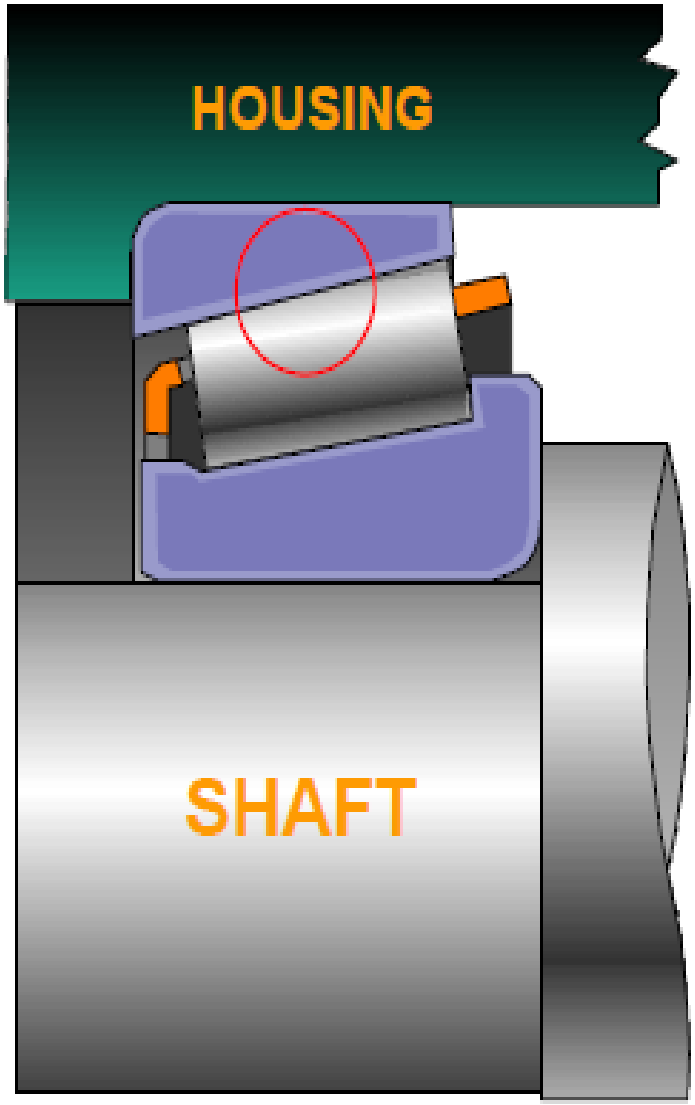
Under the high loads in the rolling contact
the oil can become 'solid' !

Endplay : TBU -



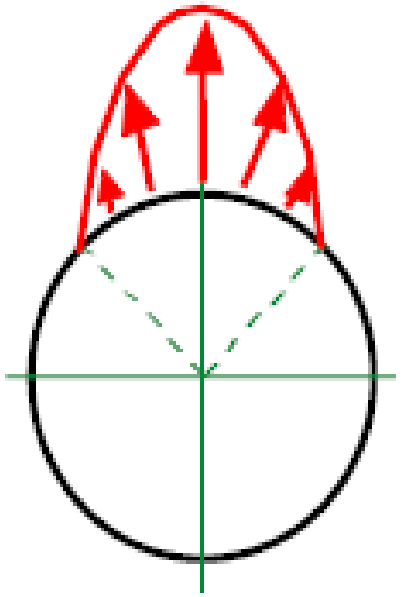
Endplay is the axial distance (or clearance) between the roller and cup raceway.

Preload – Angular contact tapered roller bearing :

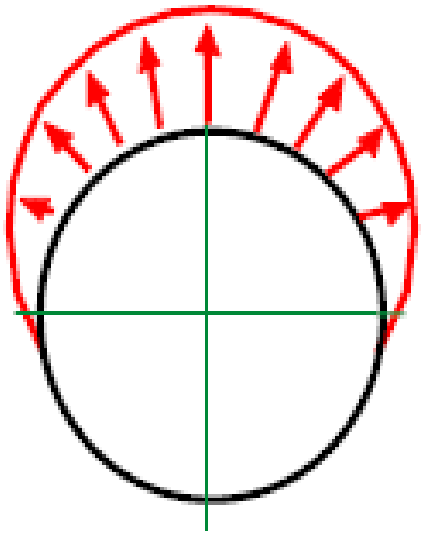


Preload: A tapered roller bearing setting where the races are forced together closer than line-to-line contact.

