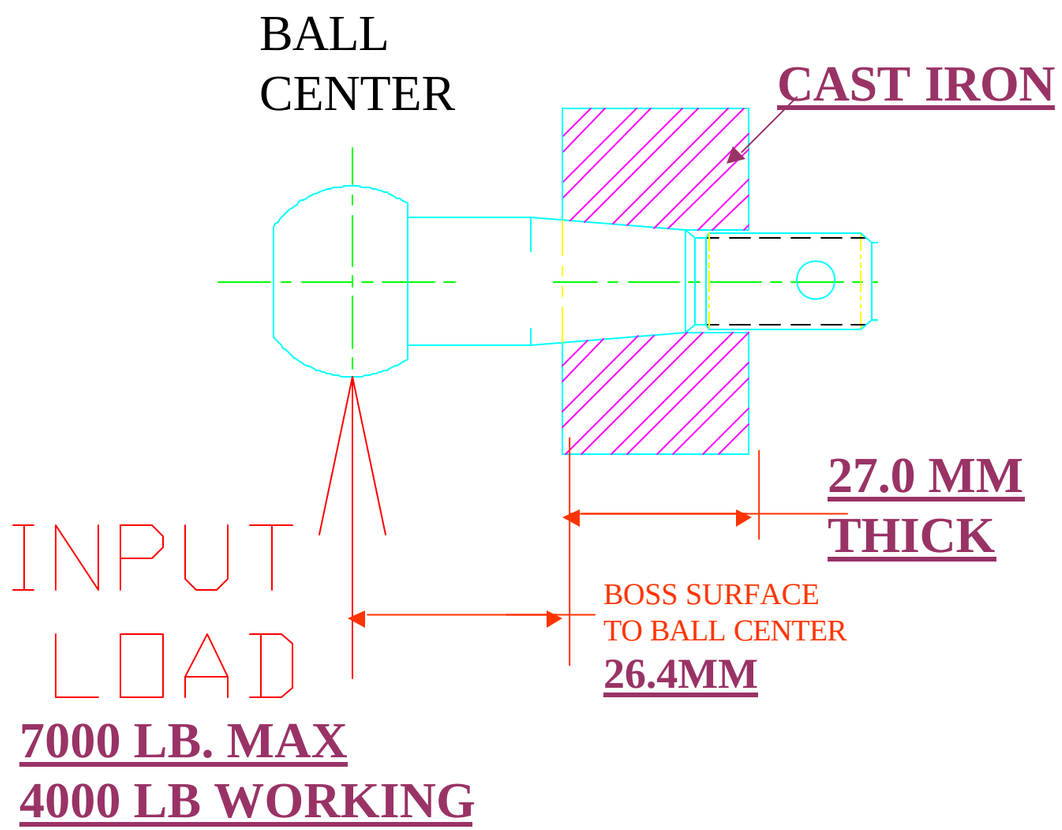
TIE ROD END DESIGN TUTORIAL

- THE FOLLOWING IS A SIMPLIFIED STEP-BY-STEP GUIDE INTENDED TO ILLUSTRATE THE DECISIONS AND COMPROMISES INVOLVED IN DESIGNING A TIE ROD END.
- THE PROCESS FOR DESIGNING ANY BALL JOINT IS VERY SIMILAR

DESIGNING A ROD END FOR THE 20XX HYPTHETICAL LIGHT TRUCK

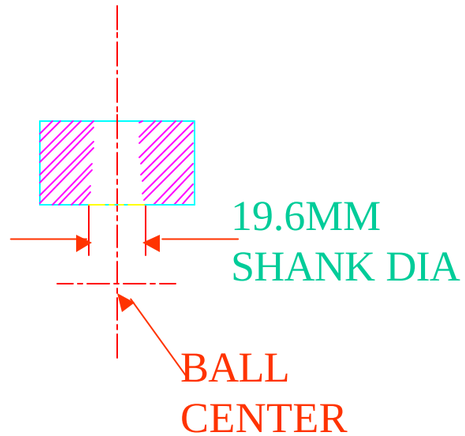
- FROM THE CUSTOMER WE LEARN:
  - **1) PT 12 RELATIVE TO KNUCKLE 26.4MM**
  - **2) LOADS 7000 MAX, 4000 WORKING**
  - **3) PACKAGE NO ISSUES, 30MM FROM BRAKE ROTOR DUST SHIELD**
  - **4) ARTICULATION TRAVEL +/- 18 DEGREES**
  - **5) MATING PARTS DETAIL CAST IRON 27MM THICK, STUD UP, CASTLE NUT/COTTERPIN**
  - **6) APPLICATION COMMERCIAL LIGHT TRUCK, R&P W/ M16X 1.5 ROD**
  - **7) GREASABLE / NON-GREASABLE GREASABLE**

