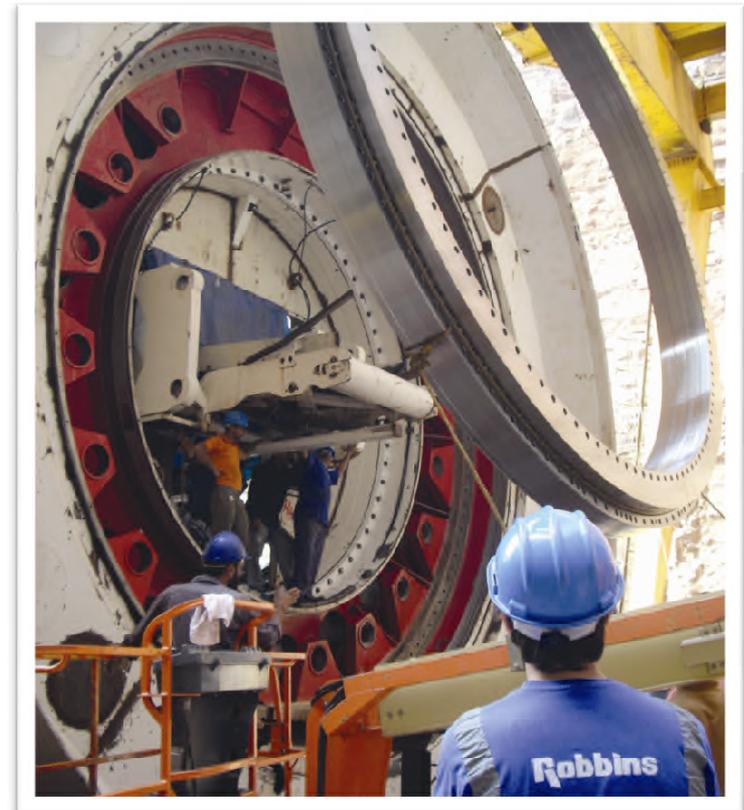


Determining the Main Bearing Life on a TBM

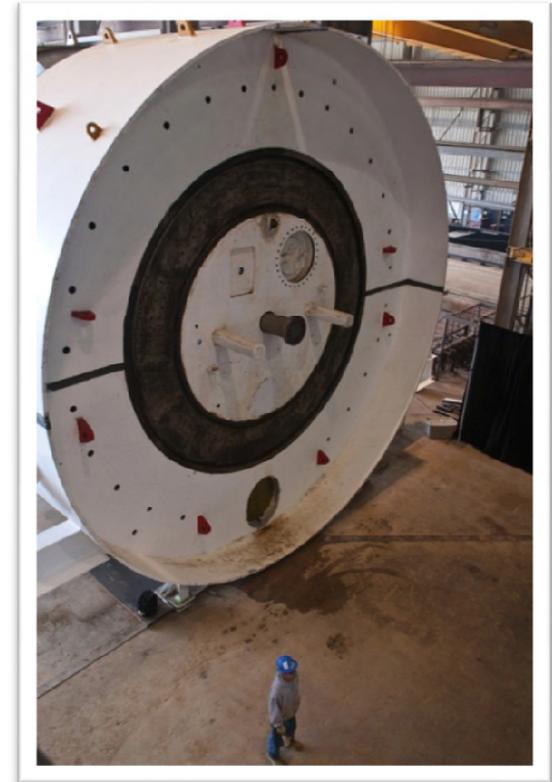
Standard Indication of Load Cases for Calculation
of Rating Life (L_{10}) of TBM Main Bearings

Presented by Brian Khalighi
Vice President, Engineering
The Robbins Company

- Introduction
- Definition of L10 Rating System
- Rating Life Equation
- Cutterhead Speed Equation
- Summary of Main Bearing Loads
- Definition of TBM Main Bearing Safety Factor
- Typical Bearing Load Assumptions by TBM Type
- Conclusions



- Standardized method of indicating main bearing load assumptions
 - L10 bearing lives offered by various TBM manufacturers
 - Provides guidance for evaluation
 - TBM types discussed:
 - Gripper
 - Single shield and double shield (SS, DS)
 - Earth pressure balance (EPB)
 - Slurry (STBM)



About Rating Life (L_{10})

Definition of Rating Life (L_{10})

Defined in ISO recommendation R281:

“The rating life of a sufficiently large number of identical bearings is expressed by the number of revolutions (or number of hours at constant speed) reached or exceeded by 90% of this bearing group before the first signs of material fatigue appear.”