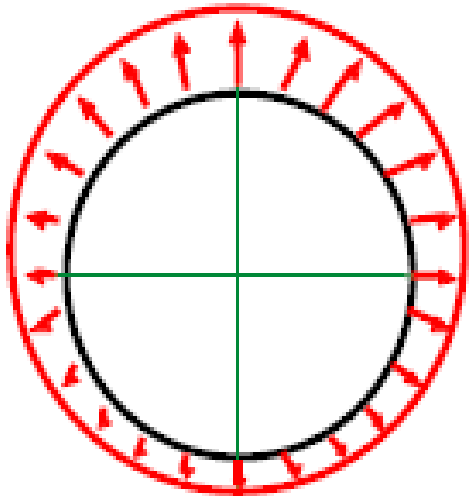
TBU : Loadings -



INTERNAL CLEARANCE



ZERO CLEARANCE



PRELOAD

L-10 bearing life :

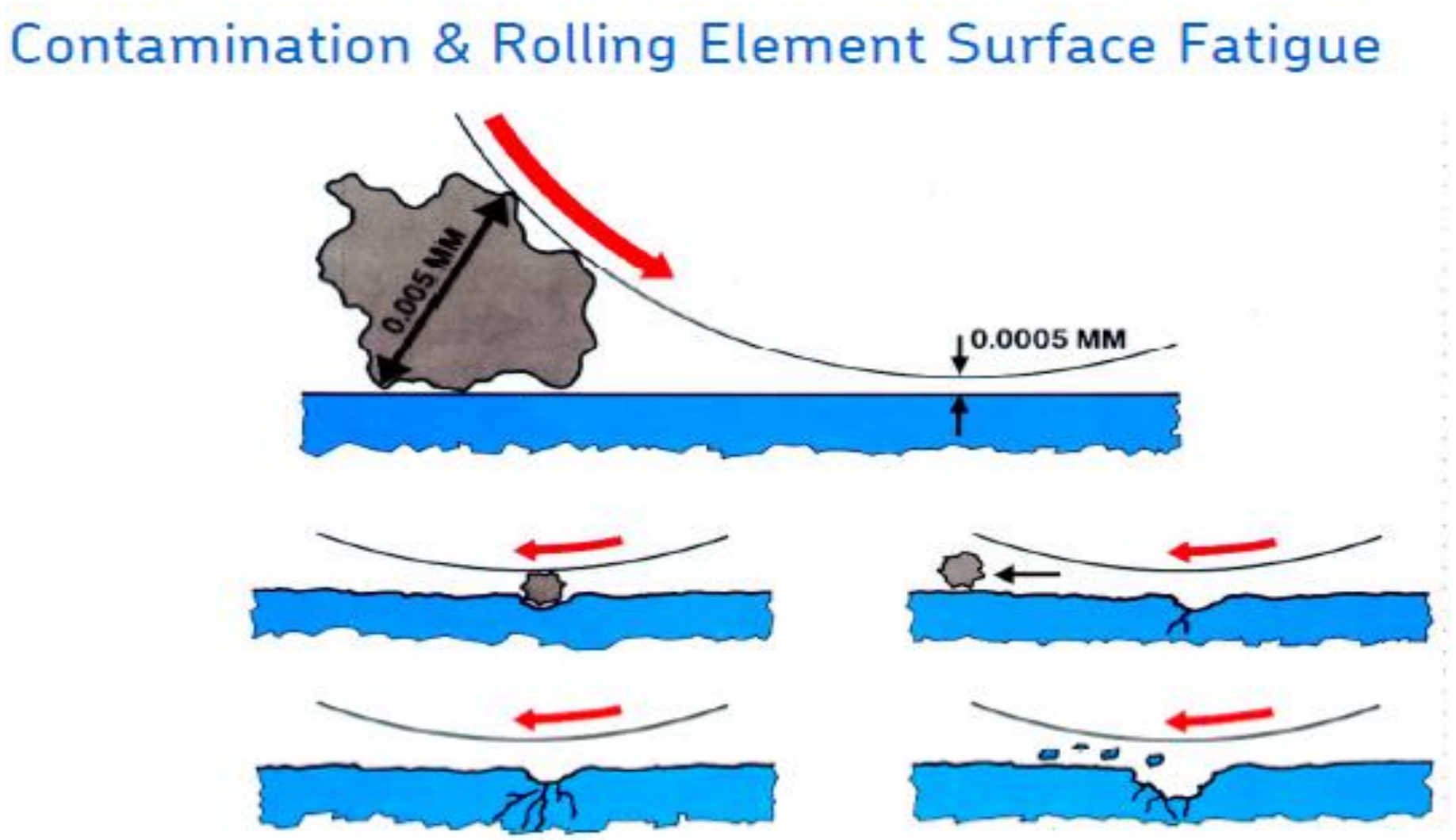
$$L_{10m} = a_1 \, a_{SKF} \, (C/P)^p$$