BALL STUD DESIGN INPUTS



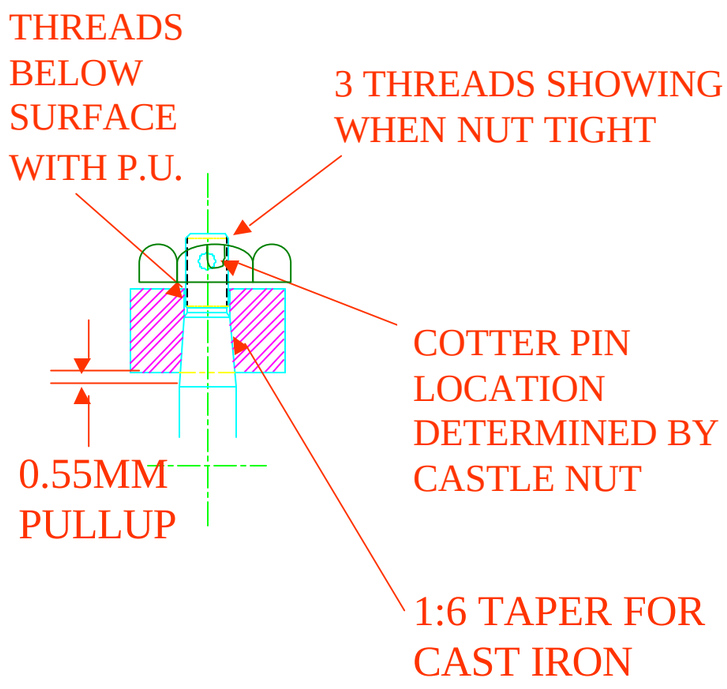
BALL STUD SHANK SIZING

- 7000 LB MAX LOAD
- 4000 LB WORKING LOAD
- 26.4MM CANTILEVER BEAM
- SHEAR-MOMENT CALCULATION
- 25% F.S.
- EFFECTIVE MATL ULT = 242KSI
- EFFECTIVE MATL YEILD = 129KSI
- => SHANK DIA = 19.6MM



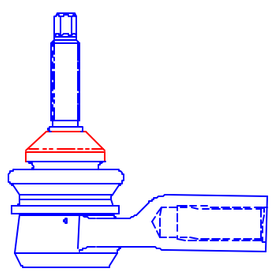
TAPER SPECIFICATION

- STEEL BOSS
  - 1:8 TAPER
  - 1.25:1 THICK/DIA
- CAST IRON, ALUMINUM
  - 1:6 TAPER
  - 1.3-1.5 THICK/DIA
- PULL UP
  - STEEL => .4-.7MM
  - CAST IRON => .4-.7MM
  - ALUMINUM =>1.0MM

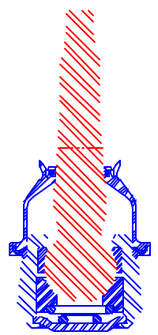


CONE WASHER VS. TAPERED BALL STUD

- CONE ADVANTAGES
  - **EASY SERVICE REMOVAL**
  - **SEAL SURFACE CONTROLLED**
  - **CHANGE GAGE LENGTH EASILY**
    - GT ADJUSTABLE

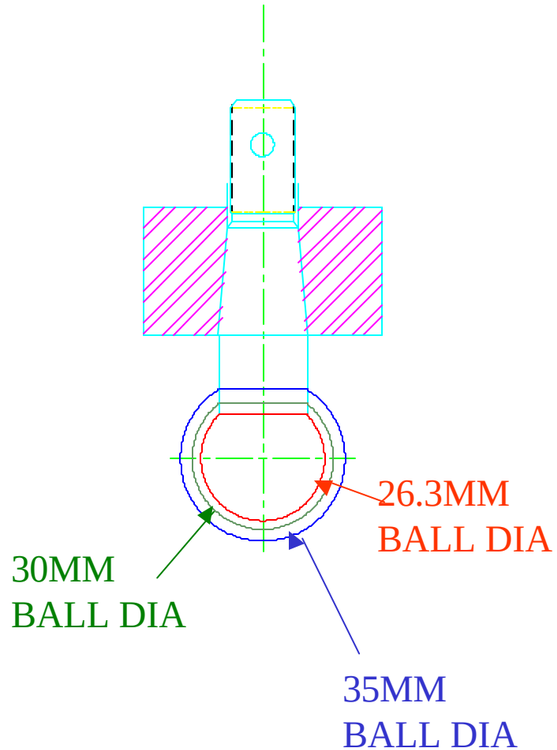


- TAPER ADVANTAGES
  - **LOCKING TAPER**
  - **CARBONITRIDE H.T.**
  - **LOWER COST**
  - **LESS SENSITIVE TO NUT TORQUE**



