Anatomy of a Shredder

ISRI Operations Forum

Webinar

October 3, 2023

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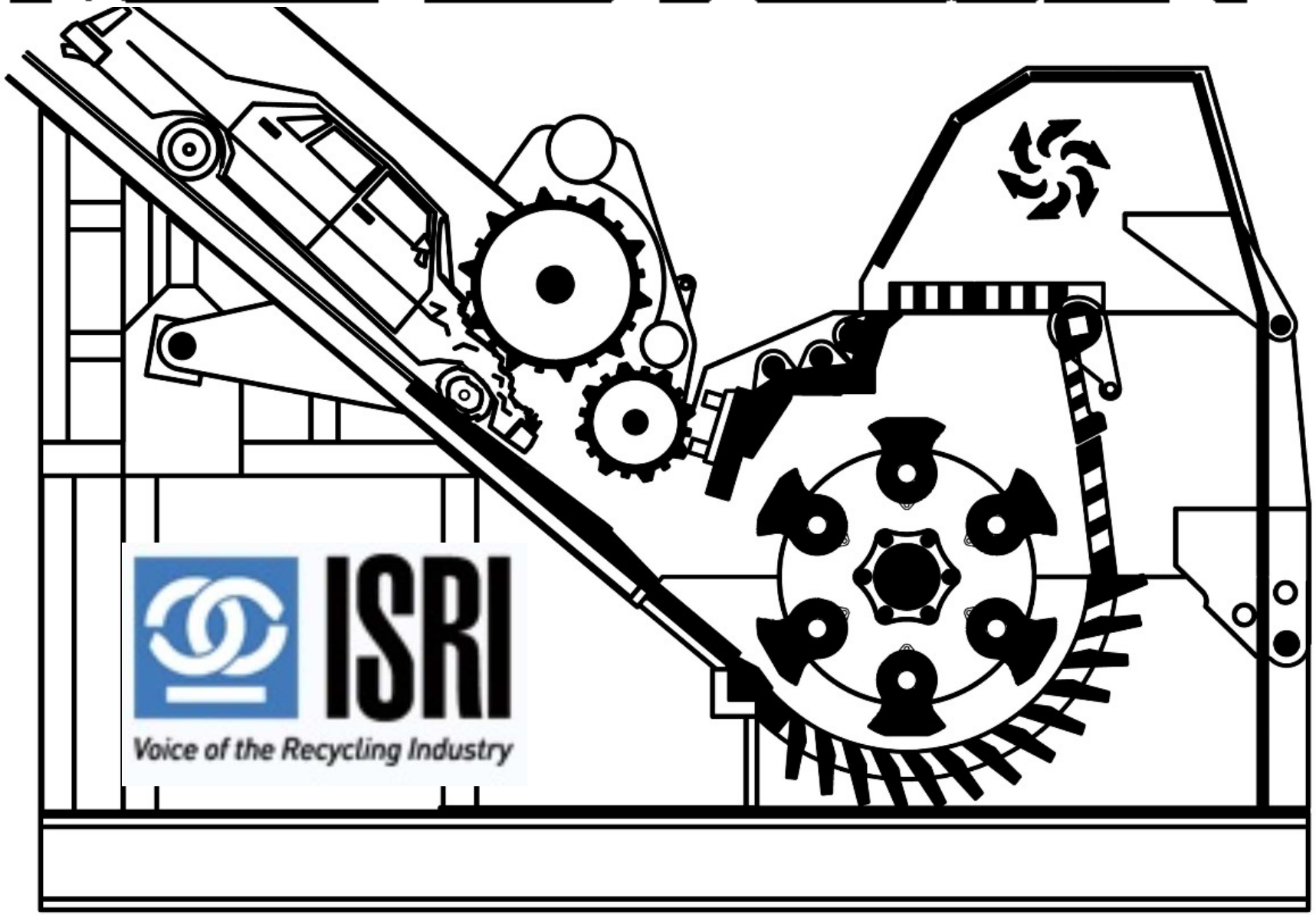
Riverside Engineering

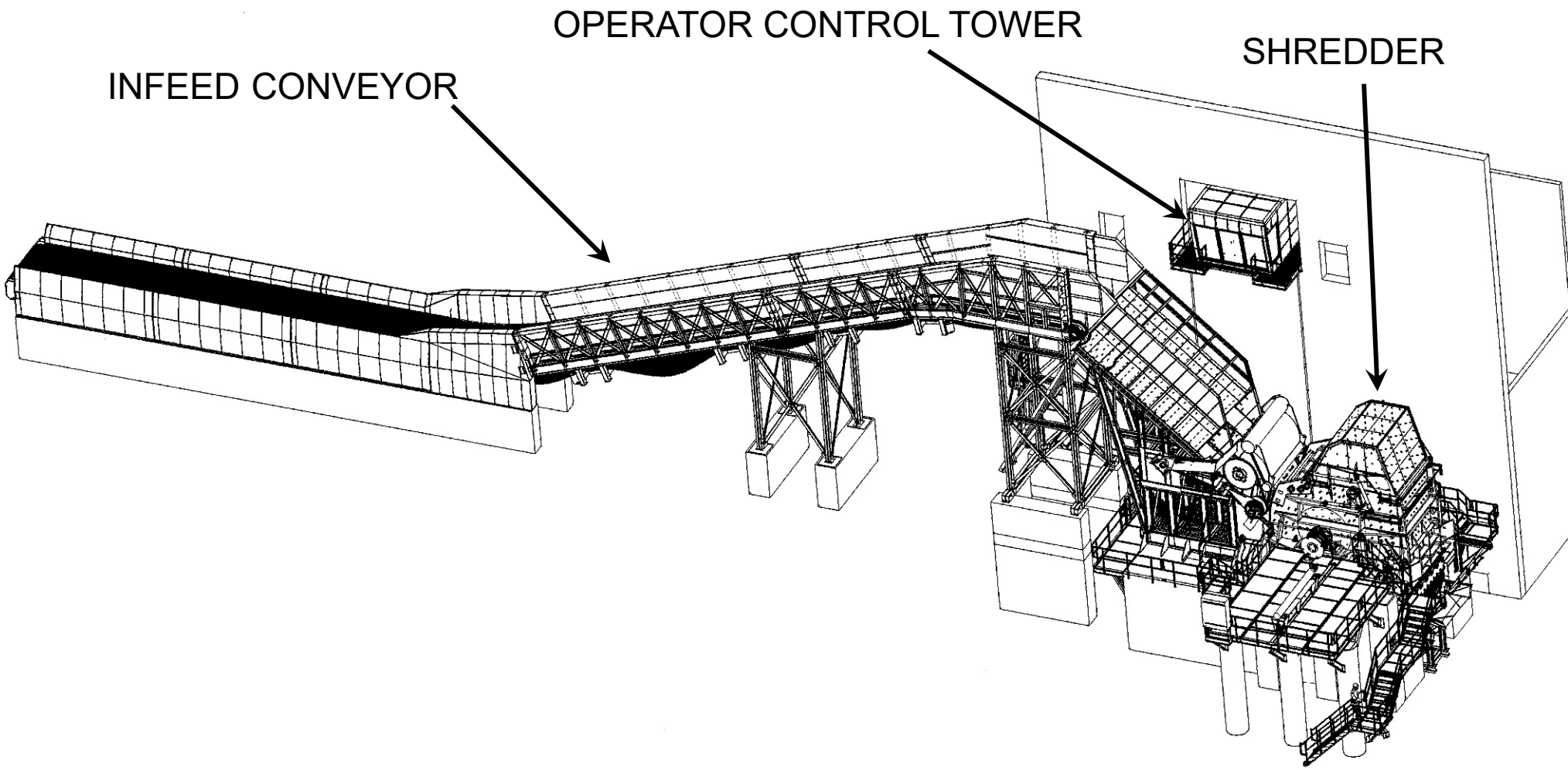
Presentation Outline

- Shredder Terminology
- Rotor Types
- Rotor Bearing Mounting Options
- Shredder Sizing and Performance
- Shredder Improvements
- Bolt Torque Table

MegaShredder®



Terminology



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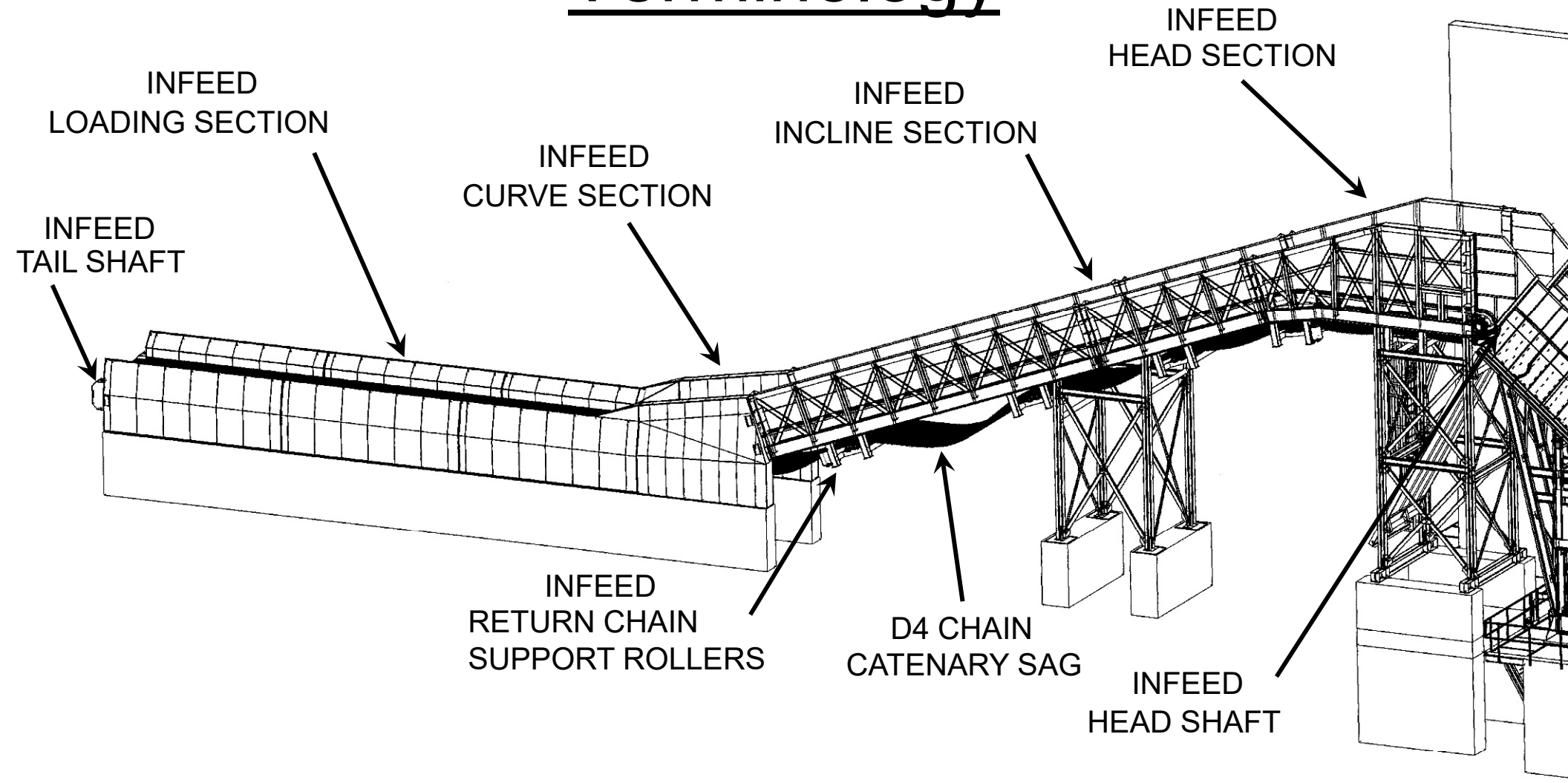