L_{10m} = Adjusted Life in millions of revolutions

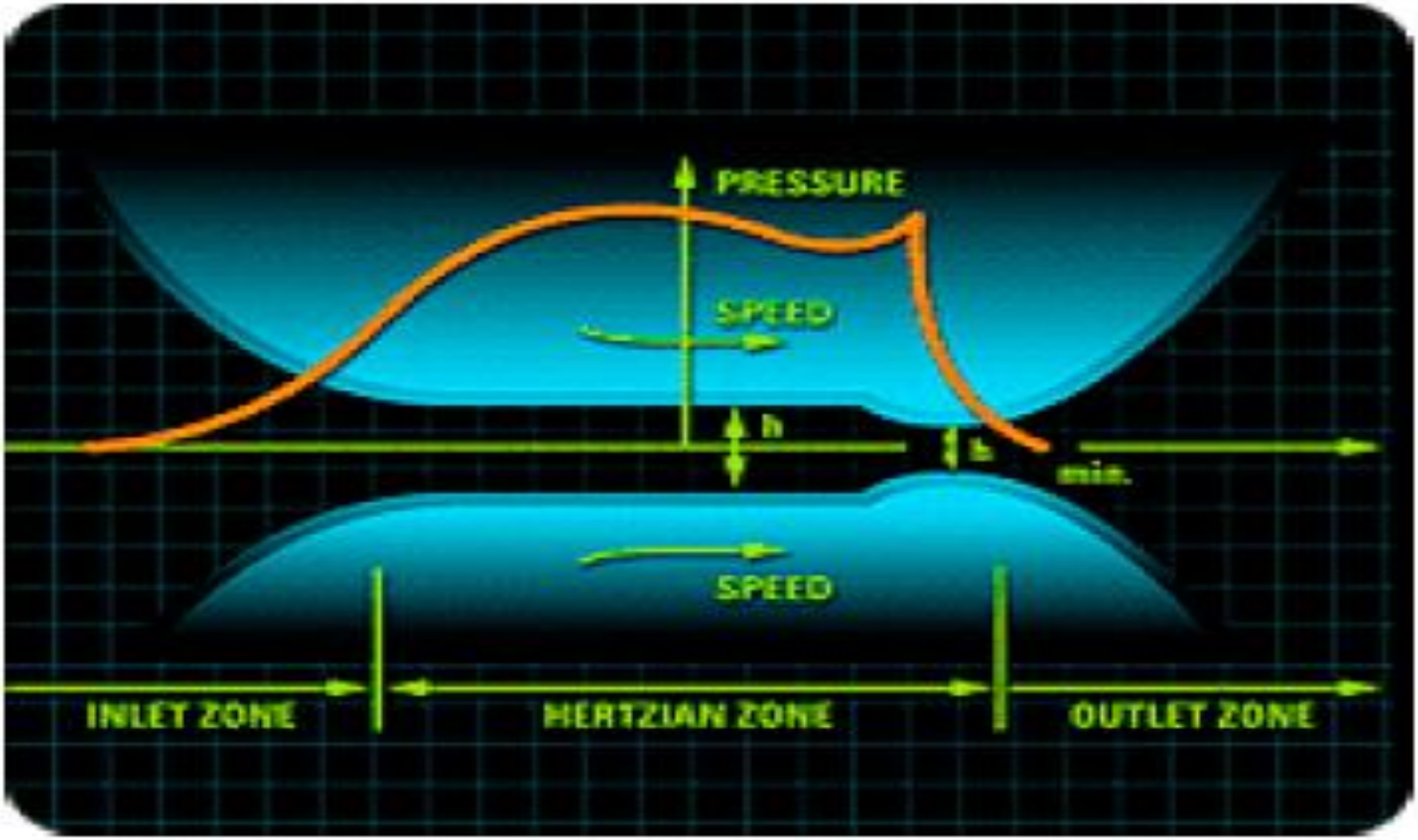
a_1 = Adjustment for reliability (a_1 = 1.0 for 90%)

a_{SKF} = Life modification factor for operating conditions including lubrication, temperature and contamination