BALL SIZING

- LARGER DIA
  - IMPROVES PULL OUT STRENGTH
  - REDUCES BEARING/LUBE PRESSURE
  - NO ARTICULATION UNDERCUT
- SMALLER DIA
  - MORE ROOM FOR SEAL
  - BETTER PACKAGE
  - LESS EXPENSIVE

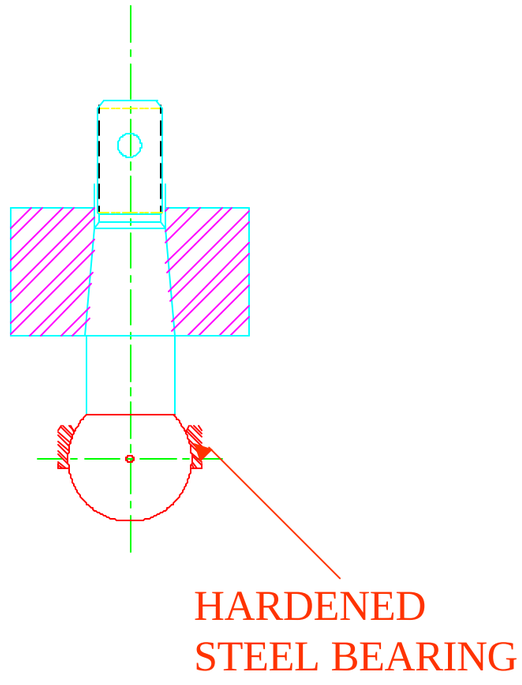


NOW IT GETS COMPLICATED

- BETWEEN THE TOP OF THE BALL AND THE KNUCKLE WE NEED TO PACKAGE:
  - BEARING
  - FORGING
  - SEAL
- AND, IT HAS TO ARTICULATE

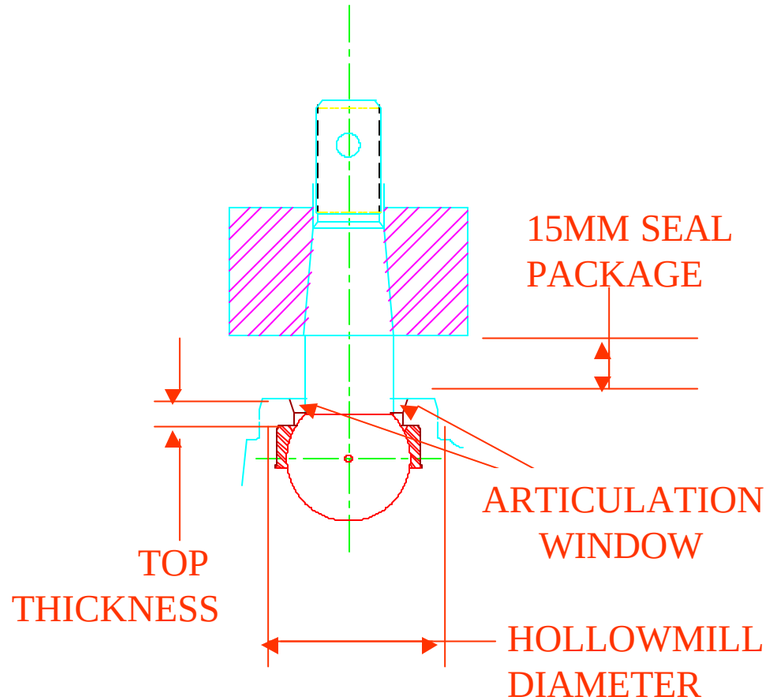
STEEL BEARING PACKAGE FOR A 26MM BALL

- STANDARD HARDENED STEEL BEARING FOR 26MM BALL
- EXCELLENT WEAR CHARACTERISTICS
- EXCELLENT PULL OUT STRENGTH
- HIGHER ROTATING TORQUES