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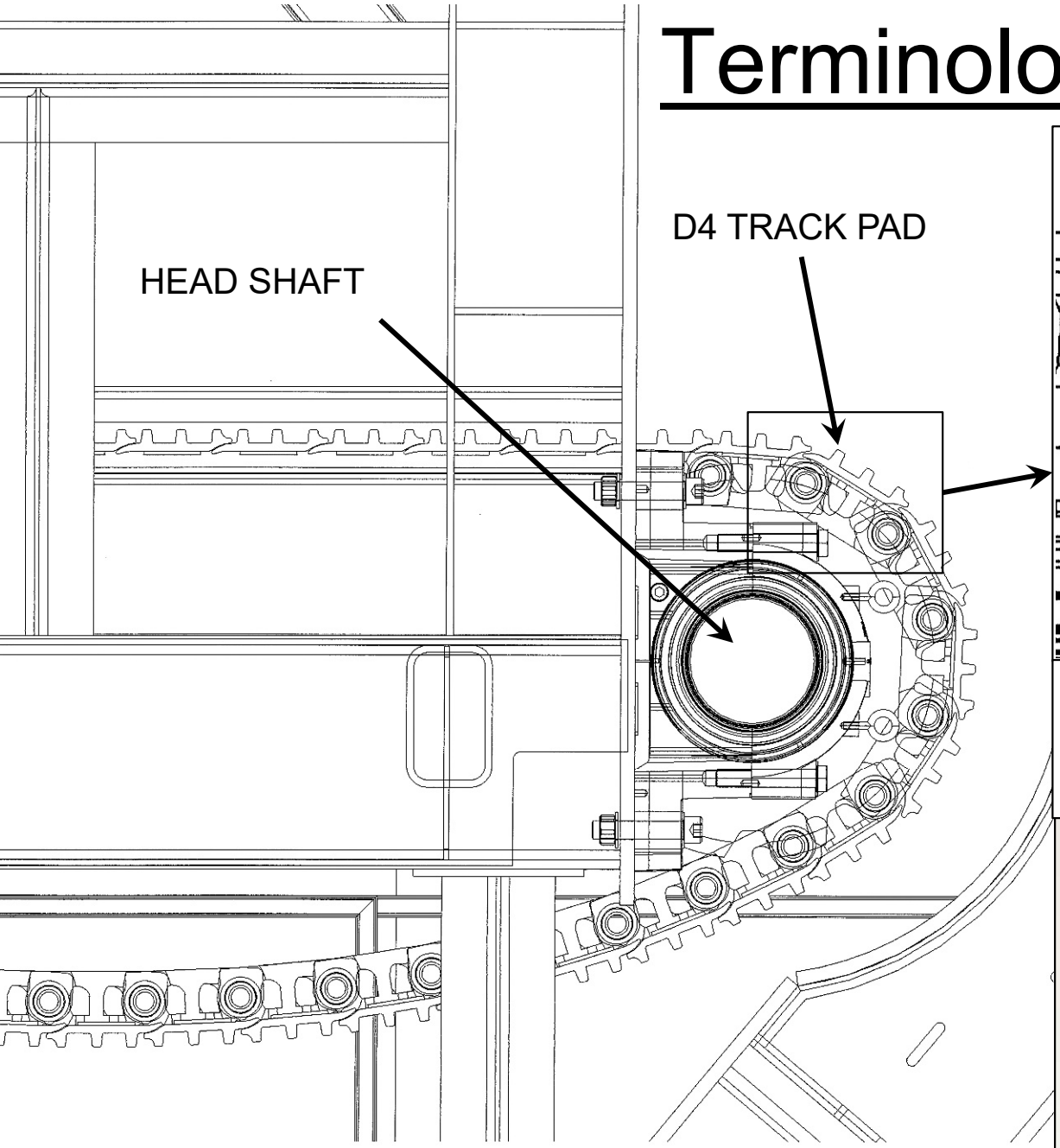
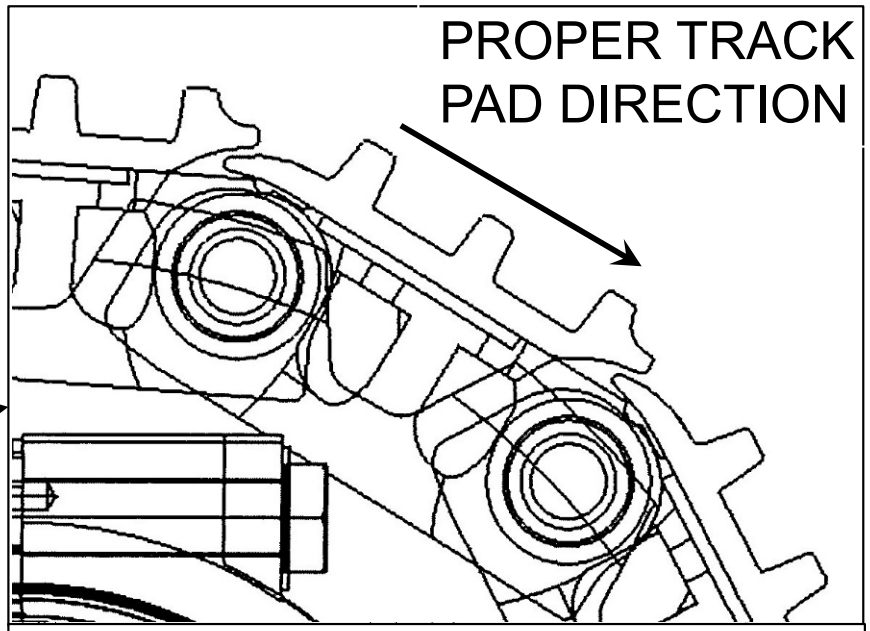
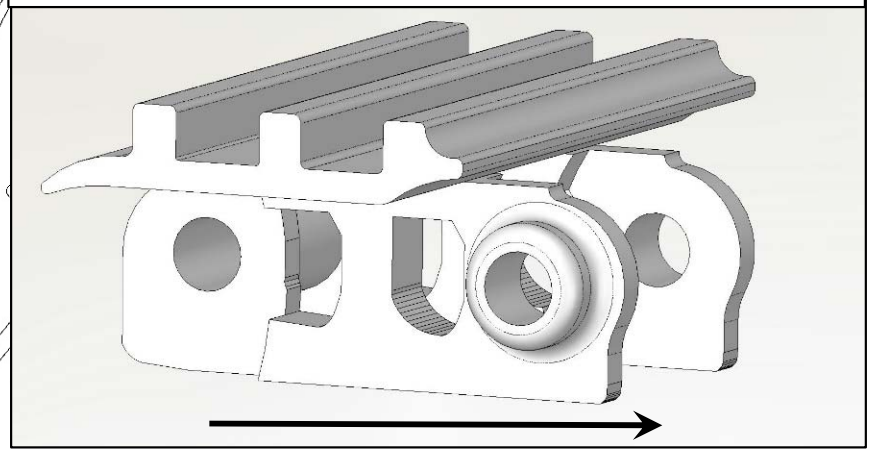
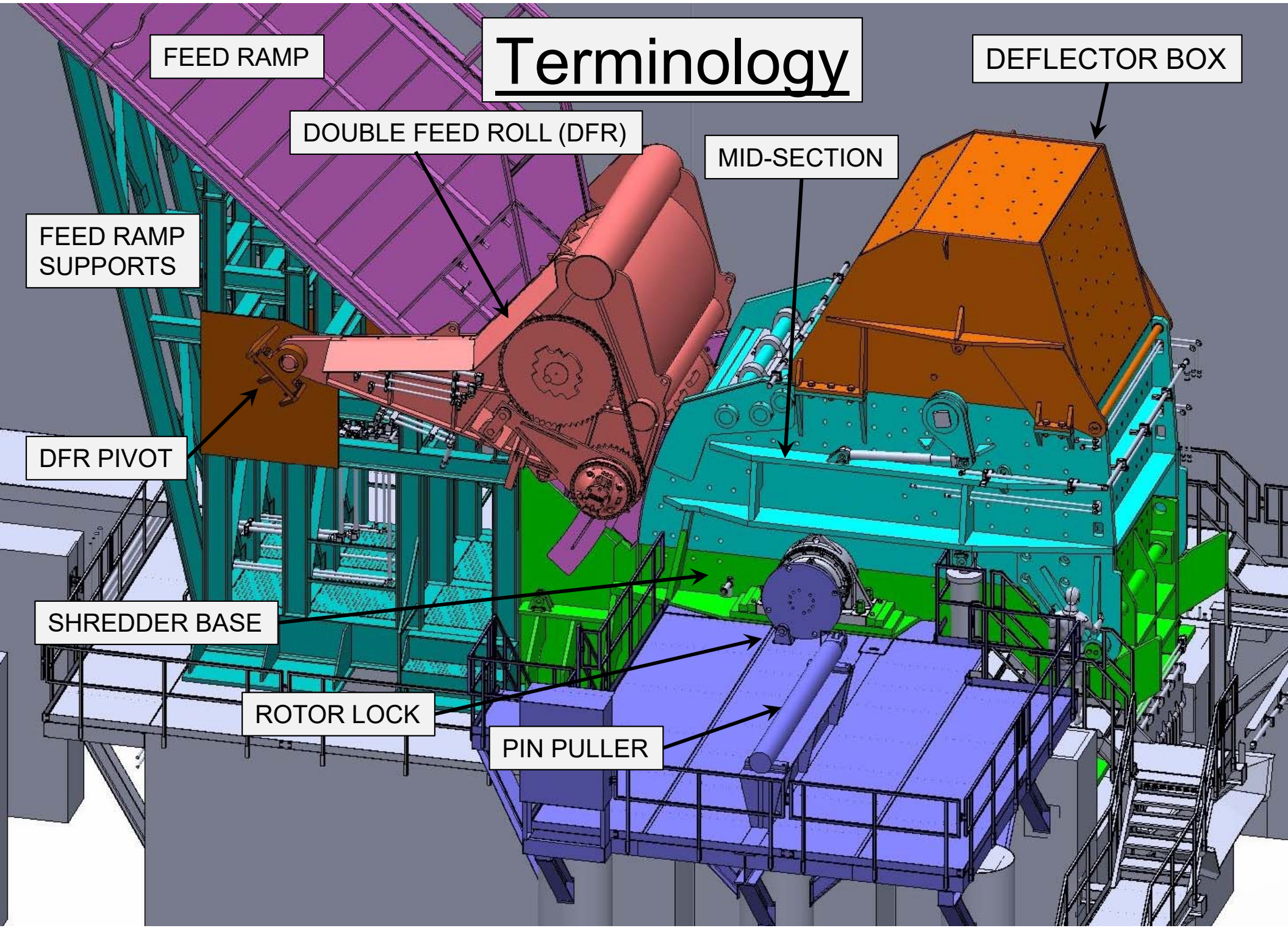


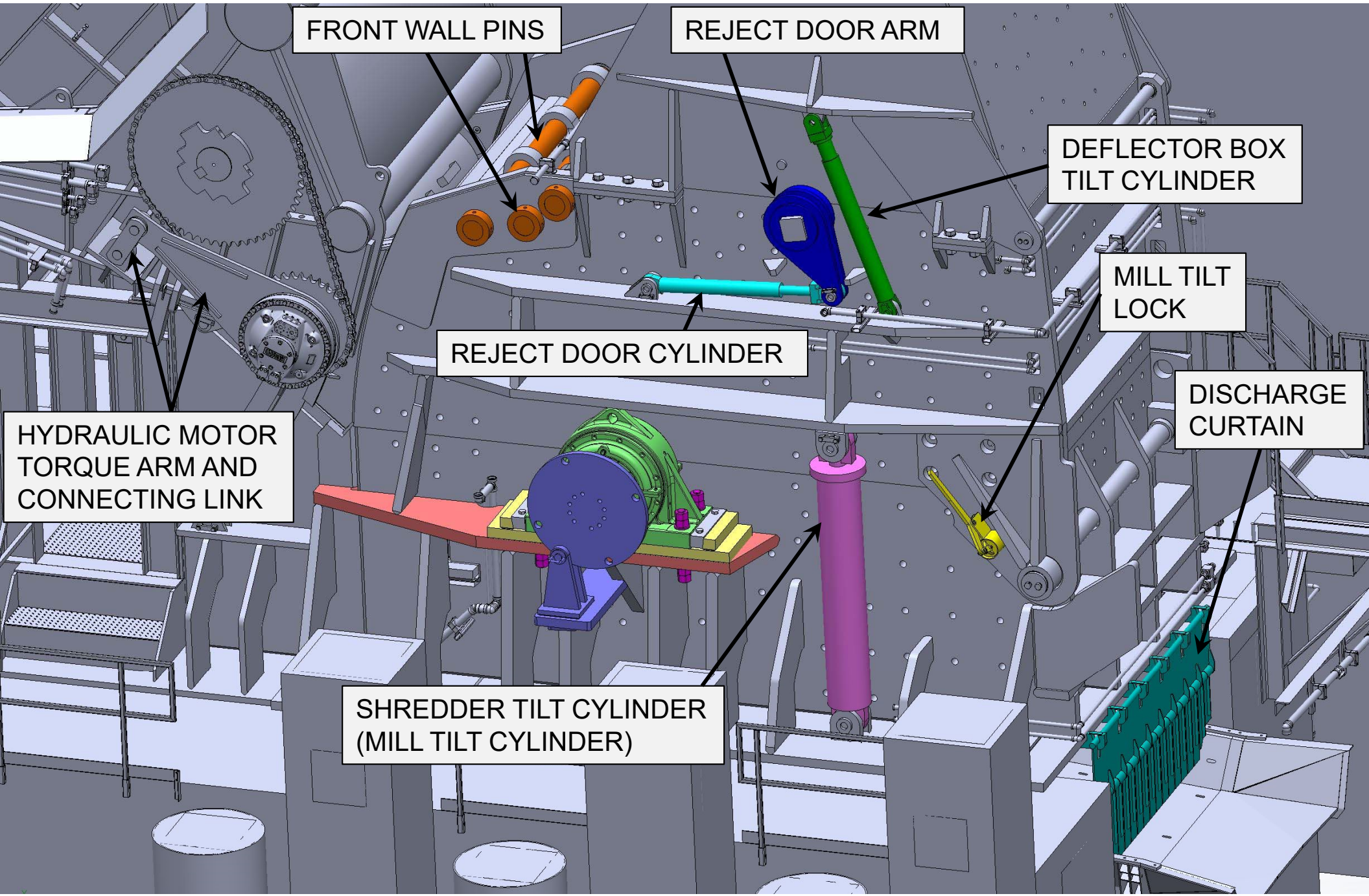


PROPER D4 CHAIN DIRECTION
IS WIDE END FORWARD
(REDUCES SPROCKET WEAR)




Terminology
FEED RAMP
DOUBLE FEED ROLL (DFR)
MID-SECTION
DEFLECTOR BOX
FEED RAMP SUPPORTS
DFR PIVOT
SHREDDER BASE
ROTOR LOCK
PIN PULLER

Terminology



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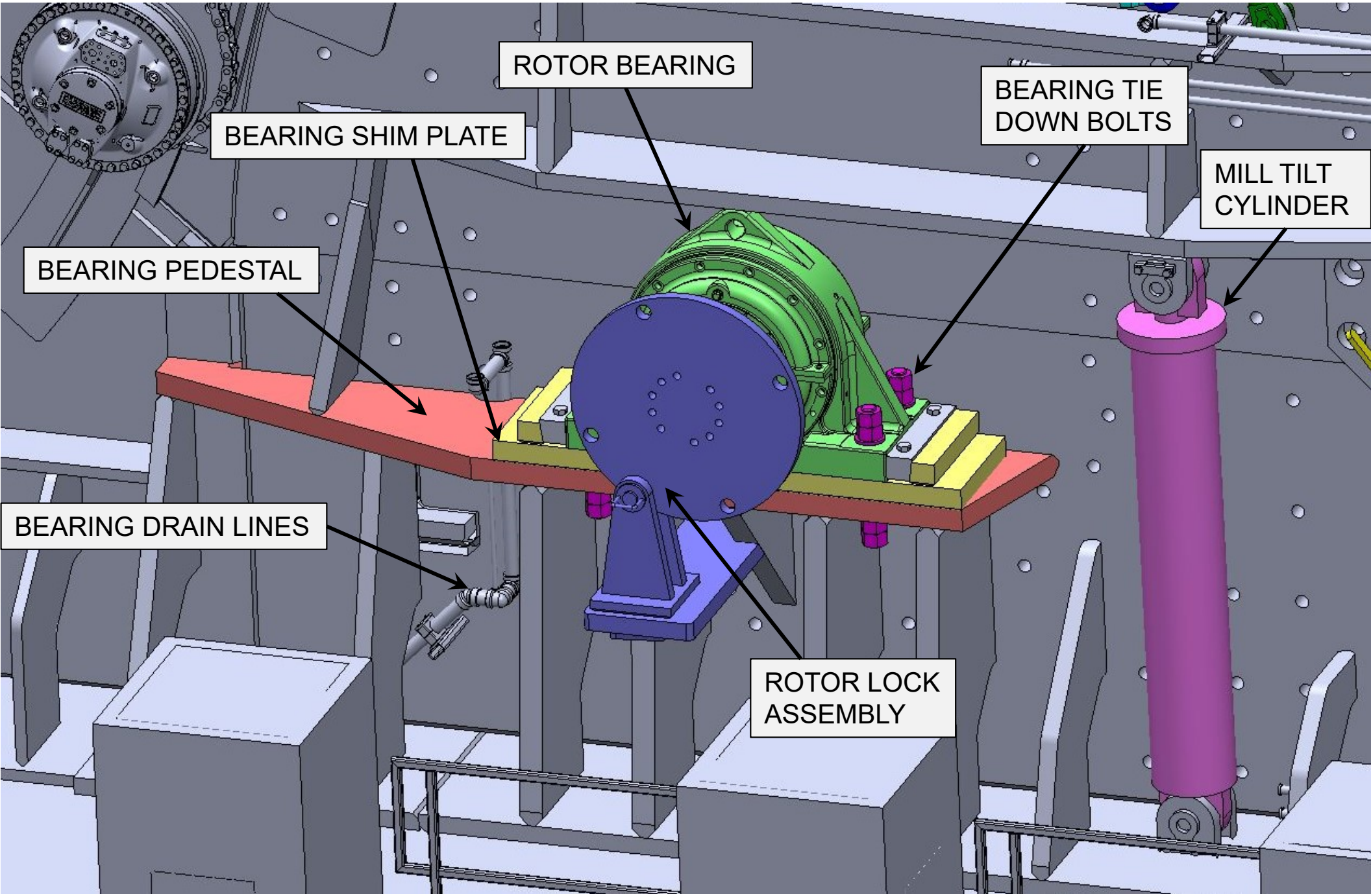