Grease contaminations



Elastohydrodynamic lubrications

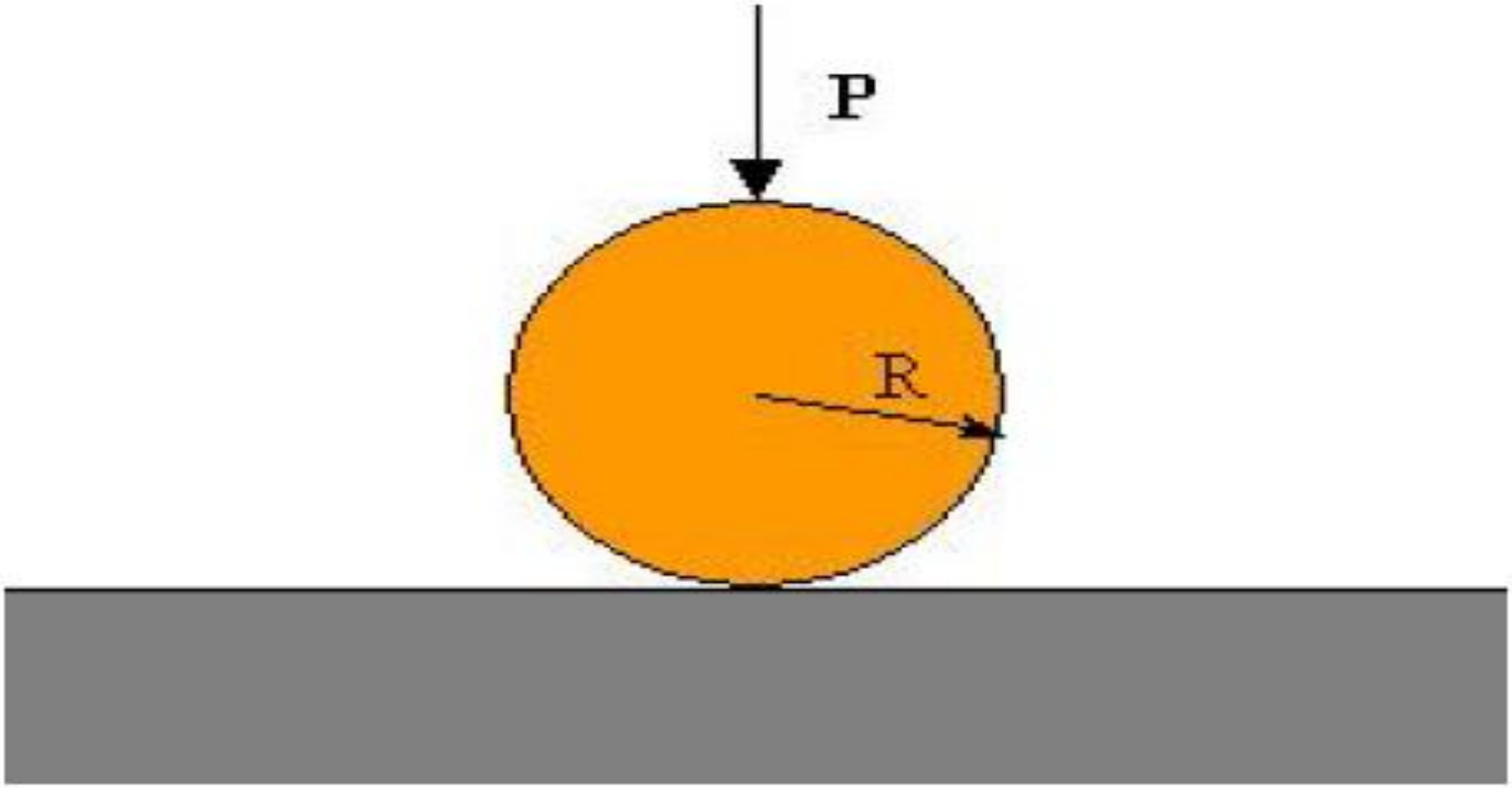


TBU : Seals - Rings

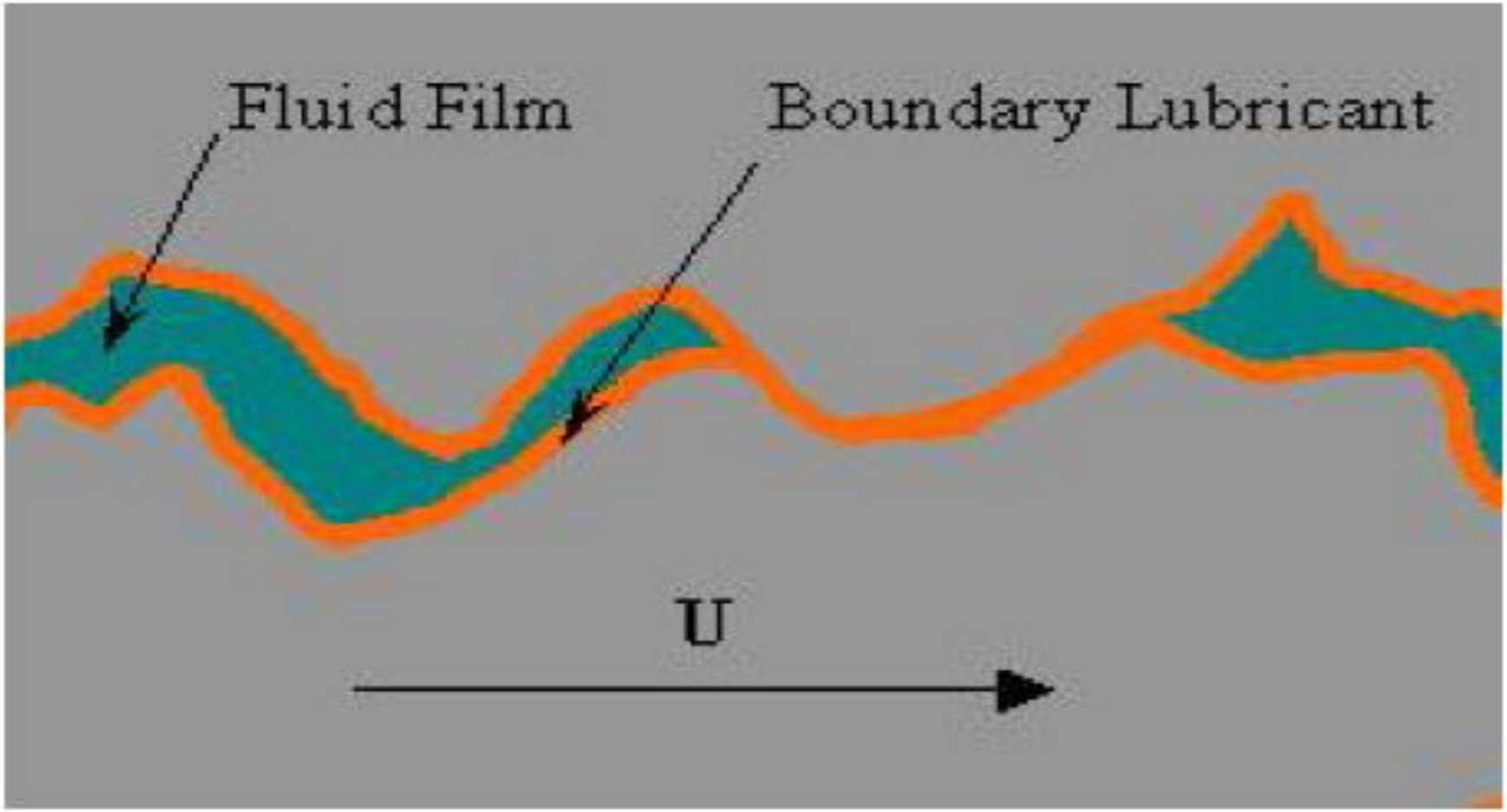


Rolling element

elastohydrodynamic lubrication (EHD).