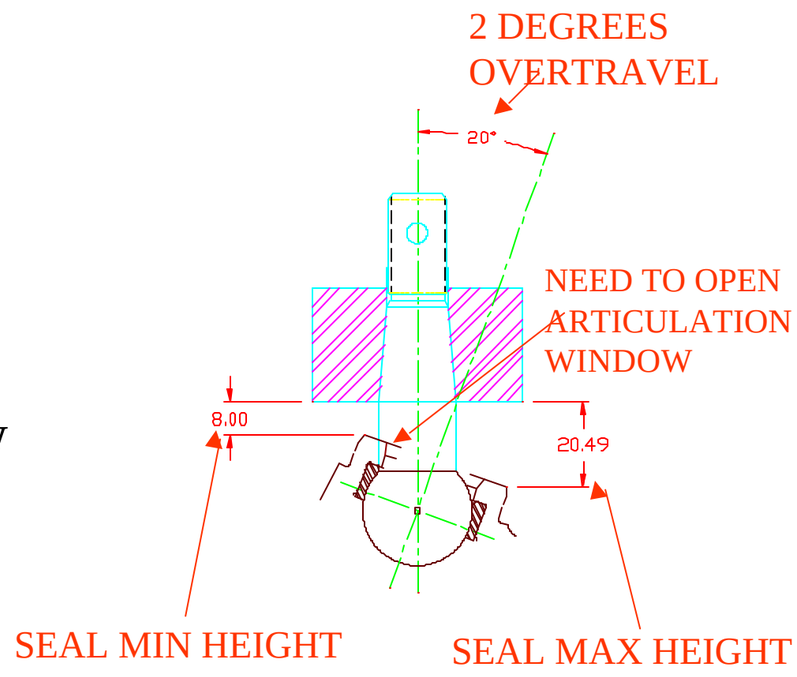
UPPER FORGING PACKAGE FOR A 26MM BALL WITH STEEL BEARING

- FORGING CONSIDERATIONS:
- 5.0MM MIN TOP THICKNESS
- HOLLOWMILL FOR SEAL RETAINER
- ARTICULATION WINDOW



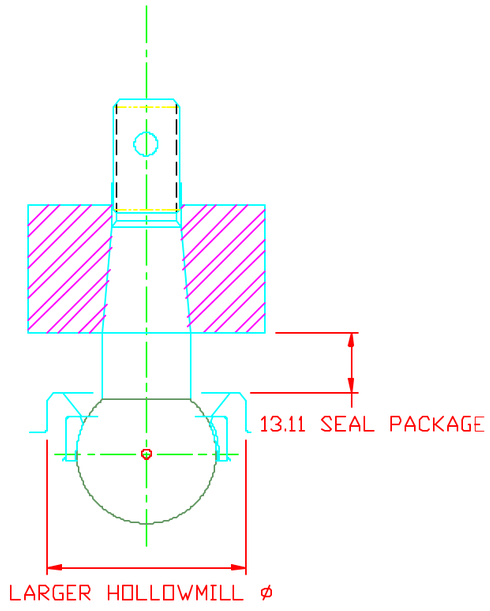
DON’T FORGET ARTICULATION

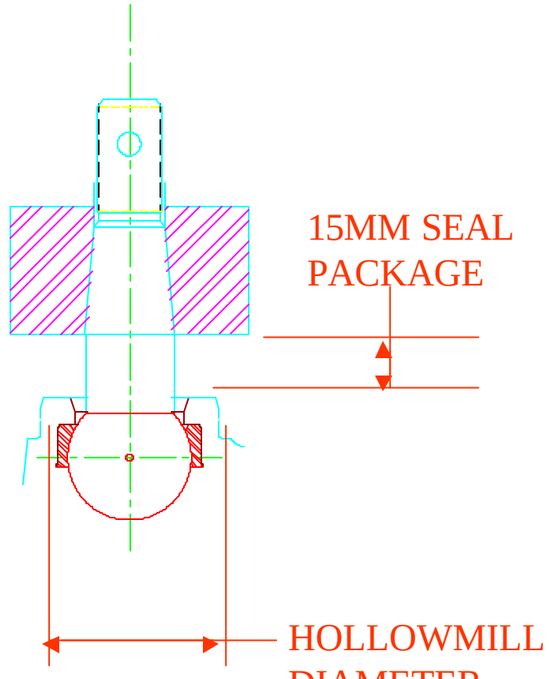
- SPECIFIED 18 DEGREE ARTICULATION ANGLE DRIVES:
  - SEAL DESIGN REQUIREMENTS
  - FORGING WINDOW



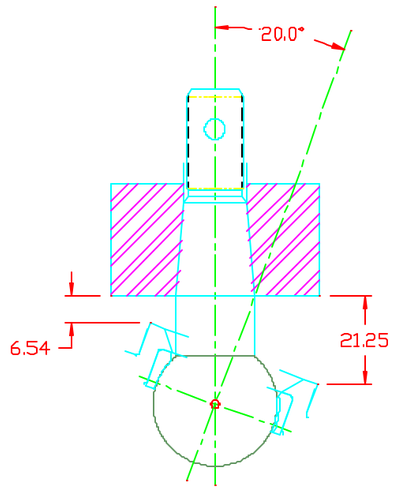
WHAT HAPPENS IF WE GO TO A 30MM BALL DIAMETER?