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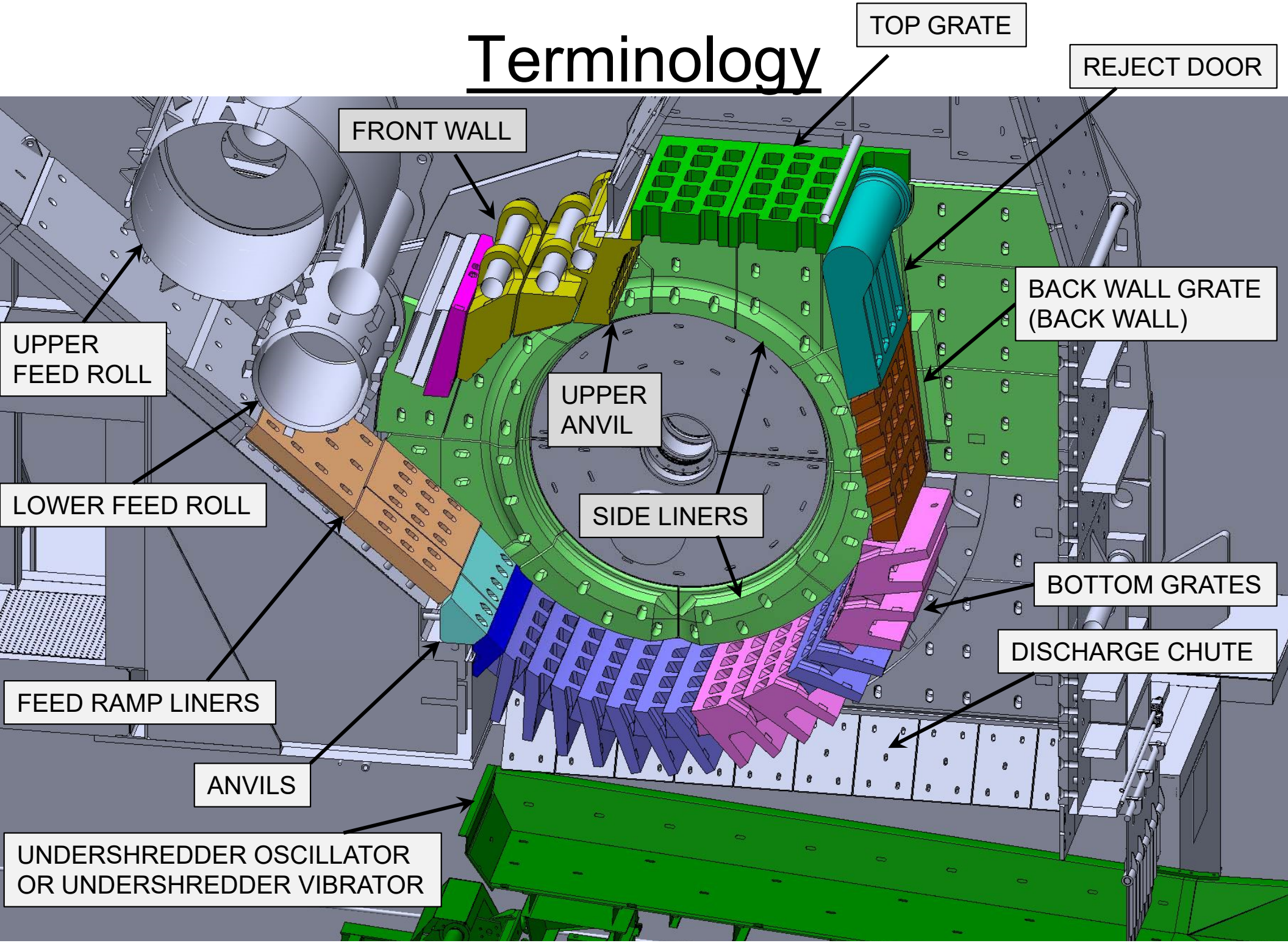

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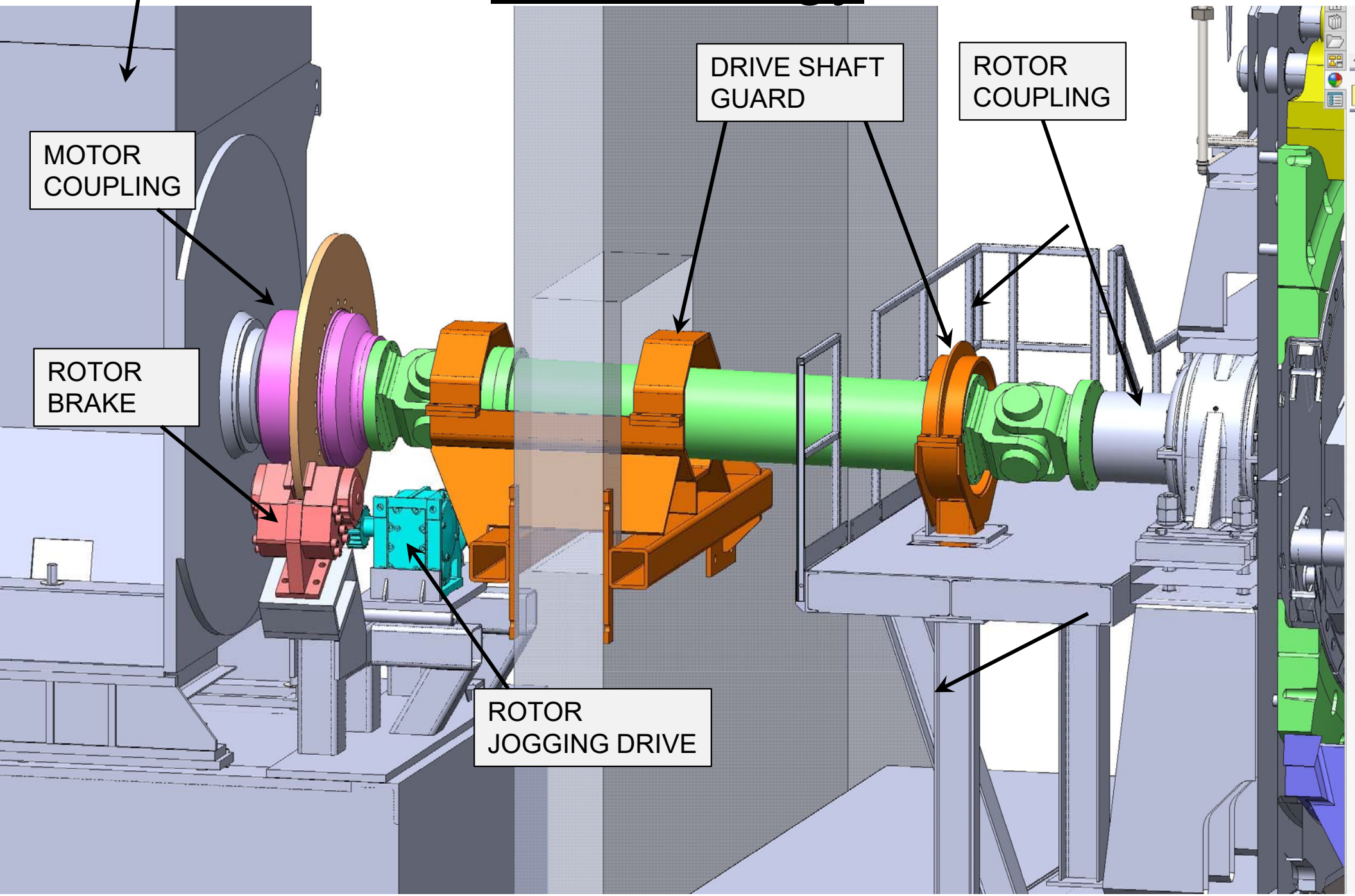
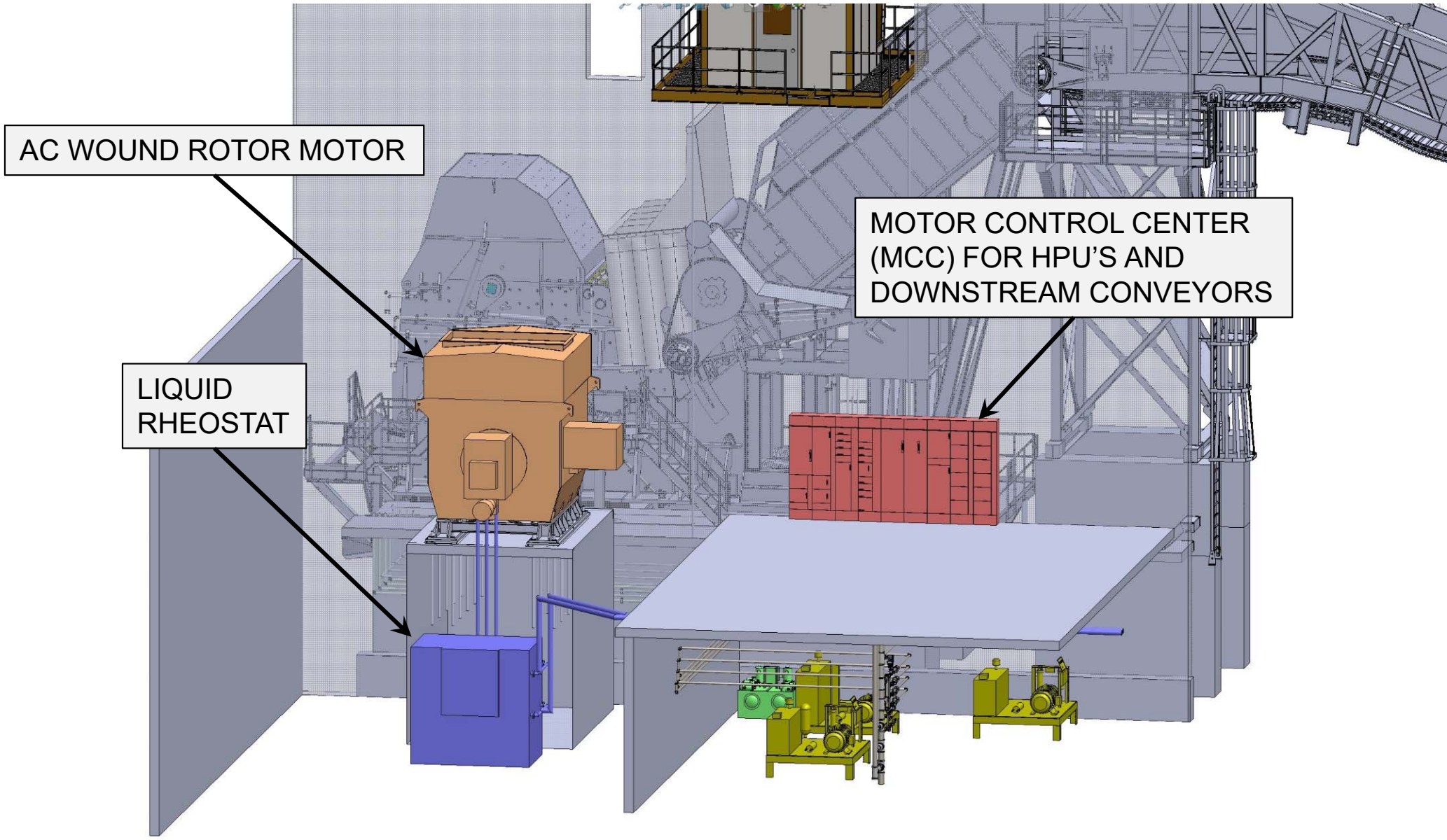
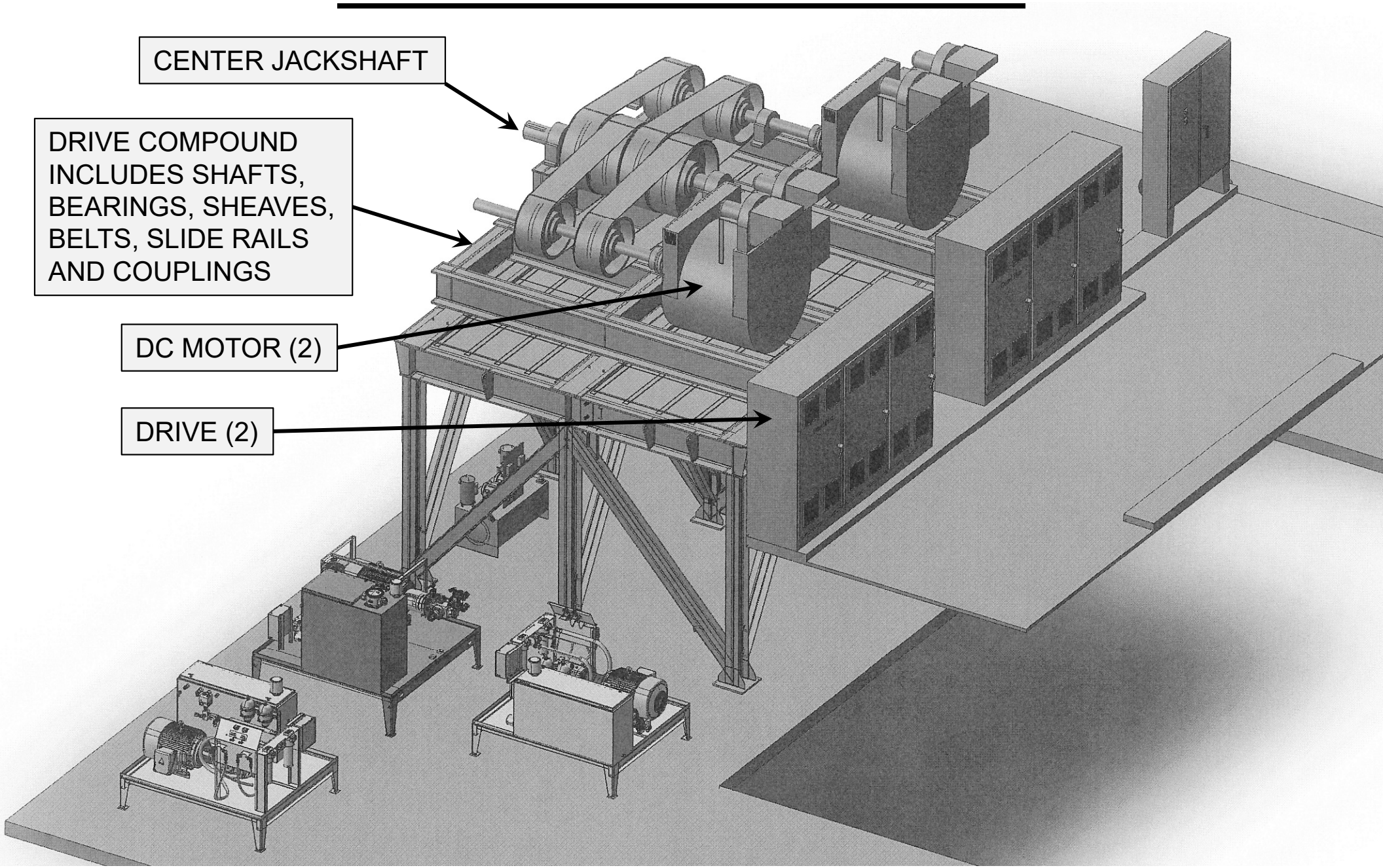