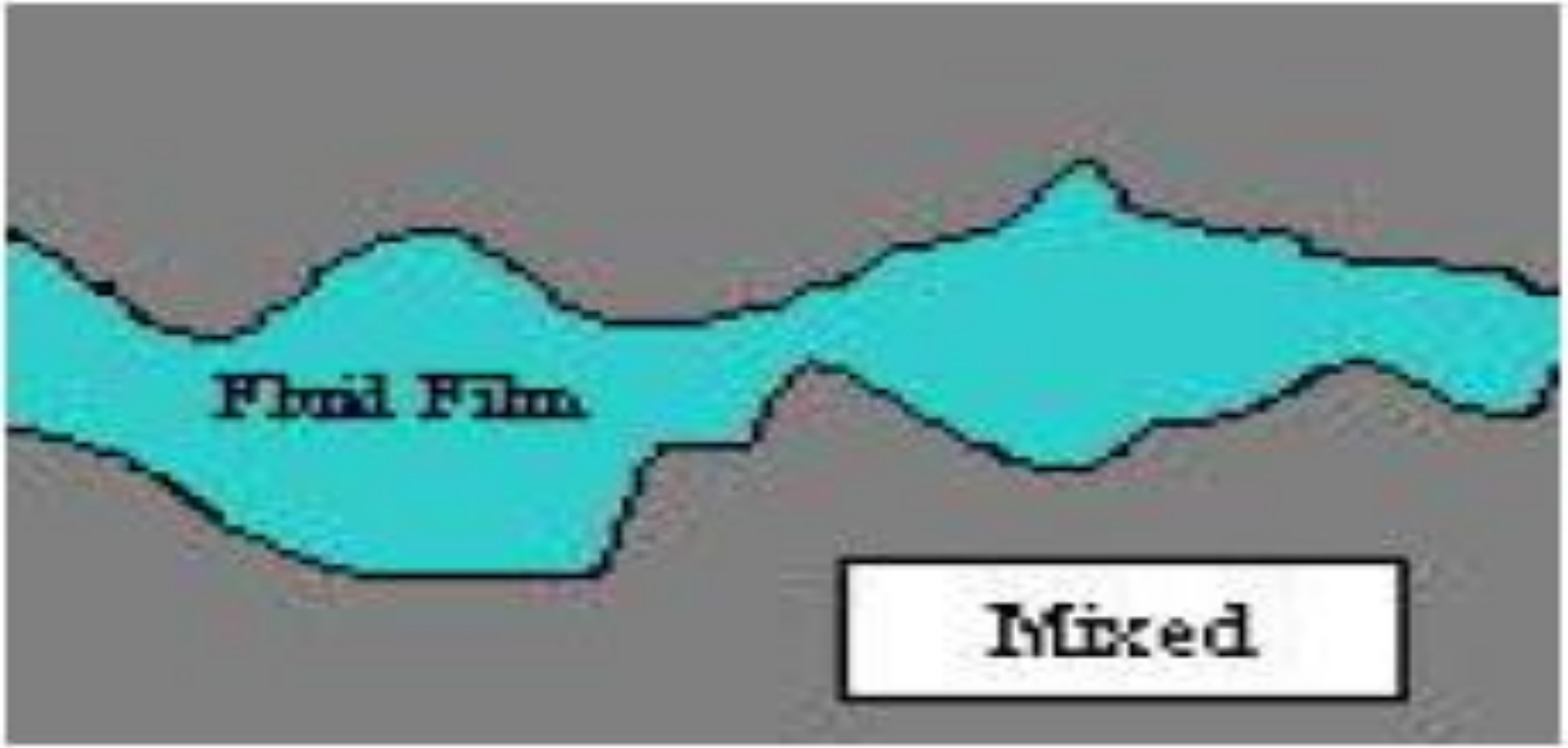


Boundary lubrication



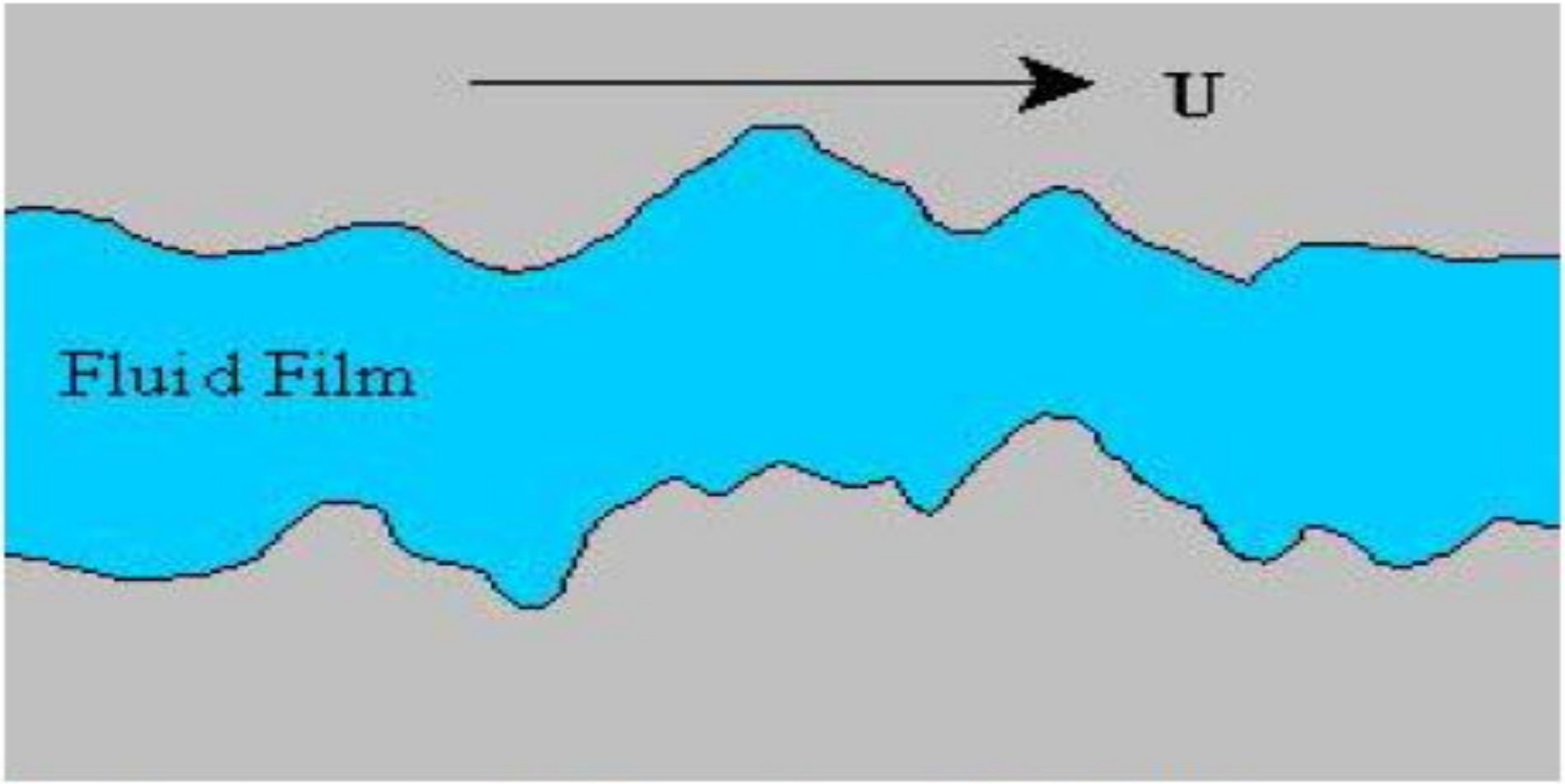
Boundary Lubrication

