

# Determining the Main Bearing Life on a TBM

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

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- 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 [ $\text{min}^{-1}$ ]
- $V$ : velocity of the last gage cutter in [ $\text{m}/\text{min}$ ]
- $D$ : cutterhead diameter in [ $\text{m}$ ]



## TBM Main Bearing Safety Factor

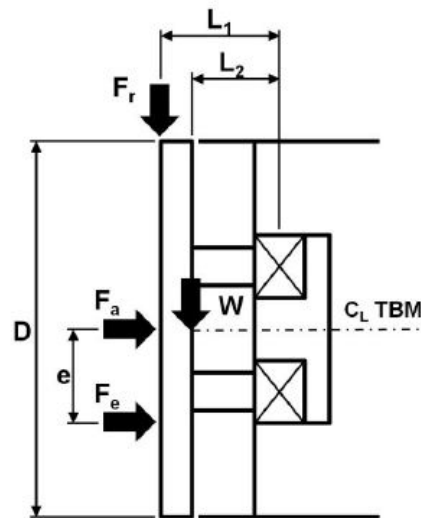
- The safety factor of a TBM main bearing is defined as the relation between calculated bearing  $L_{10}$  lifetime in hours, and the anticipated cutterhead operation time for the project
- For used bearings, the remaining lifetime should be considered



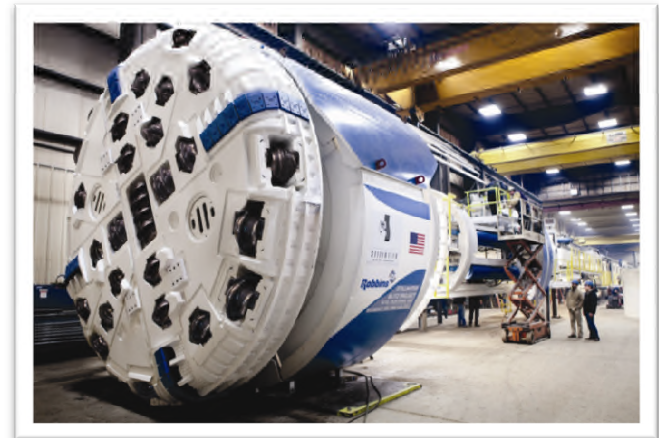


# Typical Bearing Load Assumptions as Used in the Industry

### 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] <sup>(1)</sup>  
 $n$ : cutterhead speed [min<sup>-1</sup>]  
 $O$ : Duration of operation [%]



LC	$F_a$	$F_e$	$F_r$	$W$	$e$	$T_c$	$n$	$O$
	[kN]	[kN]	[kN]	[kN]	[m]	[kNm]	[min <sup>-1</sup> ]	[%]
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?