Wound Rotor AC Motor with Liquid Rheostat



Tandem DC Motors w/ Belts and Jackshaft



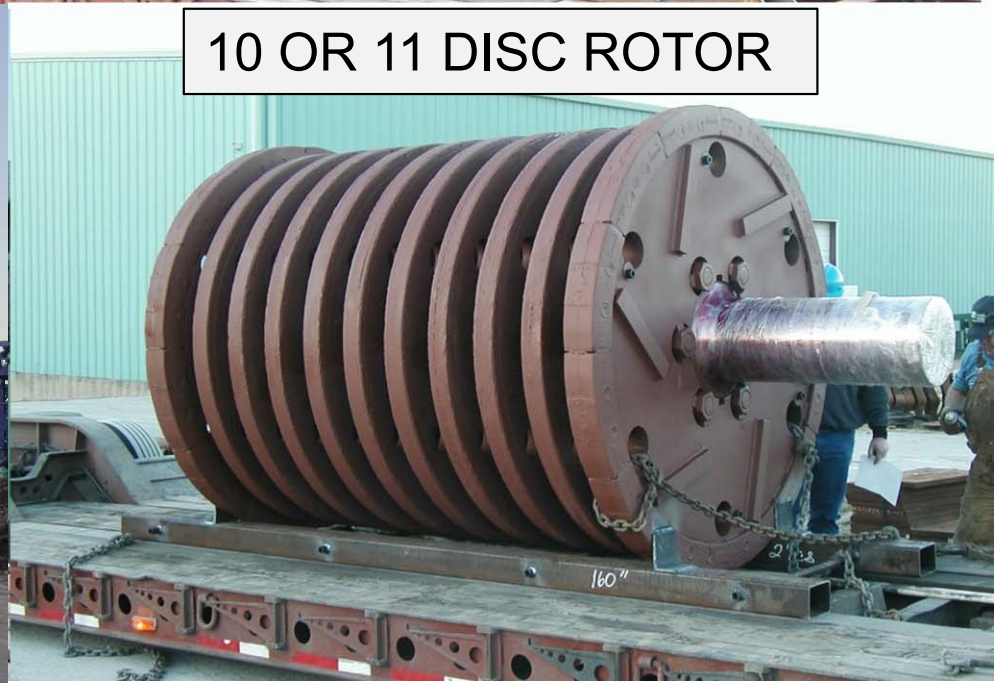
Rotor Types

4 ARM SPIDER ROTOR

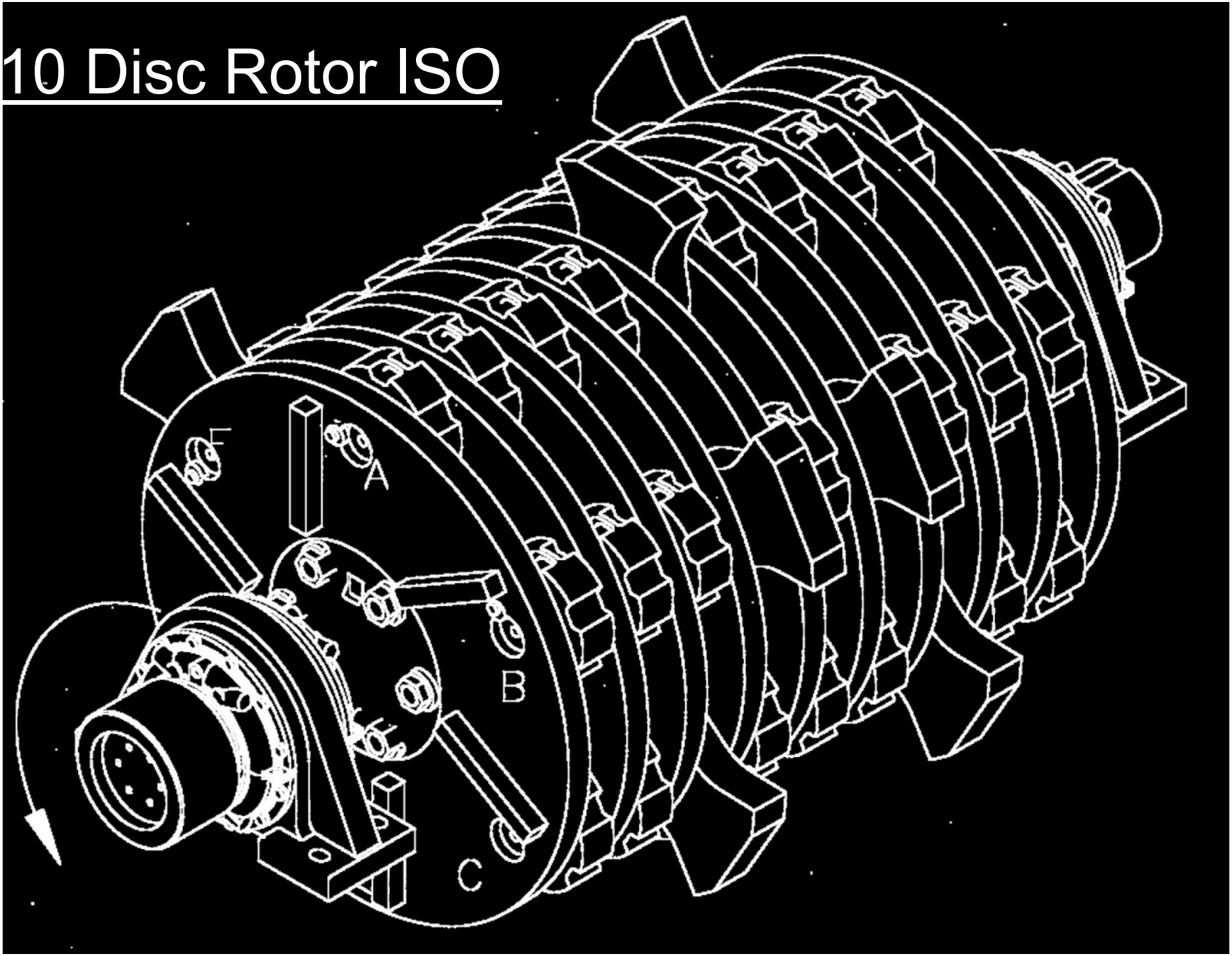
6 ARM SPIDER ROTOR

BARREL ROTOR

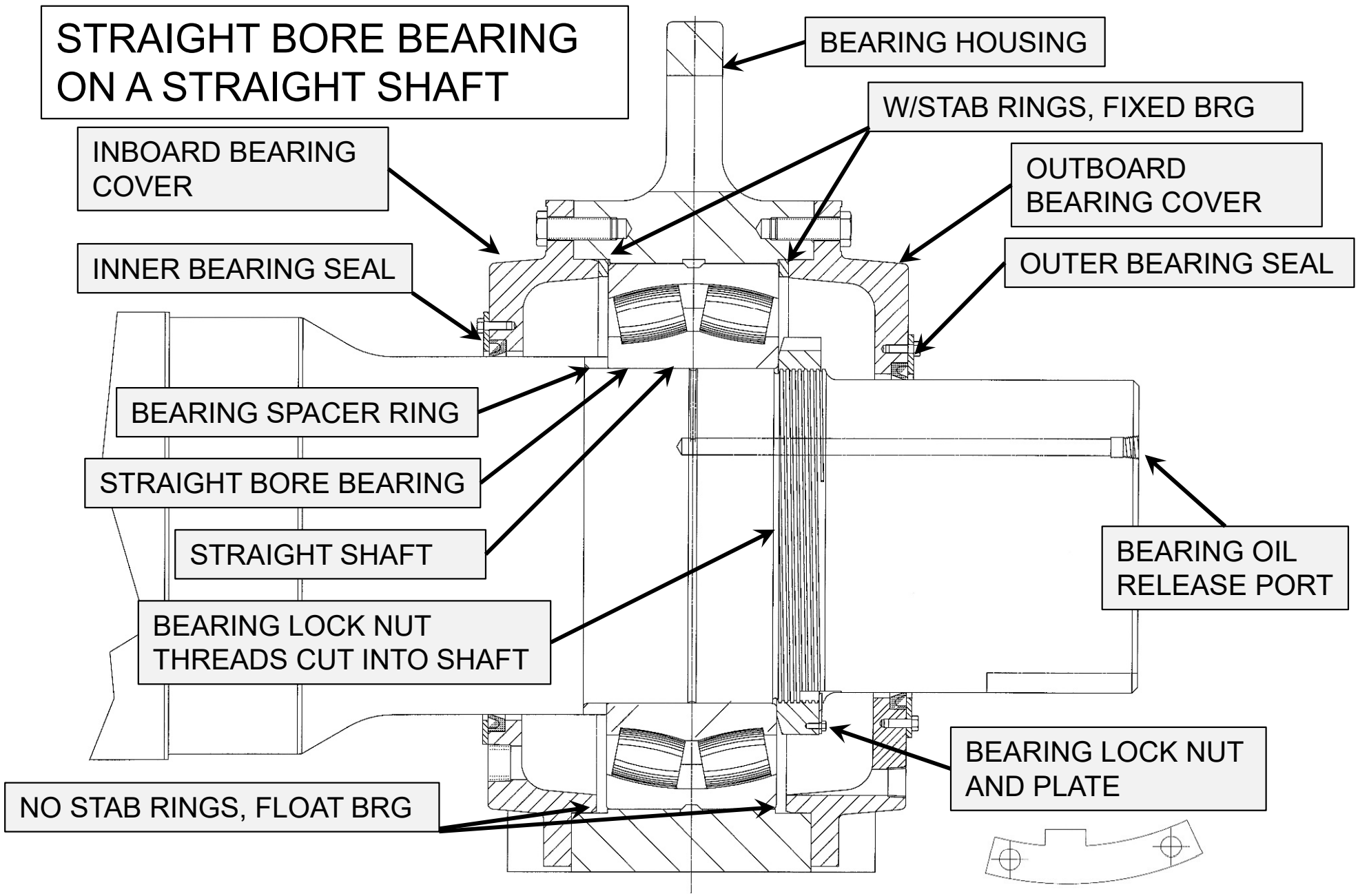
10 OR 11 DISC ROTOR



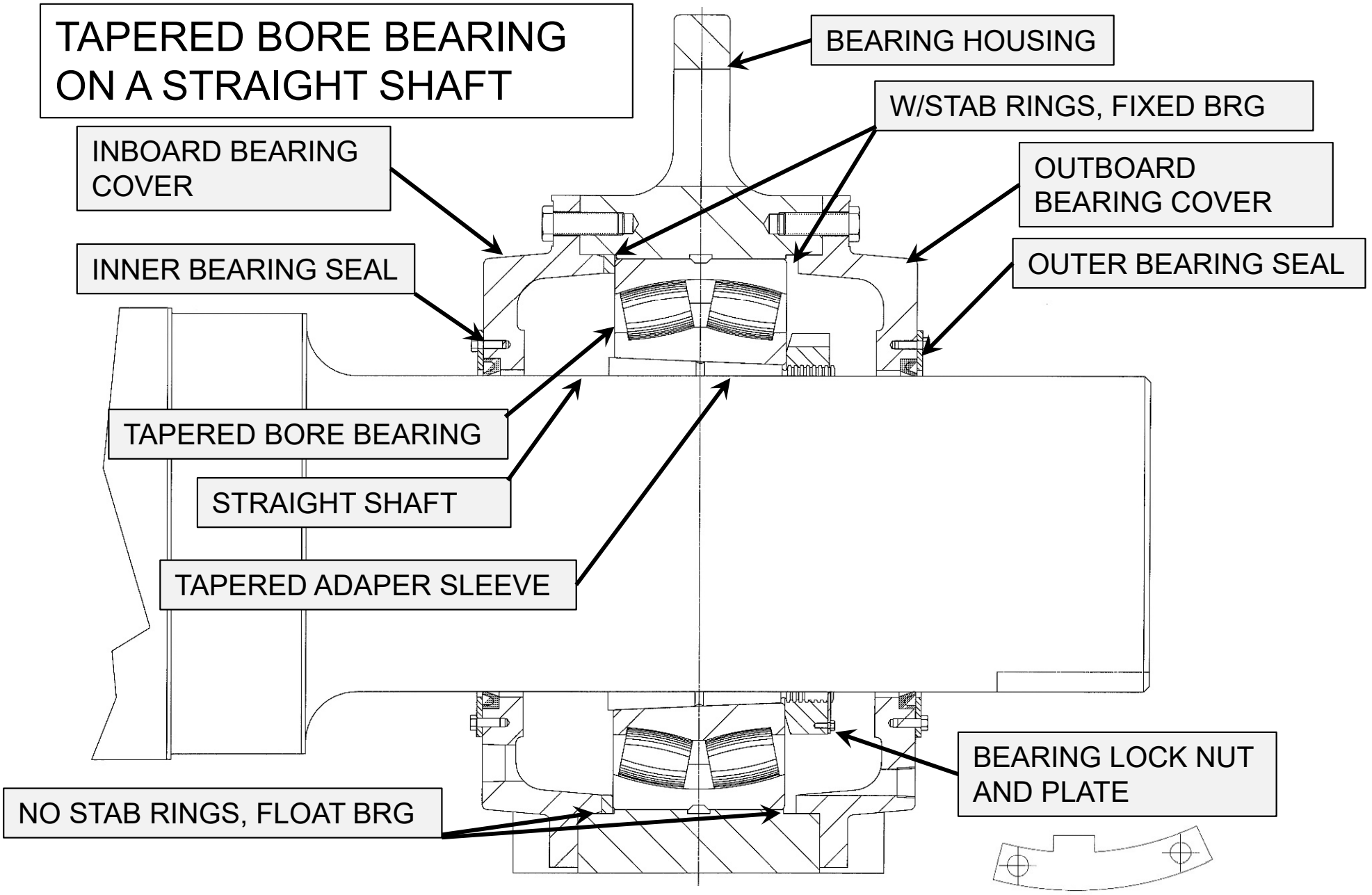
10 Disc Rotor ISO



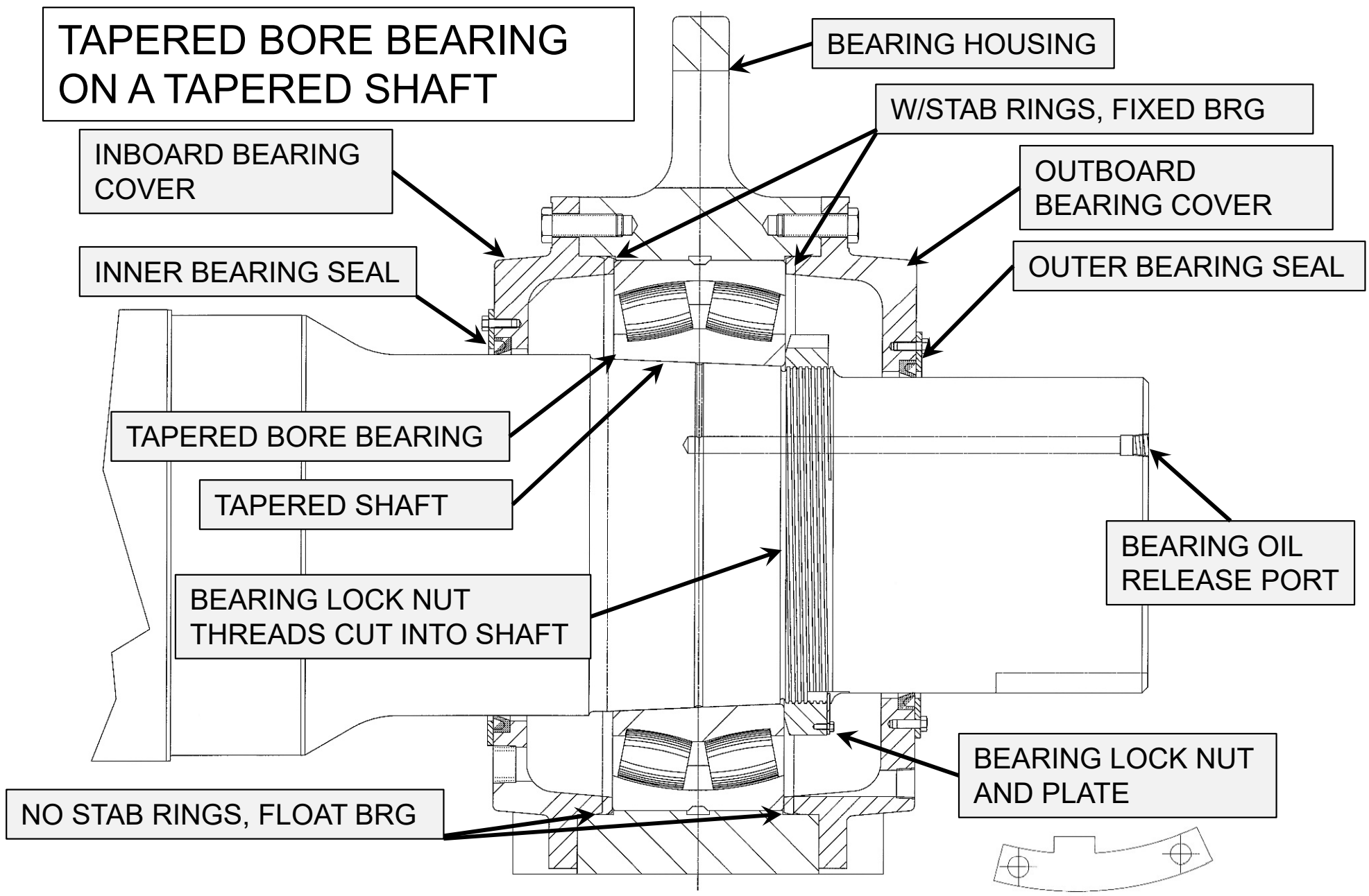
Rotor Bearing Mounting Options



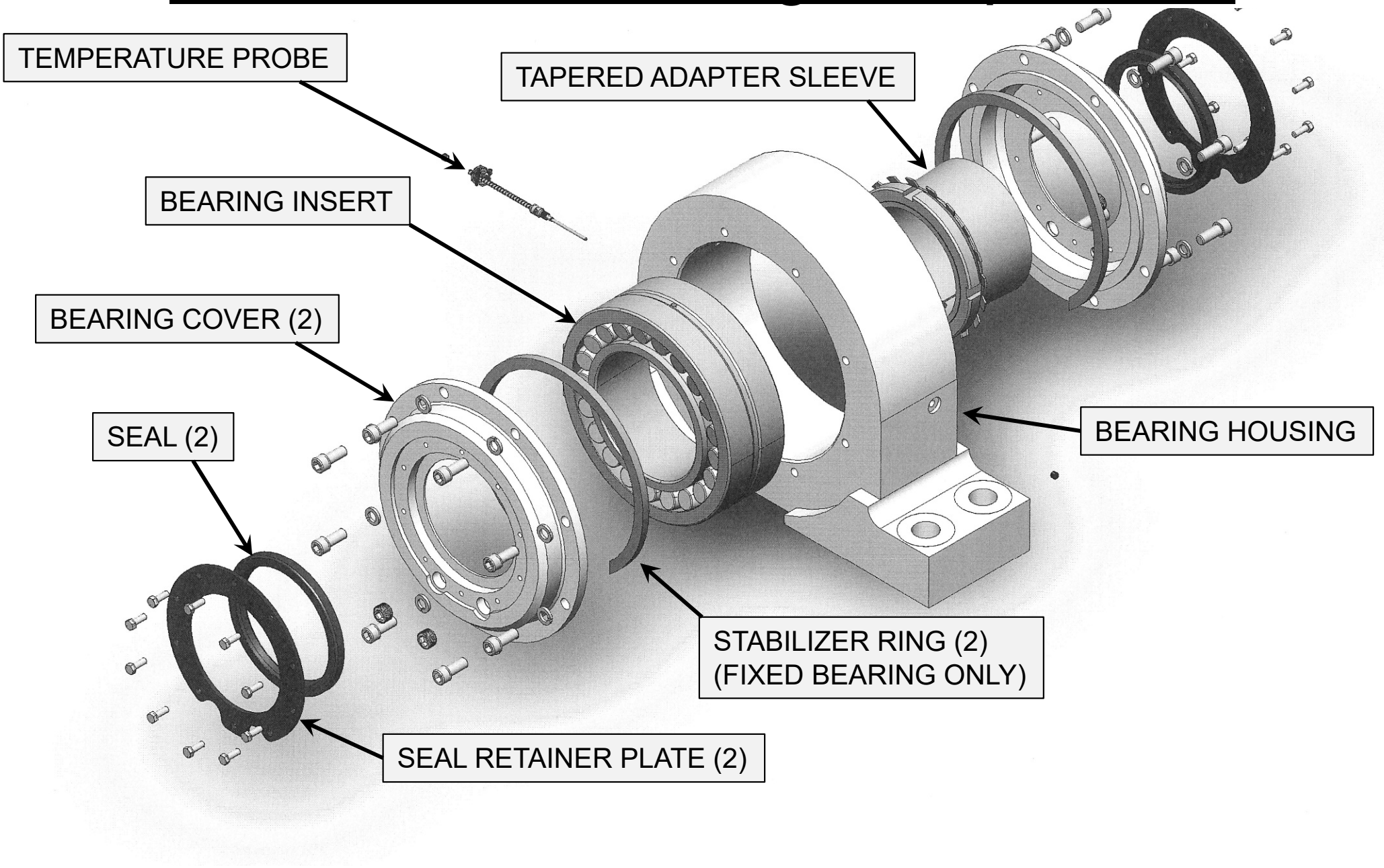