Fluid films



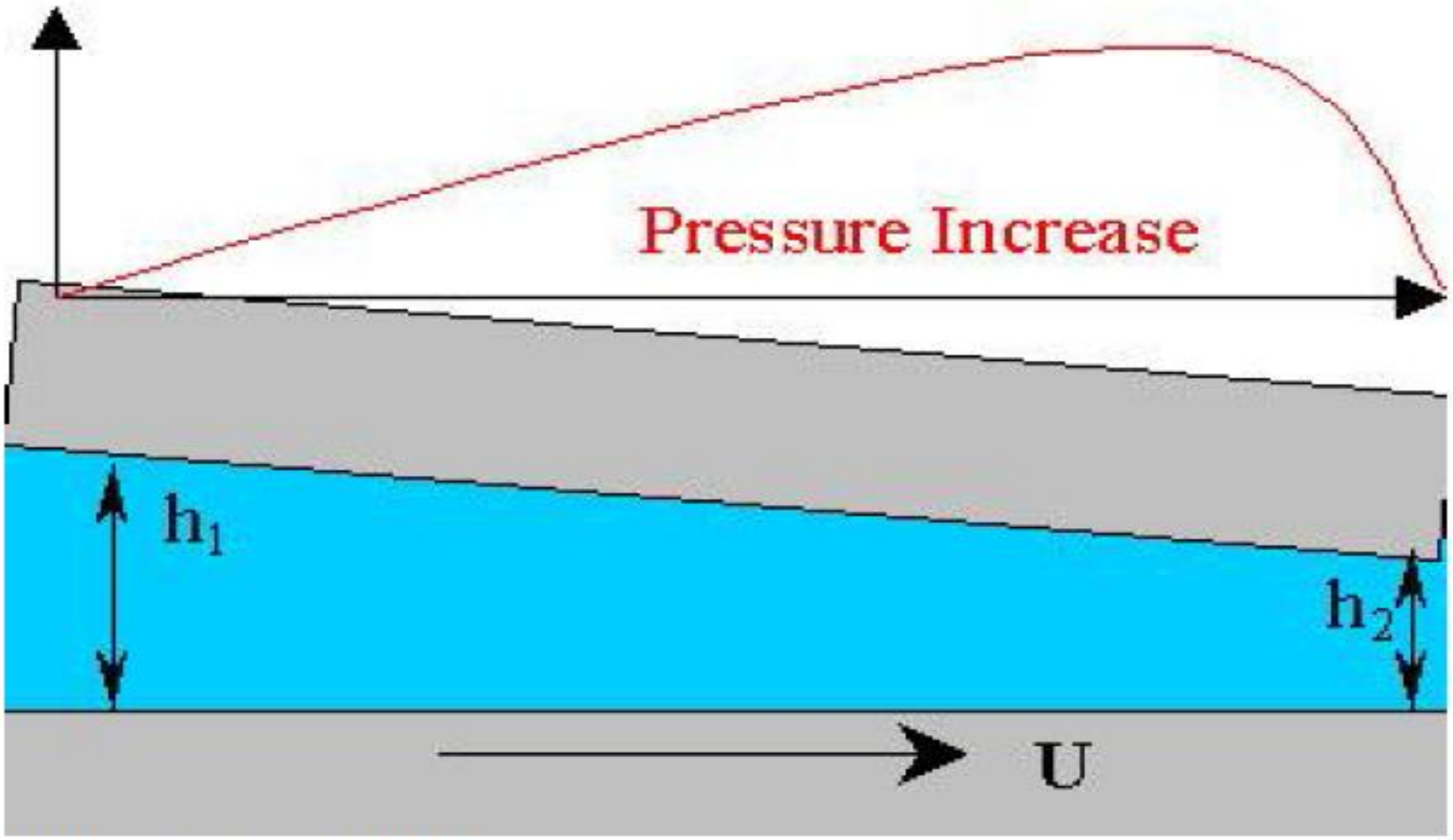
Lubrication Regimes

Hydrodynmic = Hydrodynamic