UPPER FORGING PACKAGE FOR 30MM BALL VS. 26MM BALL

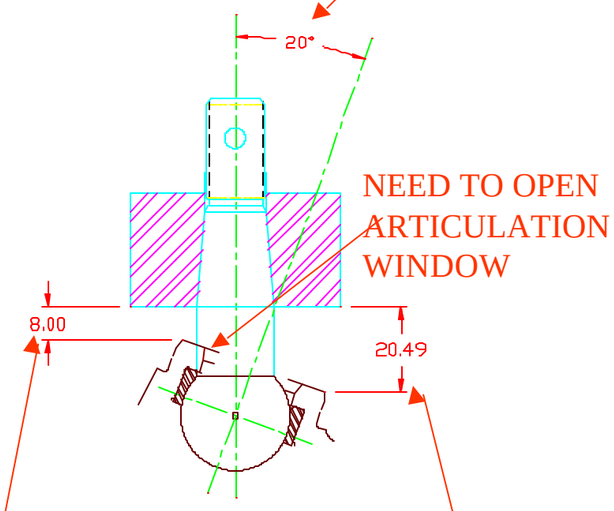




ARTICULATION STUDY
30MM VS 26MM BALL



30MM



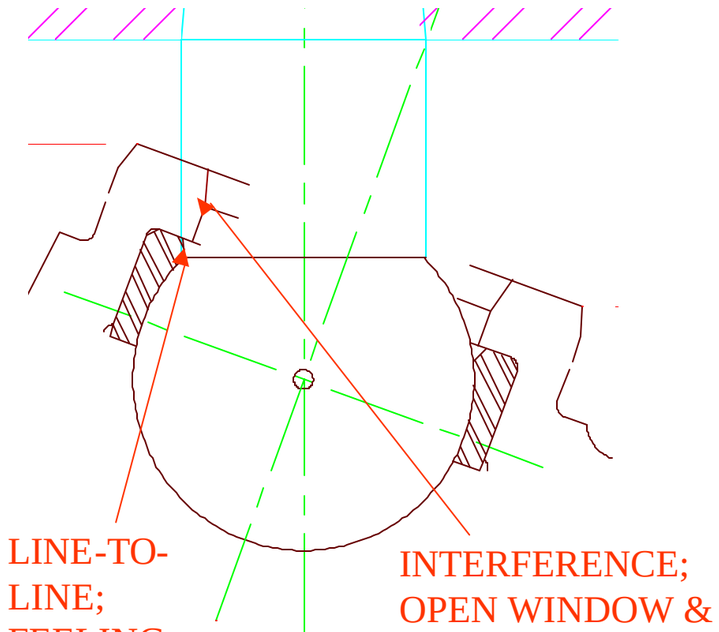
26MM

TO AVOID PINCHING THE SEAL, WE'LL USE A 26MM BALL

(BESIDES, IT'S CHEAPER)