Rotor Bearing Mounting Options



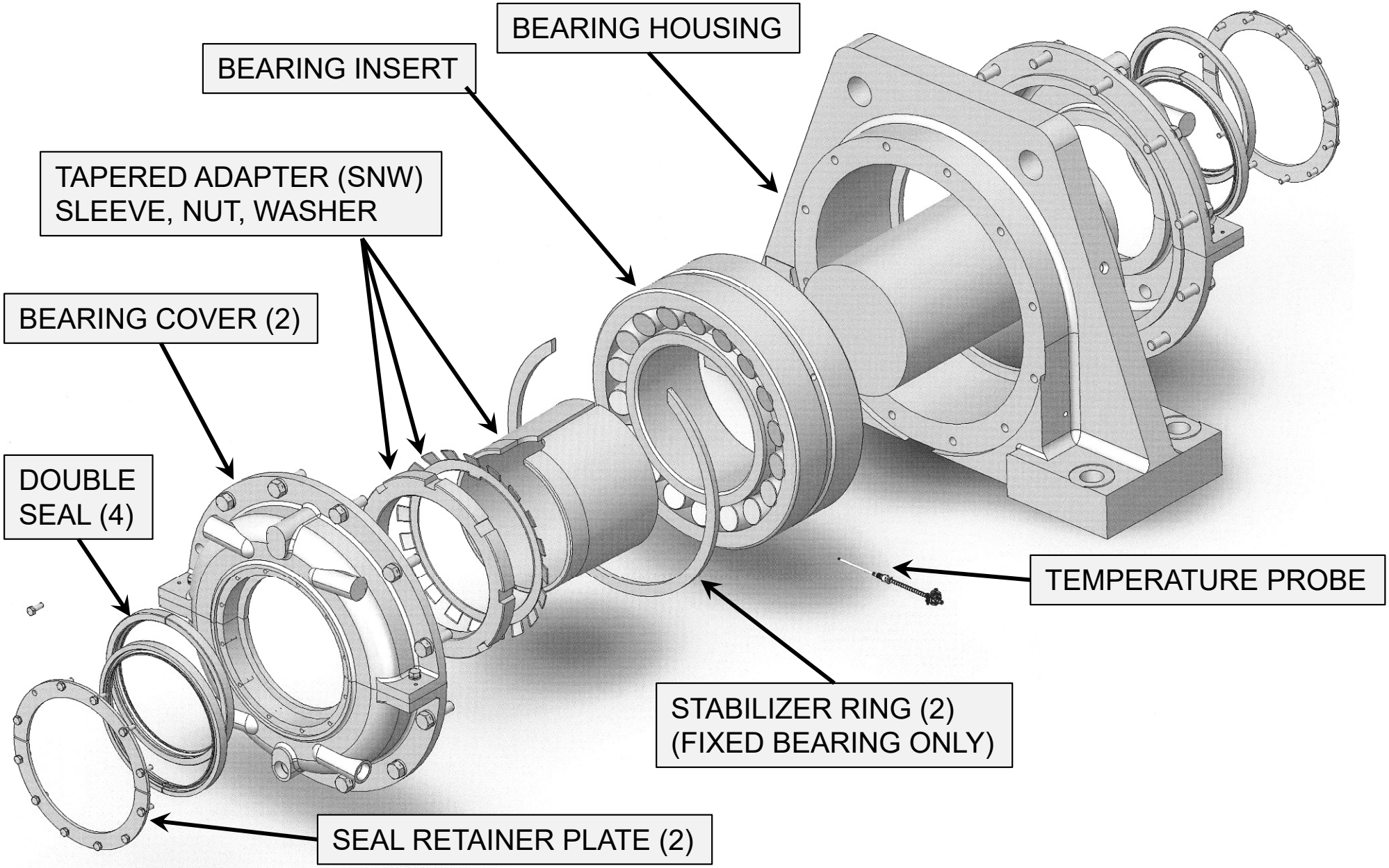
Rotor Bearing Mounting Options



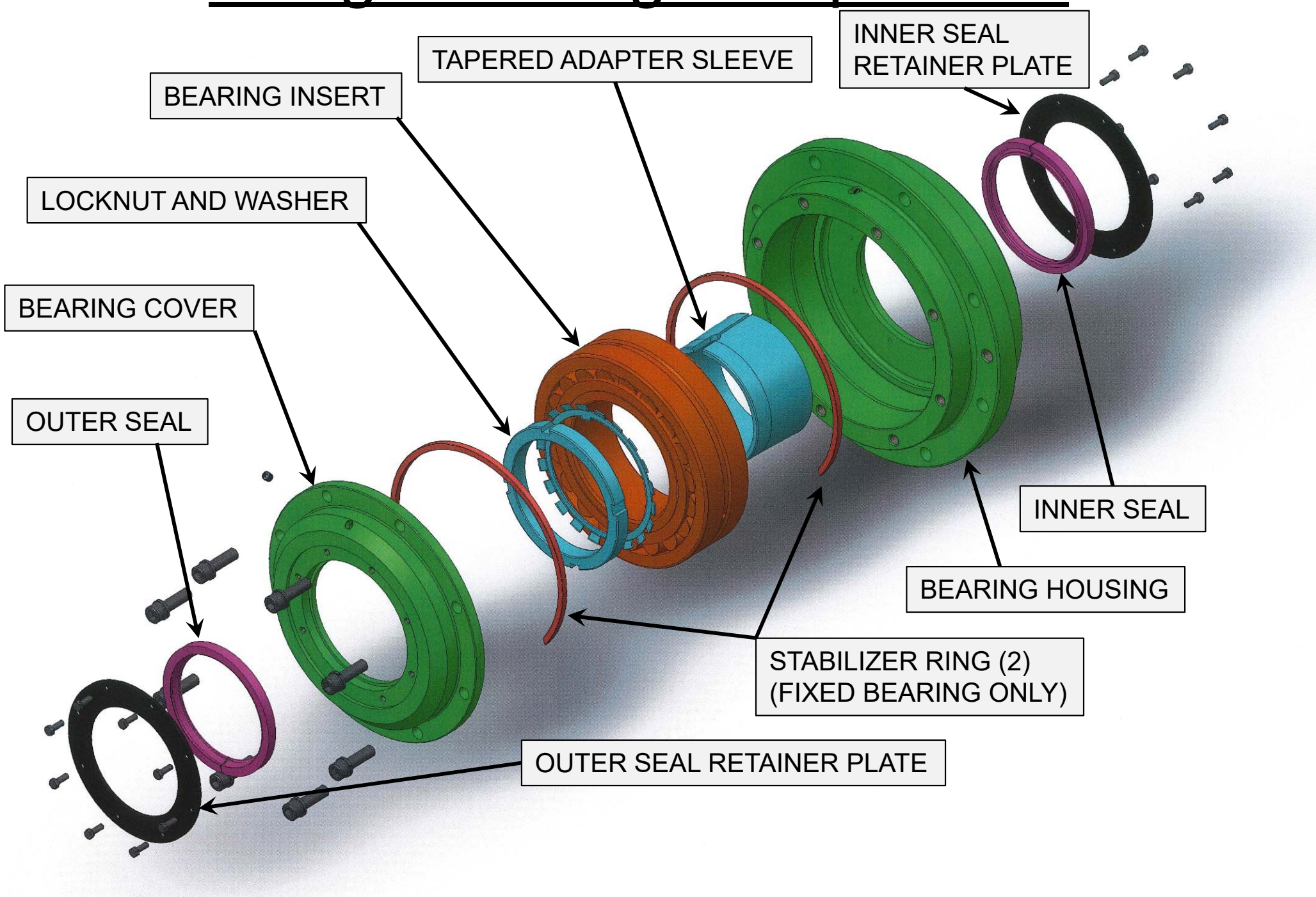
Pillow Block Bearing Components



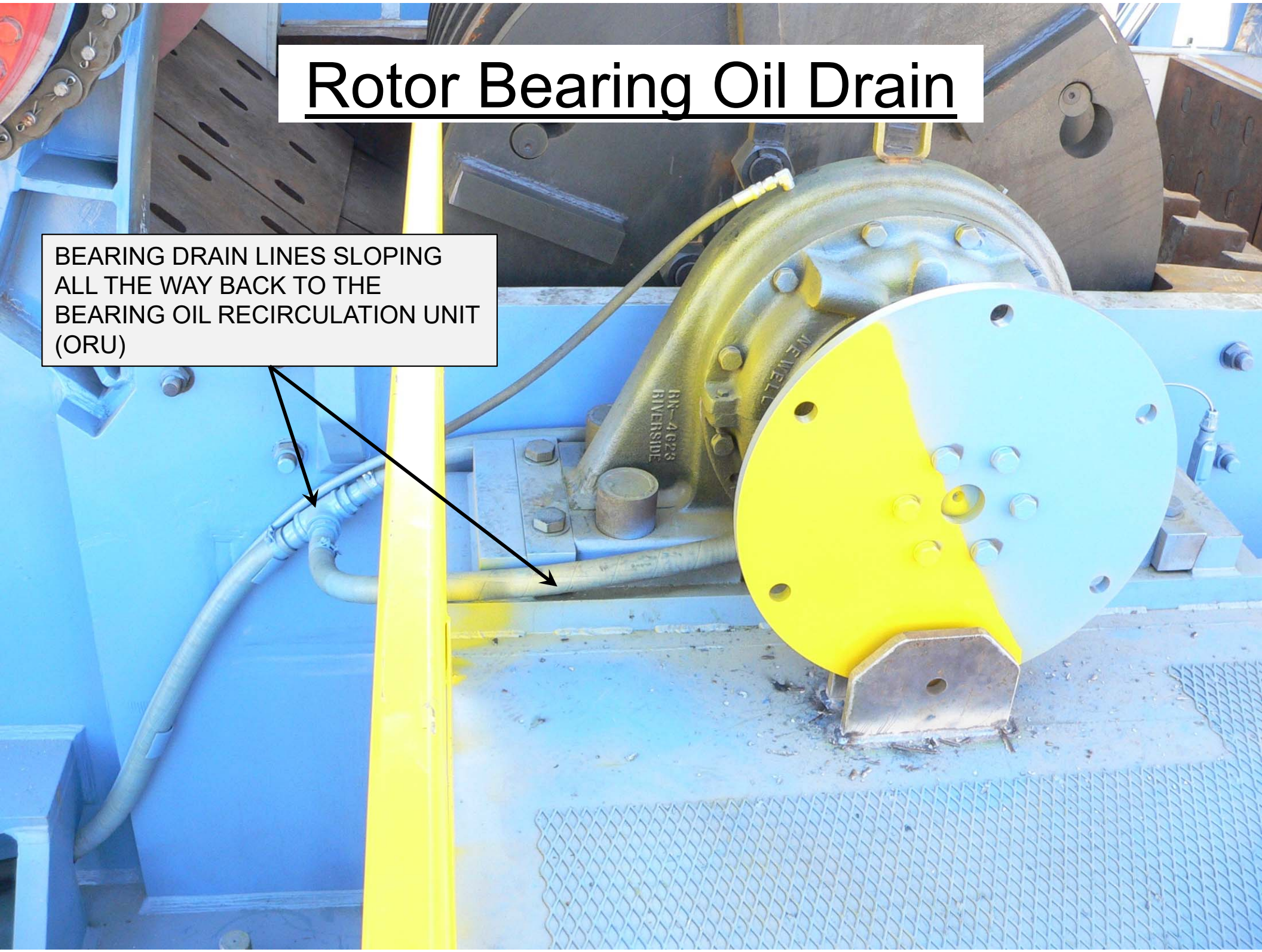
Pillow Block Bearing Components



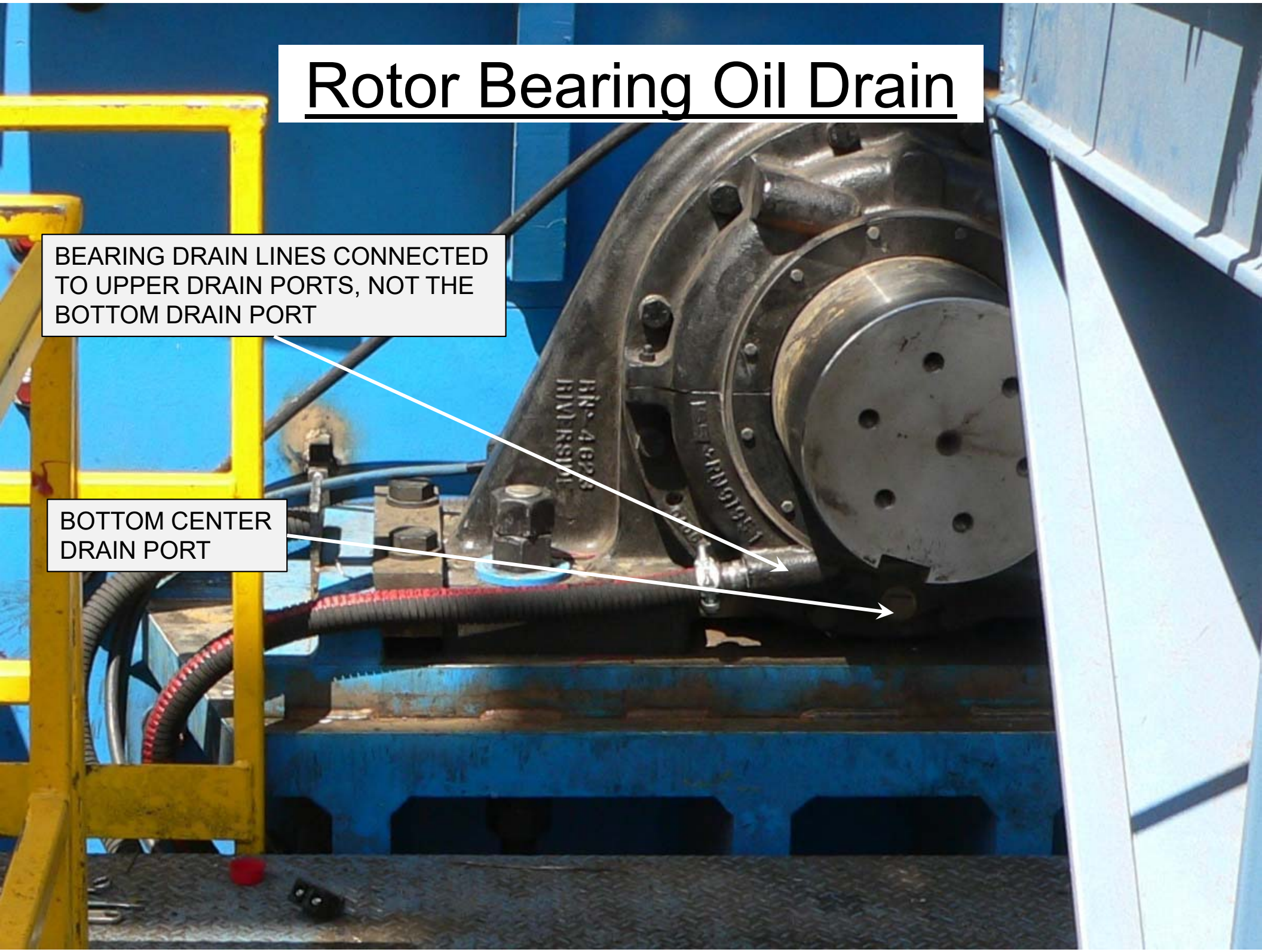
Flange Bearing Components



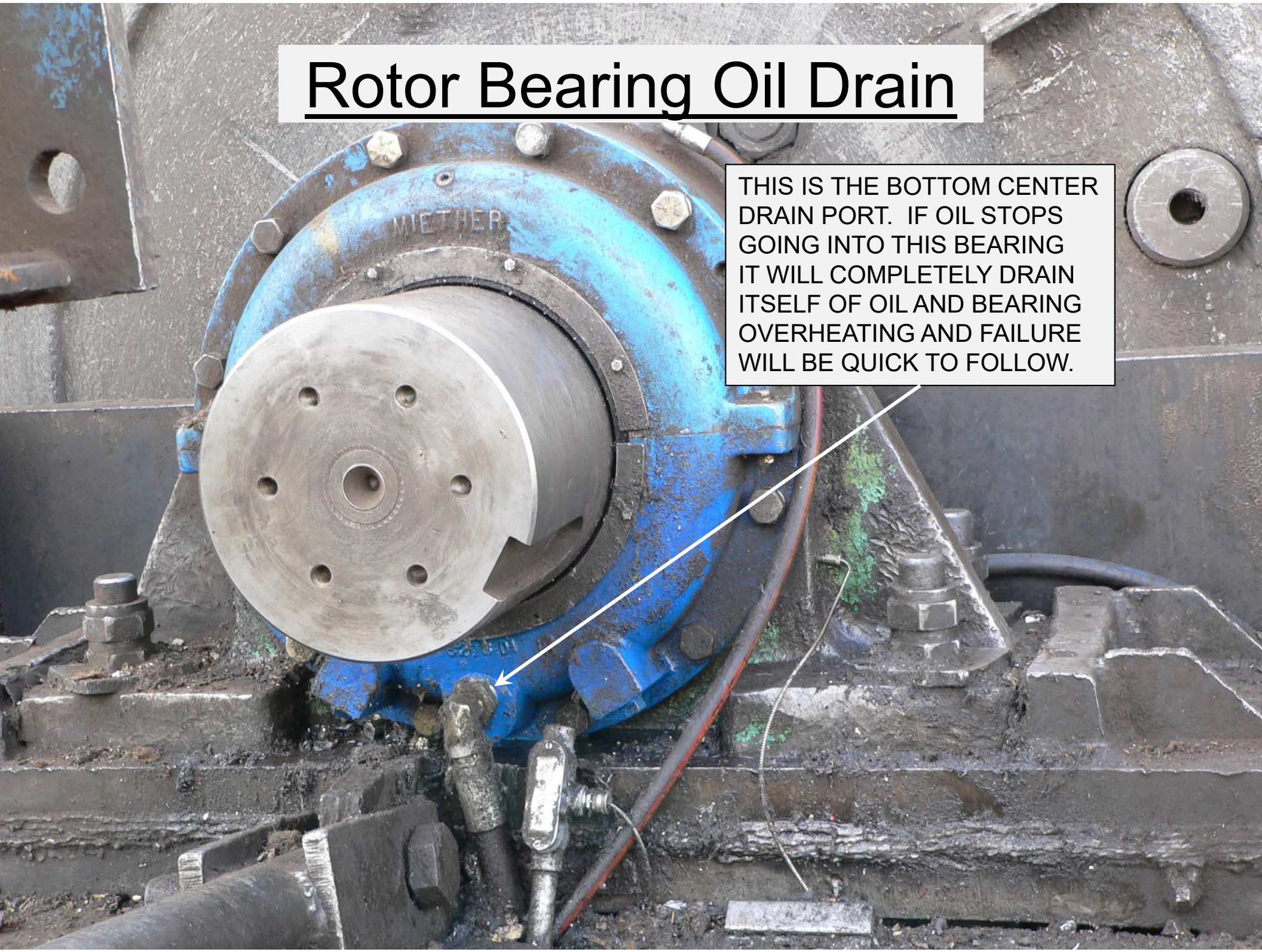
Rotor Bearing Oil Drain



Rotor Bearing Oil Drain



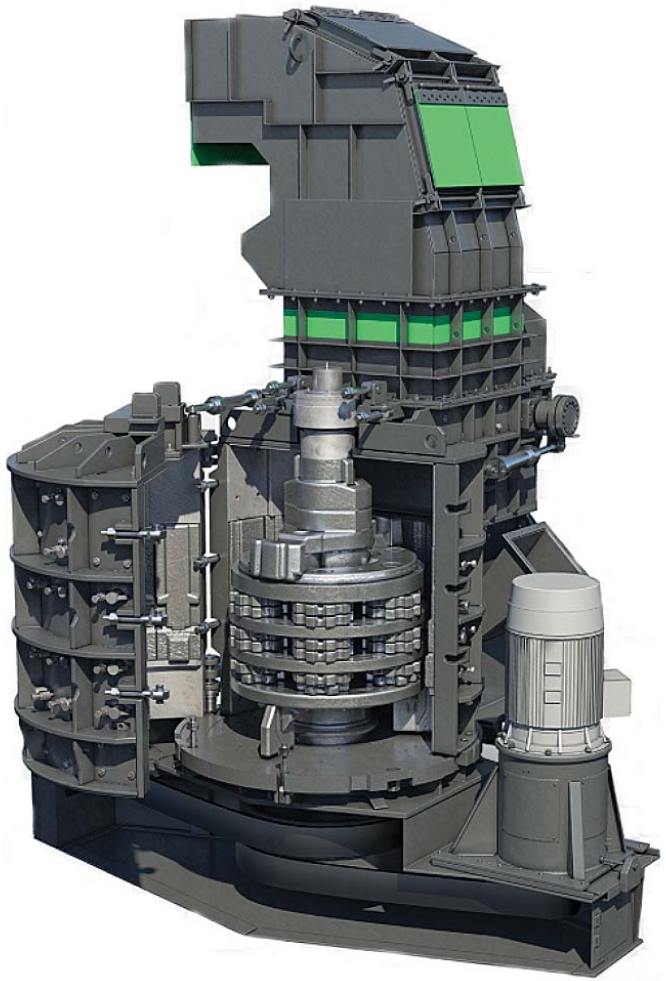