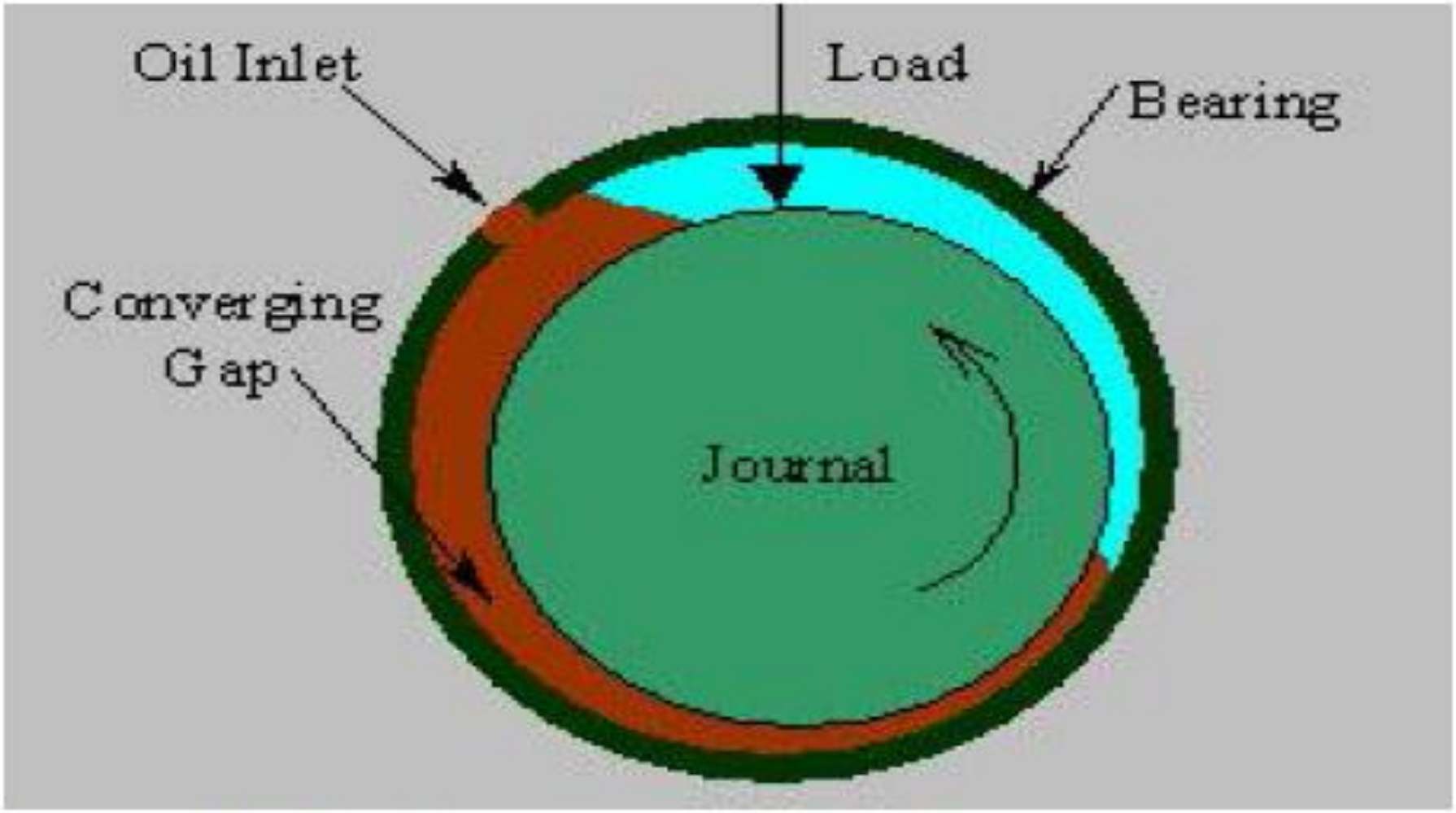
Hydrodynmic Lubrication Fluid Film

“Hydrostatic” lubrication



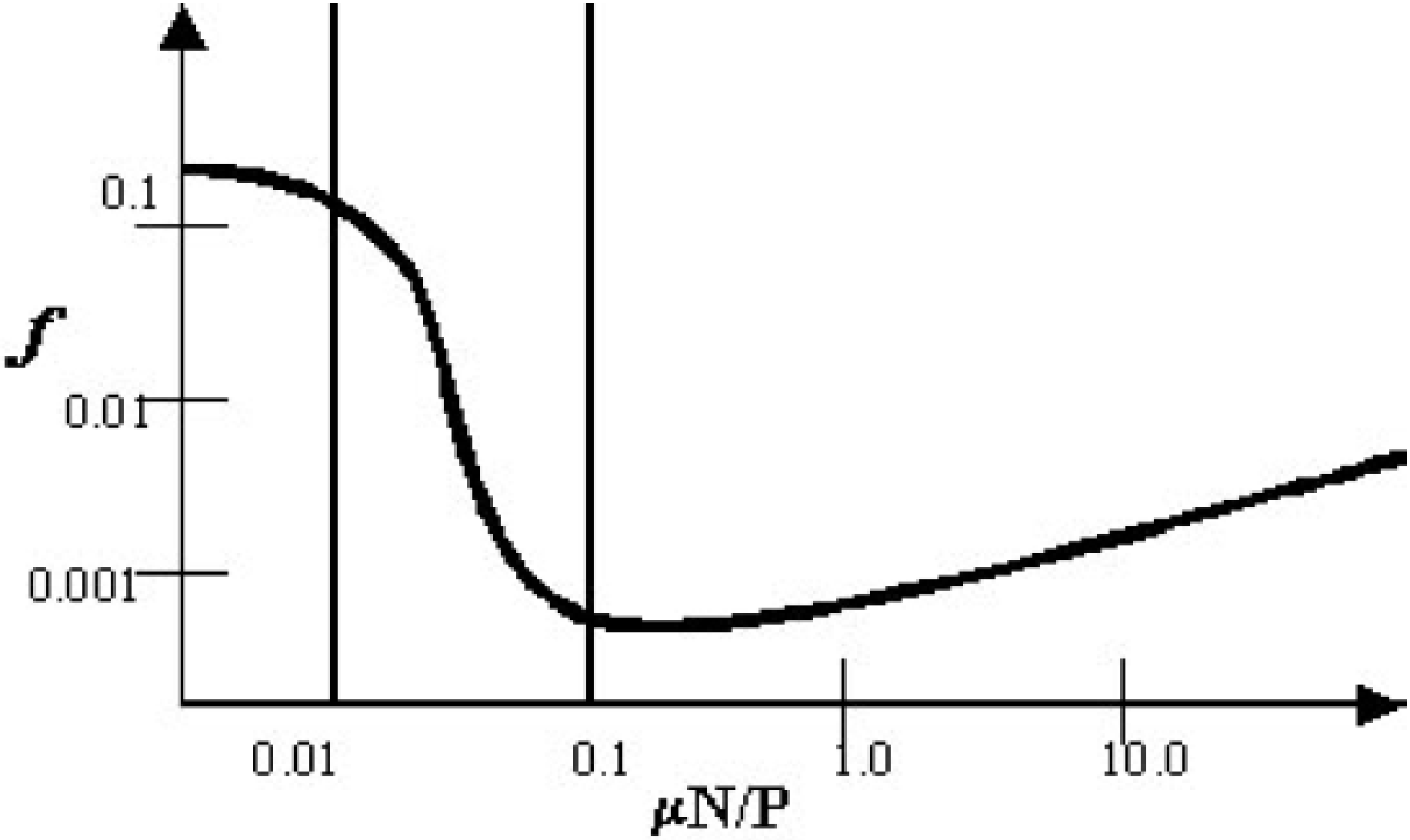
Hydrodynamic Lift

Hydrodynamic lubrication



Journal Bearing

Stribeck curve



CONCLUDED : THANKS -