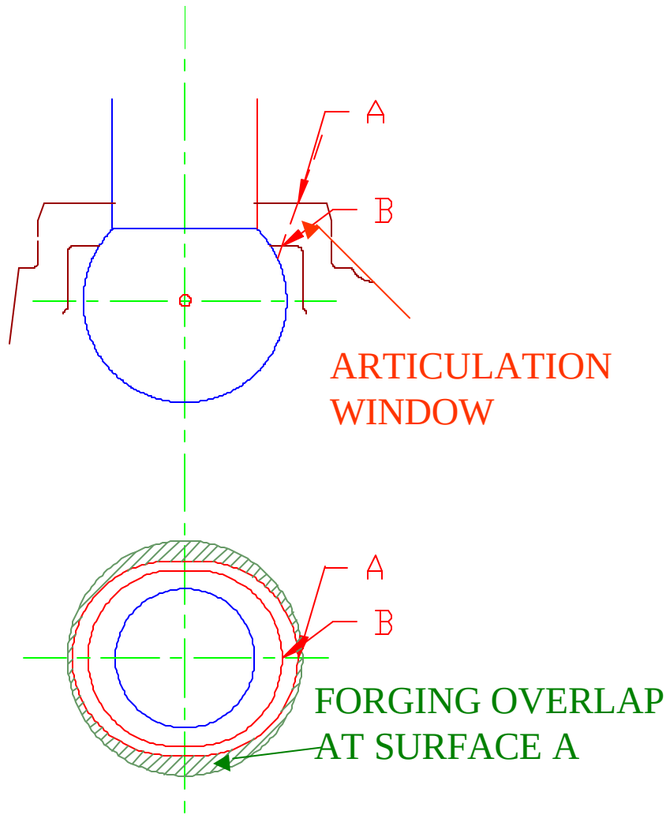
READDRESS ARTICULATION WITH 26MM BALL

- 2 ISSUES
  - SHANK-FORGING CRASH OPEN WINDOW
  - SHANK-BEARING LINE-TO-LINE @ 2 DEGREE OVERTRAVEL LOW RISK
- COULD UNDERCUT STUD - ADDED $$$



PULL OUT STRENGTH ANALYSIS

- STUD ARTICULATED 20 DEGREES DEFINES WINDOW SURFACE A-B
- FORGING OVERLAP = .199 SQ. IN
- PULL OUT FORCE = SIN(18DEG)*1.25*7000 LB =2704LB.
- RESISTING CROSS SECTION= .199 SQ. IN.
- PULL OUT STRESS = 2704 LB/.199 SQ IN = 13587 PSI
- MATERIAL YIELD >30000 PSI
- NO PROBLEM



ACCOMPLISHMENTS

- BALL STUD DESIGN - COMPLETE
- SEAL REQUIREMENTS - COMPLETE
- BEARING ARRANGEMENT - 50%
- HOUSING - 25%
- LUBRICATION - 0%

BEARINGS AND LUBRICATION

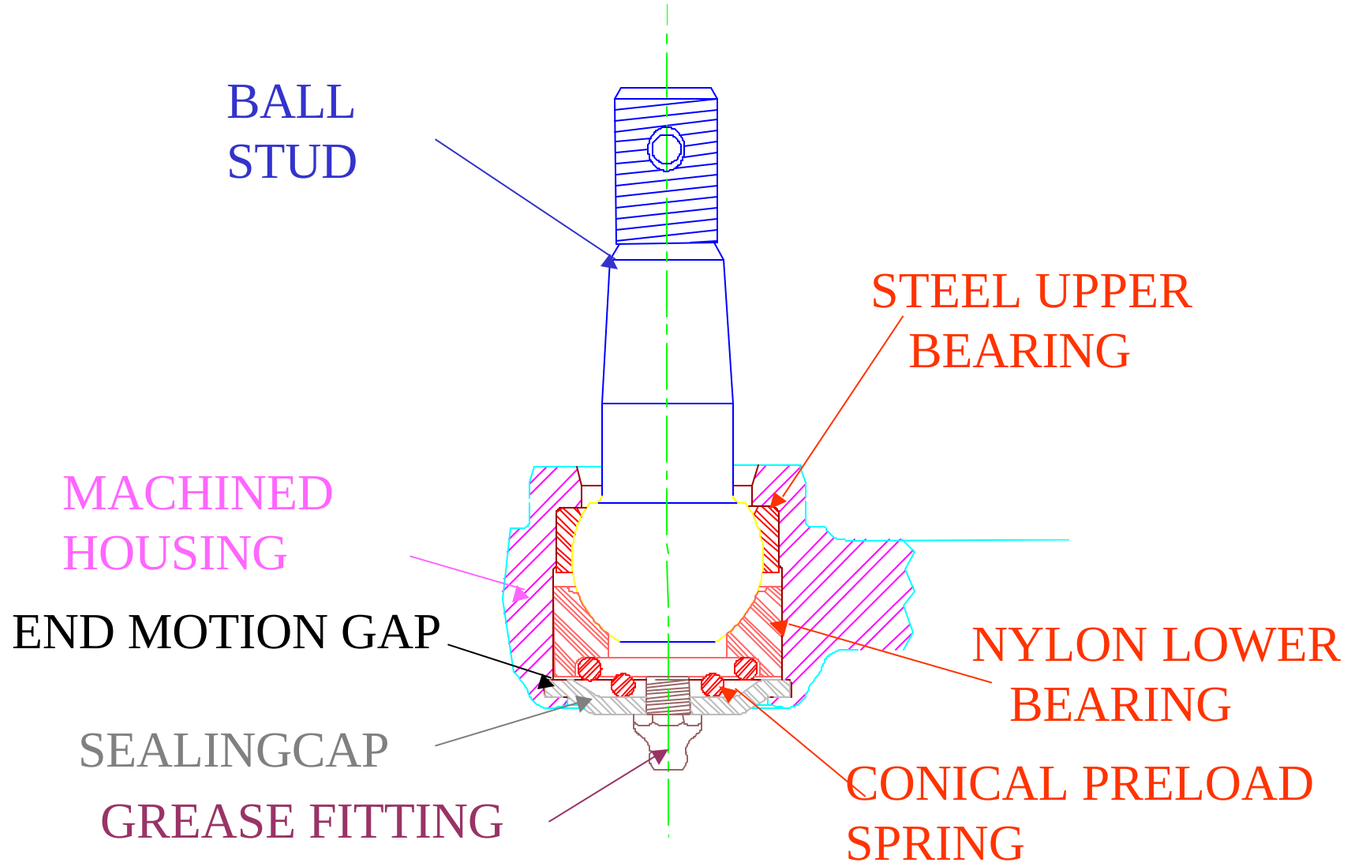
- WE CHOSE A HARDENED STEEL UPPER BEARING BECAUSE OF ROBUSTNESS. THE APPLICATION (COMMERCIAL FLEET) PLACES A HIGH PRIORITY ON DURABILITY AND IS WILLING TO SACRIFICE SOME ROTATING TORQUE
- WE NOW NEED TO CHOSE A LOWER BEARING