Rotor Bearing Oil Drain

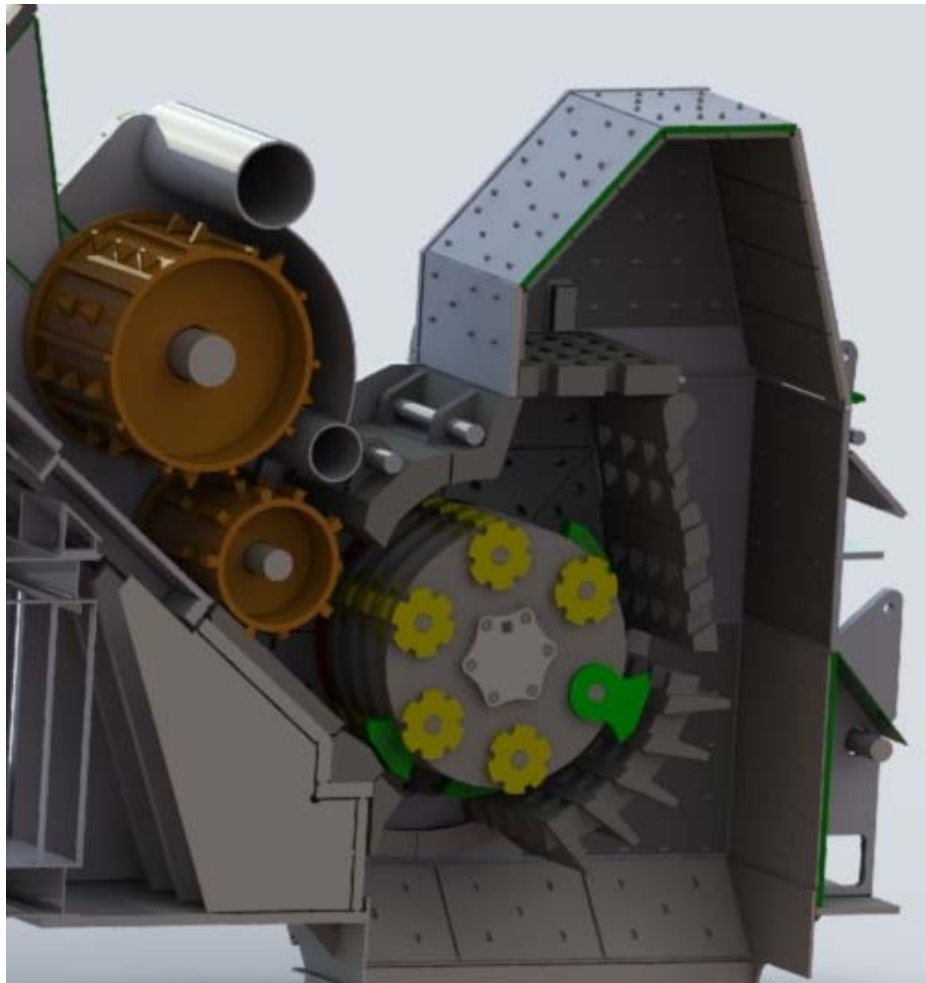


Shredder Types and Sizes

Hammermill Shredders

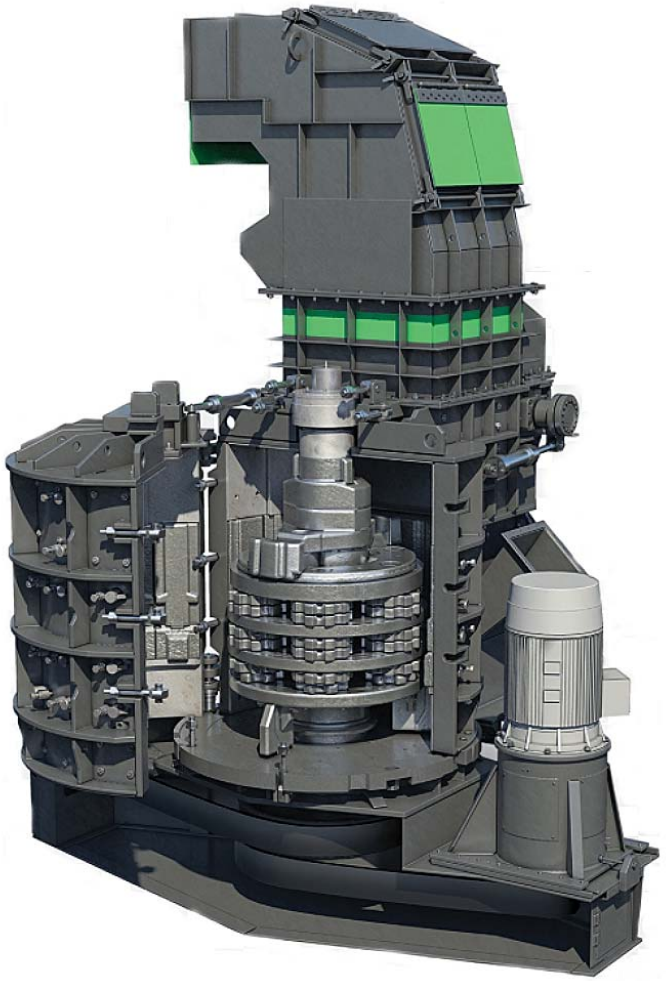
- Vertical Shaft vs Horizontal Shaft





Shredder Types and Sizes

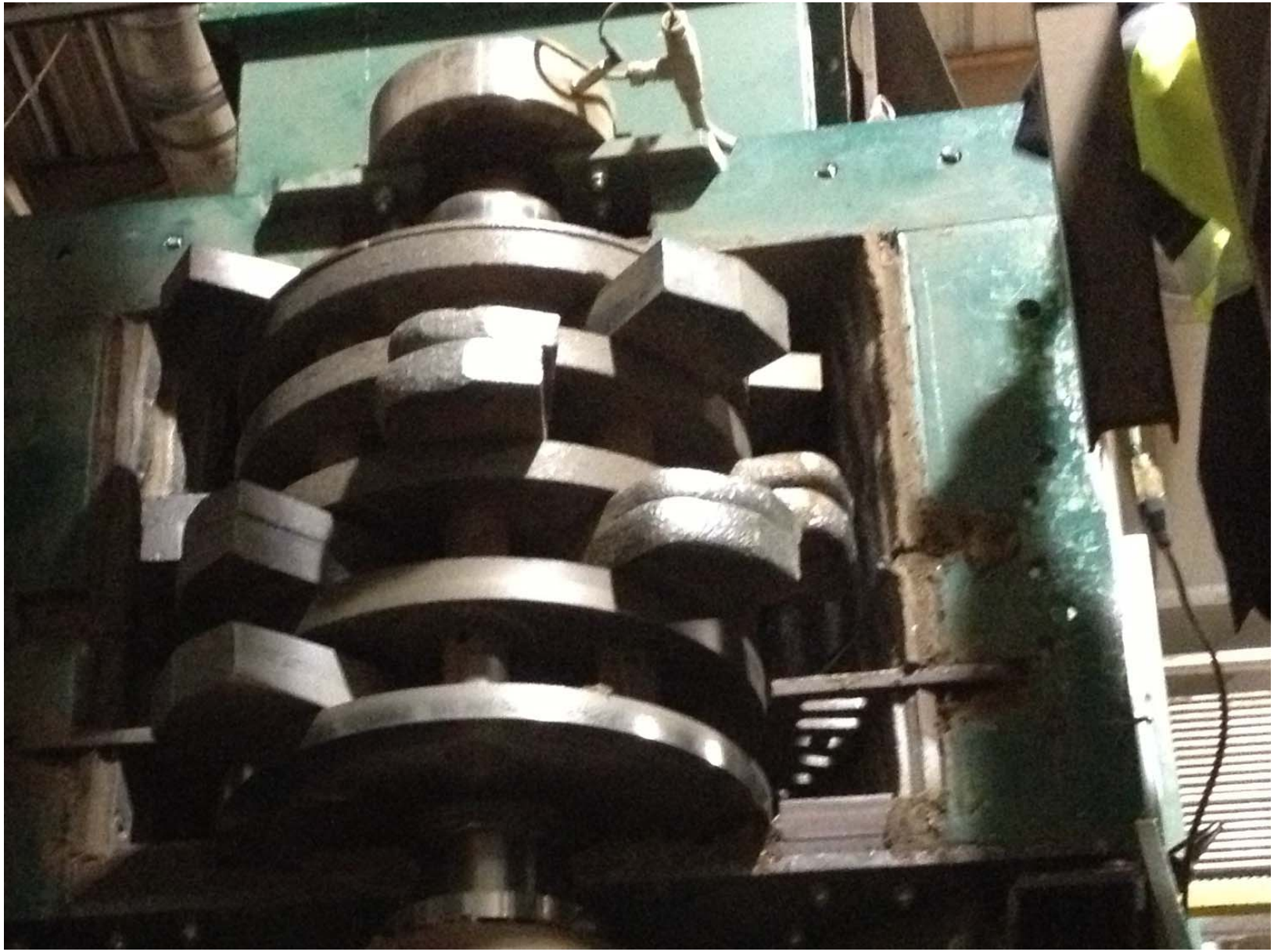
Vertical Shaft Shredders



- Typically used for NF metals
- Normally fed with a belt conveyor
- Tight clearances for “fine grinding”
- Designed to liberate metals
- Utilize a “sizing screen(s)”