THE RATING LIFE (L_{10}) EQUATION

$$L_{10} = (C/P)^k$$

- L_{10} : rating life in [10^6 revolutions]
- C: dynamic load bearing capacity of the bearing in [kN]
- P: applied load in [kN]
- K: for roller bearings = 10/3



- To convert the Rating Life into hours, a certain cutterhead speed must be considered as follows:

$$n = V/\pi D$$

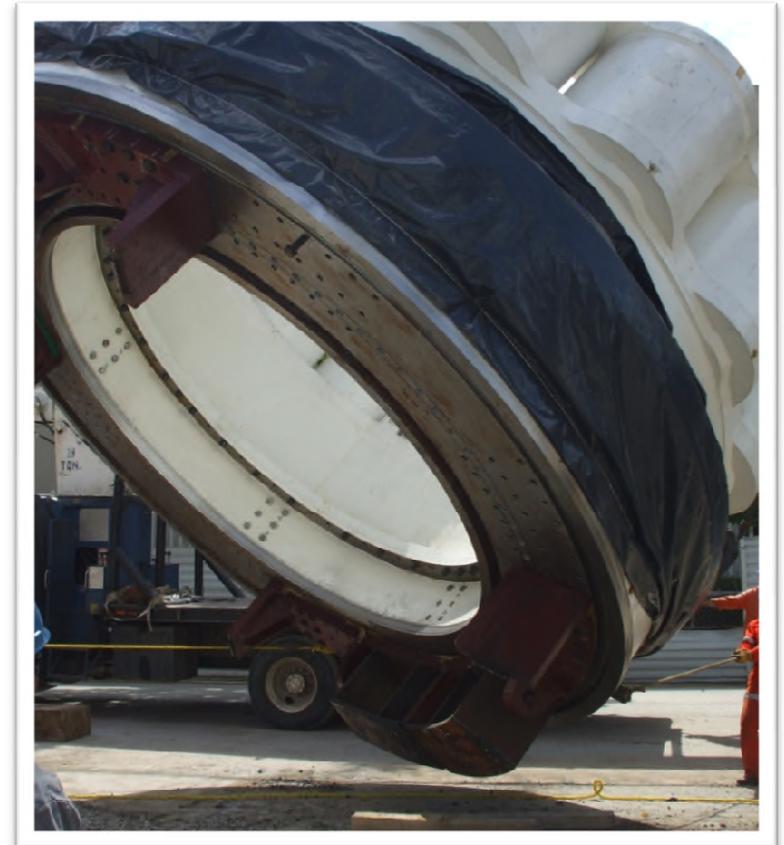
$$\text{Life in Hours} = L_{10} / 60 \times n$$

- n: cutterhead rotational speed in revolutions per minute [min^{-1}]
- V: velocity of the last gage cutter in [m/min]
- D: cutterhead diameter in [m]



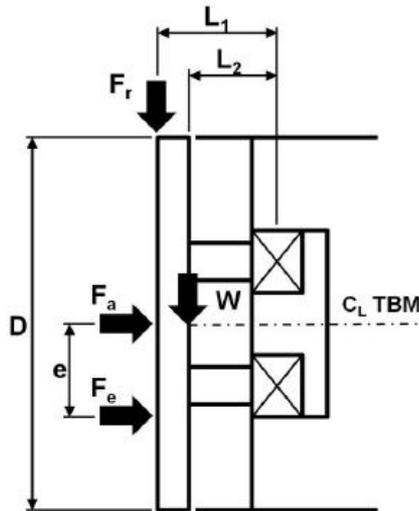
TBM Main Bearing Safety Factor

- The safety factor of a TBM main bearing is defined as the relation between calculated bearing L_{10} lifetime in hours, and the anticipated cutterhead operation time for the project
- For used bearings, the remaining lifetime should be considered



Typical Bearing Load Assumptions as Used in the Industry

Hard Rock TBM (Gripper, SS, DS)



- LC: Load case [-]
- F_a : axial load (centric) [kN]
- F_e : axial load eccentric [kN]
- F_r : operational radial load [kN]
- W : own weight [kN]
- e : eccentricity of F_e [m]
- L_1 : moment arm operational radial load F_r [m]
- L_2 : moment arm of own weight W [m]
- T_c : cutterhead torque [kNm] ⁽¹⁾
- n : cutterhead speed [min^{-1}]
- O : Duration of operation [%]



LC	F_a	F_e	F_r	W	e	T_c	n	O
	[kN]	[kN]	[kN]	[kN]	[m]	[kNm]	[min^{-1}]	[%]
I	F_{CH}	0	0	$1 \times W$	0	optional	max	90
II	0	F_{CH}	$1 \times F_r$	$1 \times W$	$0,16 \times D$	optional	max	10
III	0	F_{CH}	0	$1 \times W$	$0,4 \times D$	--	--	stat.

Remarks

- F_{CH} : the cutterhead thrust is defined as “total # of disc cutters” x “disc cutter load capacity”
- F_r : the operational radial load F_r (resulting from steering loads) is defined as 2 x “disc cutter load capacity”
- The anticipated cutterhead torque “ T_c ” is only required in case a gear calculation should be performed
- In load cases LC I and LC II, the dynamic roller pressure allowable must not be exceeded
- In load cases LC III, the static roller pressure allowable may not be exceeded

QUESTIONS?