LOWER BEARING - STEEL OR PLASTIC?

- STEEL / POWDERED METAL
  - BETTER WEAR
  - LESS COMPLIANCE
- NYLON
  - NOISE ISOLATION
  - LESS EXPENSIVE
  - MORE COMPLIANCE
  - LESS MASS
  - LOWER FRICTION

NYLON IS CHOSEN

SOCKET PACKAGE



GREASE SELECTION

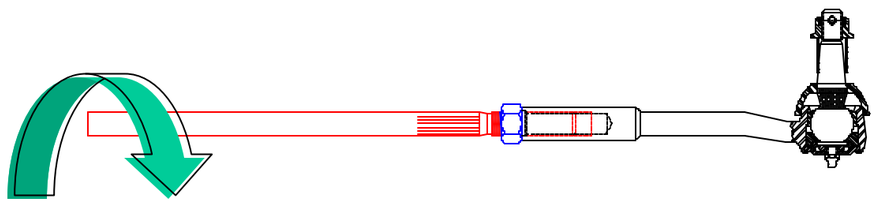
- LUBRICANT IS AN ESSENTIAL ELEMENT OF JOINT DESIGN
- GREASABLE VS. NON-GREASABLE
- TRIBOLOGY STUDIES
- COSTS

FINISHING THE MACHINED FORGING DESIGN

- **INTERNAL/ EXTERNAL THREADS**
- **STEM LENGTH**
- **STEM ANGLE**
- **MATING FASTENERS**
- **“COBRA” SECTION**
- **INPUT REQUIREMENTS**
  - **LOADS 7000 MAX, 4000 WORKING**
  - **STEM ANGLE 90 DEGREES @ CURB**
  - **PACKAGE REQUIREMENTS STRAIGHT, 150MM LONG**
  - **APPEARANCE PROTECTION 240 HR SALT SPRAY**
  - **MATING PARTS DETAIL**
    - **ROD / SLEEVE THREAD SIZE & LENGTH M16X1.5**