- Often use “ring hammers”

Shredder Types and Sizes

Vertical Shaft Shredders



Shredder Types and Sizes

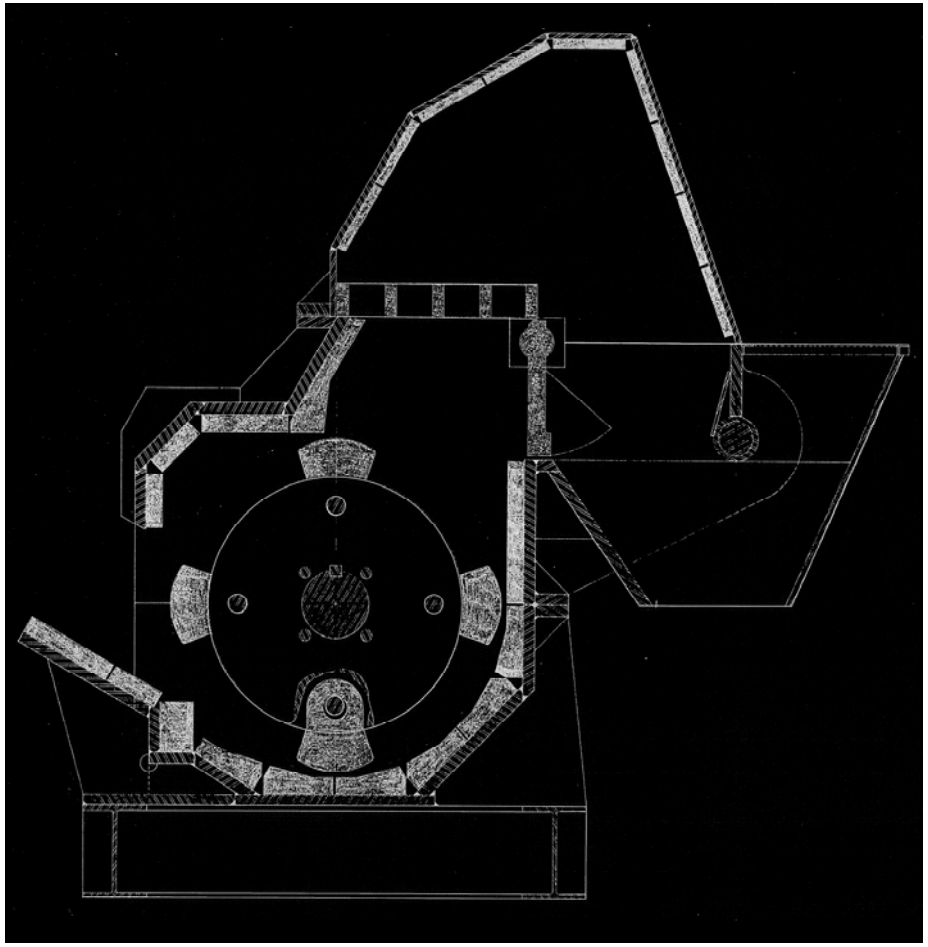
Vertical Shaft Shredders

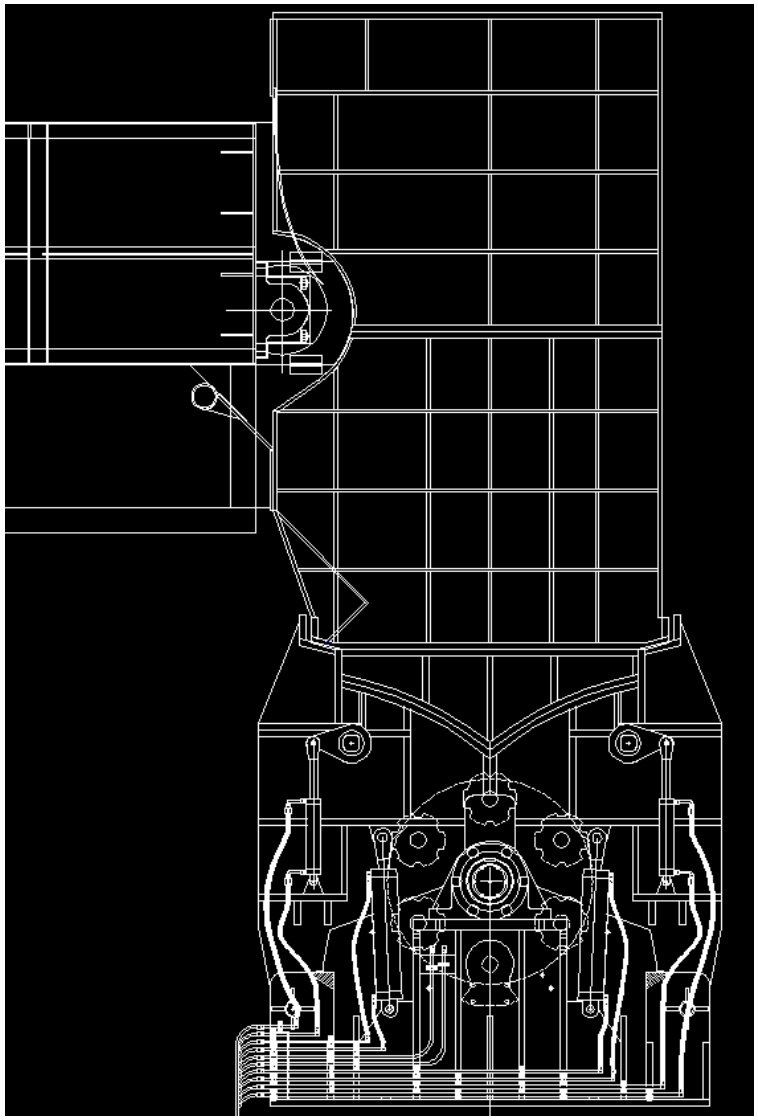
Shredder Types and Sizes

- Shredder Types
  - Vertical shaft (non-ferrous sizing)
  - Horizontal shaft
    - Top feed/bottom discharge
    - Side feed/top discharge
    - Side feed/top and bottom discharge
- Shredder Sizes
  - Hammer tip diameter x width