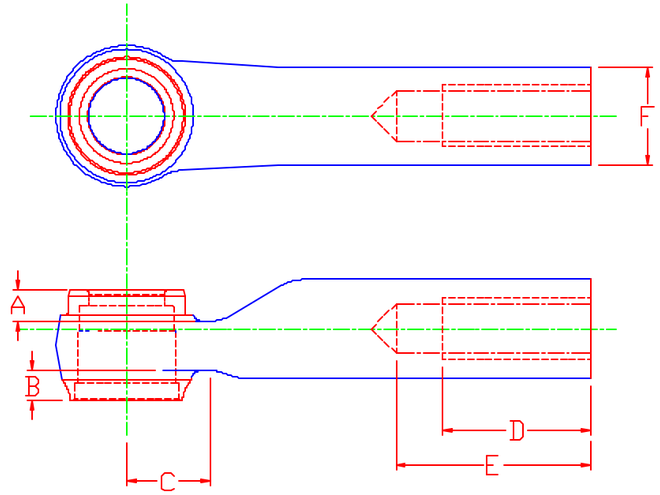
LENGTH ADJUSTMENT FOR TOE SET

- RACK AND PINION
  JAM NUT
- INNER END
  ROTATES
- 1.5MM/REV



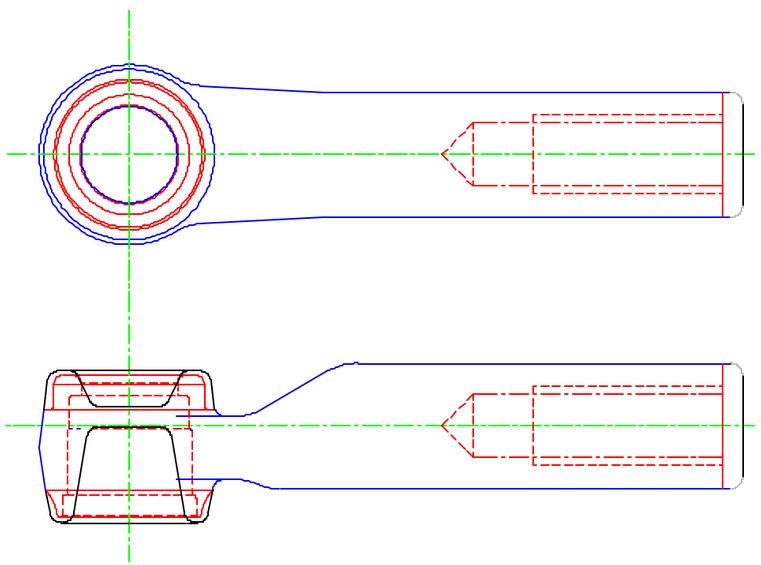
DETAILING THE MACHINED FORGING

- STEM ANGLE & LENGTH ARE GIVEN
- COBRA THICKNESS & LENGTH DEFINED BY “A”, “B” AND “C” TOOL RADIUS
- D=2.5*THD SIZE +TOE ADJUST
- E FOR PILOT HOLE + THREAD RUN OUT
- F= WASHER FACE OF MATING JAM NUT



FORGING DESIGN - ADDING WHAT WE WILL MACHINE AWAY

- FORGING TOLERANCES +/- .75MM
- DRAFT ANGLES
  - **7-9 DEGREES**
- DIE SHIFT .75MM
- ANGULAR +/- 2 DEGREES
- E-COAT BEFORE MACHINING

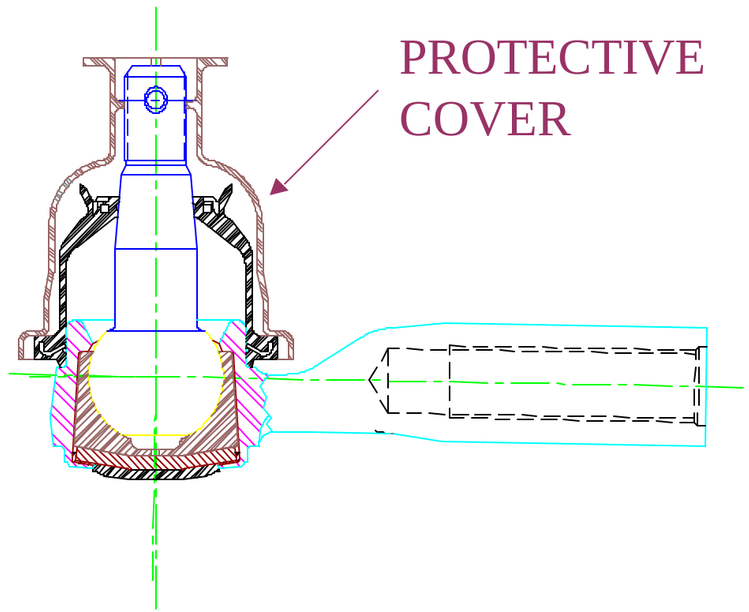


QUOTATION CHECKLIST

- FORGING
  - DRAWING COMPLETE RFQ ISSUED
- BALL STUD
  - DRAWING COMPLETE RFQ ISSUED
- SEAL
  - DRAWING COMPLETE RFQ ISSUED
- BEARINGS
  - DRAWING COMPLETE RFQ ISSUED
- MACHINING / ASSEMBLY
  - TIME STUDIES COMPLETE
- PACKAGING
  - 2000 PIECE BULK - NEED PROTECTIVE COVER

PACKAGING

- PROTECTIVE COVER
  - MUST NOT FALL OFF IN TRANSIT
  - MUST COME OFF EASILY AT ASSY PLANT
- COST OF EXPENDABLE SHIPPING CONTAINER



CONGRATULATE YOURSELF

- DESIGN IS DONE
- PART IS QUOTED
- READY TO START PROTOTYPES