Shredder Types and Sizes

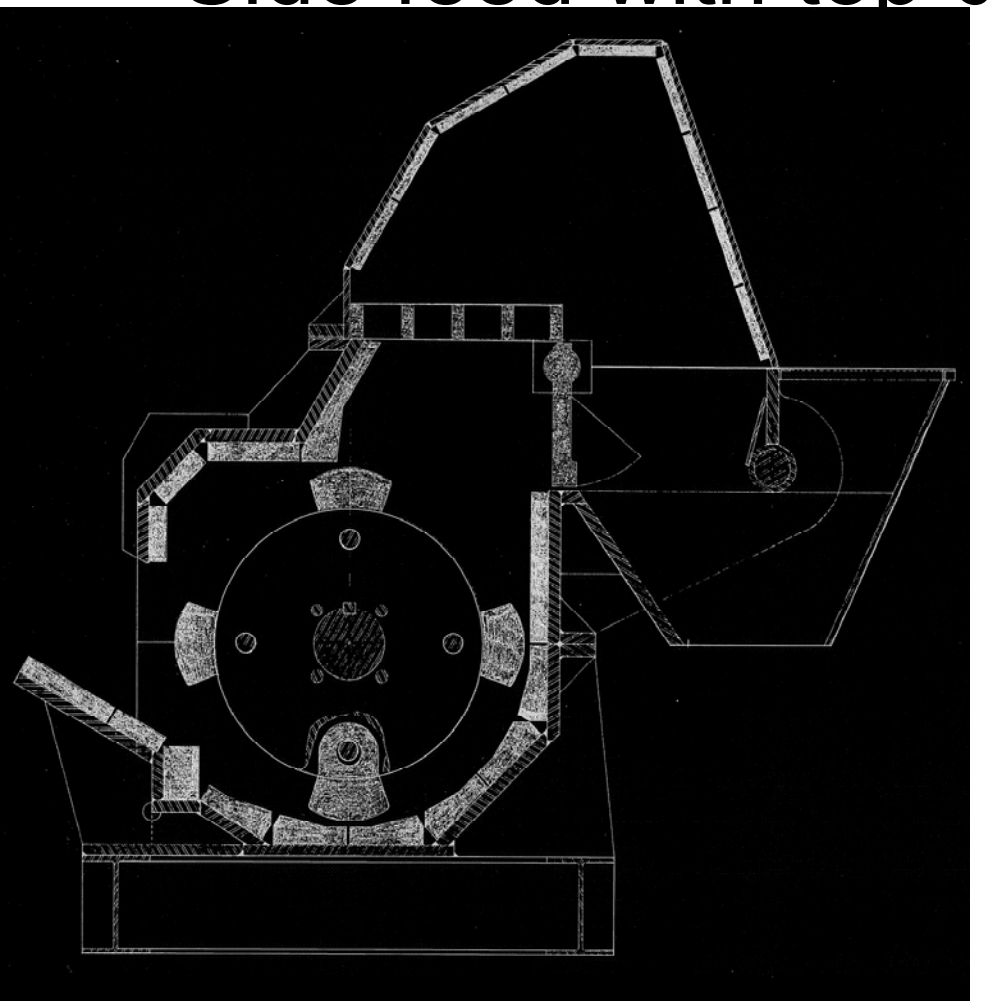
Side feed and Top feed





Shredder Types and Sizes

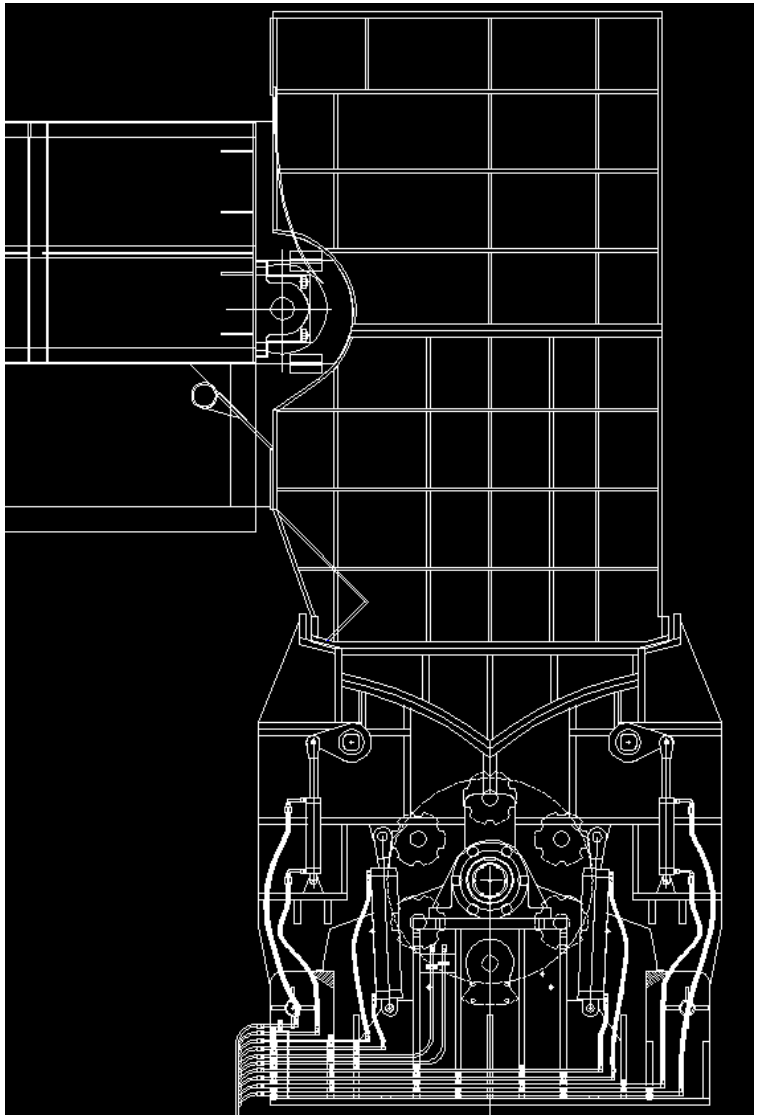
Side feed with top discharge



- Controlled rate of feed
- Less shock on drive line
- Can process long material
- Discharged onto belt
- Air pick-up at shredder
- Low profile
- Tilts open for rotor access

Shredder Types and Sizes

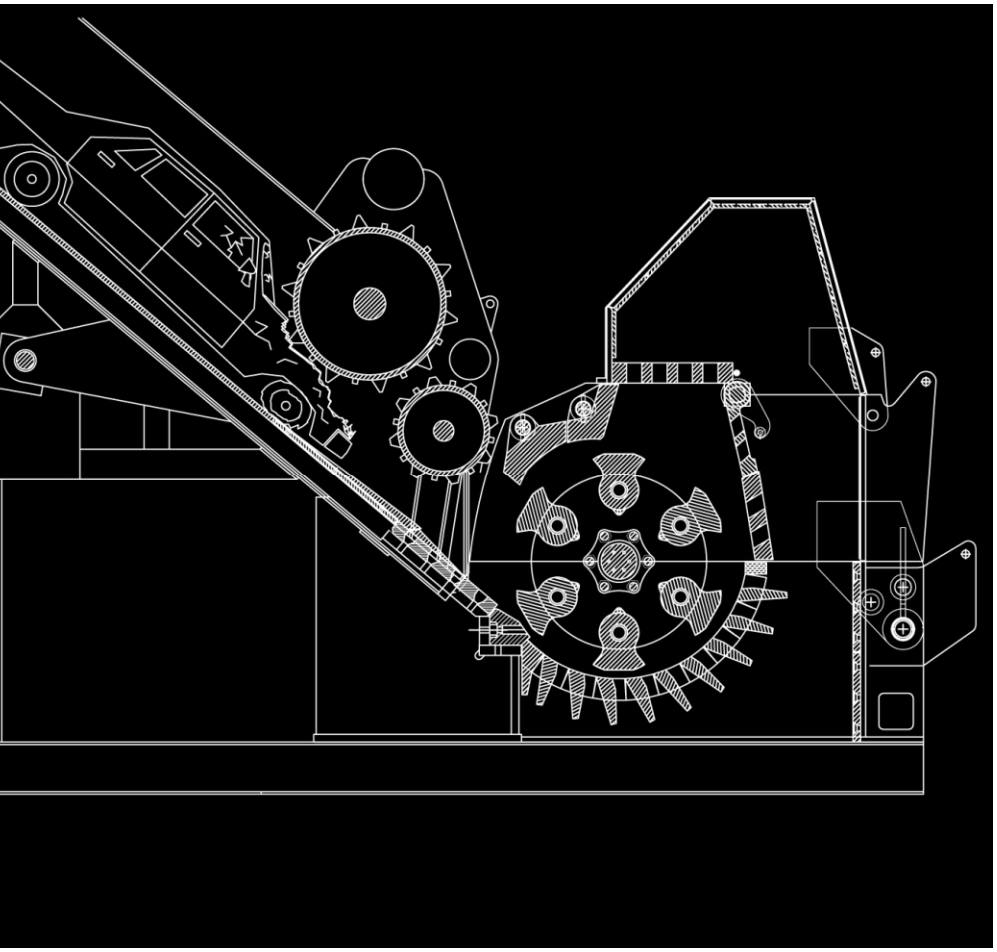
Top feed with bottom discharge



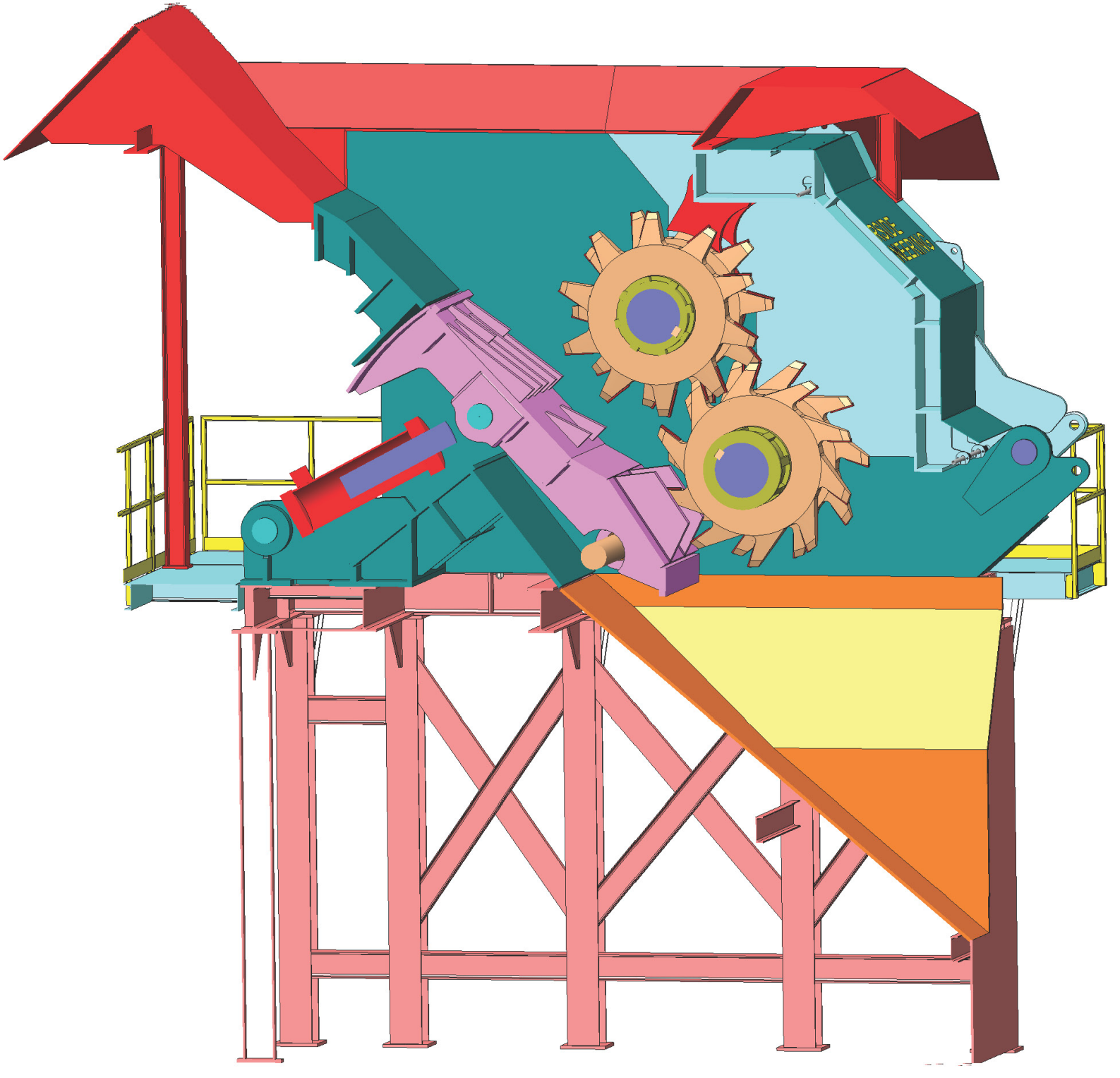
- No feed roll(s)
- Smaller ones for loose tin and white goods only
- Larger ones for autos, loose tin and white goods
- Ideal for shredding low density material (MSW, C&D)

Shredder Types and Sizes

Side feed with top and bottom discharge



- High shredding efficiency
- High throughput/HP input
- Quick acting reject door
- Controlled rate of feed
- Can process wide range of scrap metal effectively
- Tilts open for rotor access



Shredder Types and Sizes

- Shredder Types
  - Vertical shaft (non-ferrous sizing)
  - Horizontal shaft
    - Top feed/bottom discharge
    - Side feed/top discharge
    - Side feed/top and bottom discharge
- Shredder Sizes
  - Hammer swing diameter x width

Shredder Types and Sizes

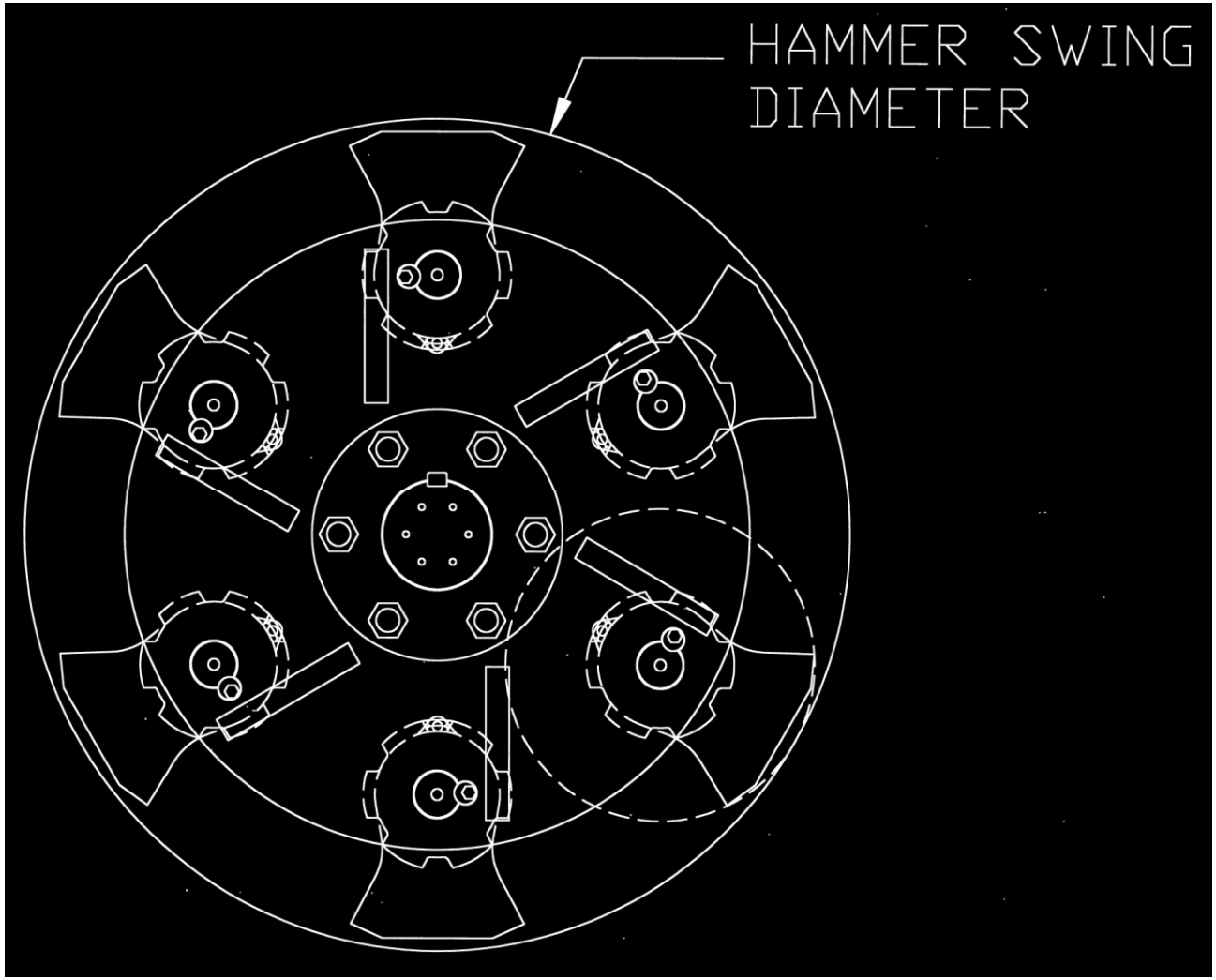
Hammer swing diameter x width

Example: 80 x 104

80 is the “Hammer Swing Diameter”
104 is the “Shredder Nominal Width”

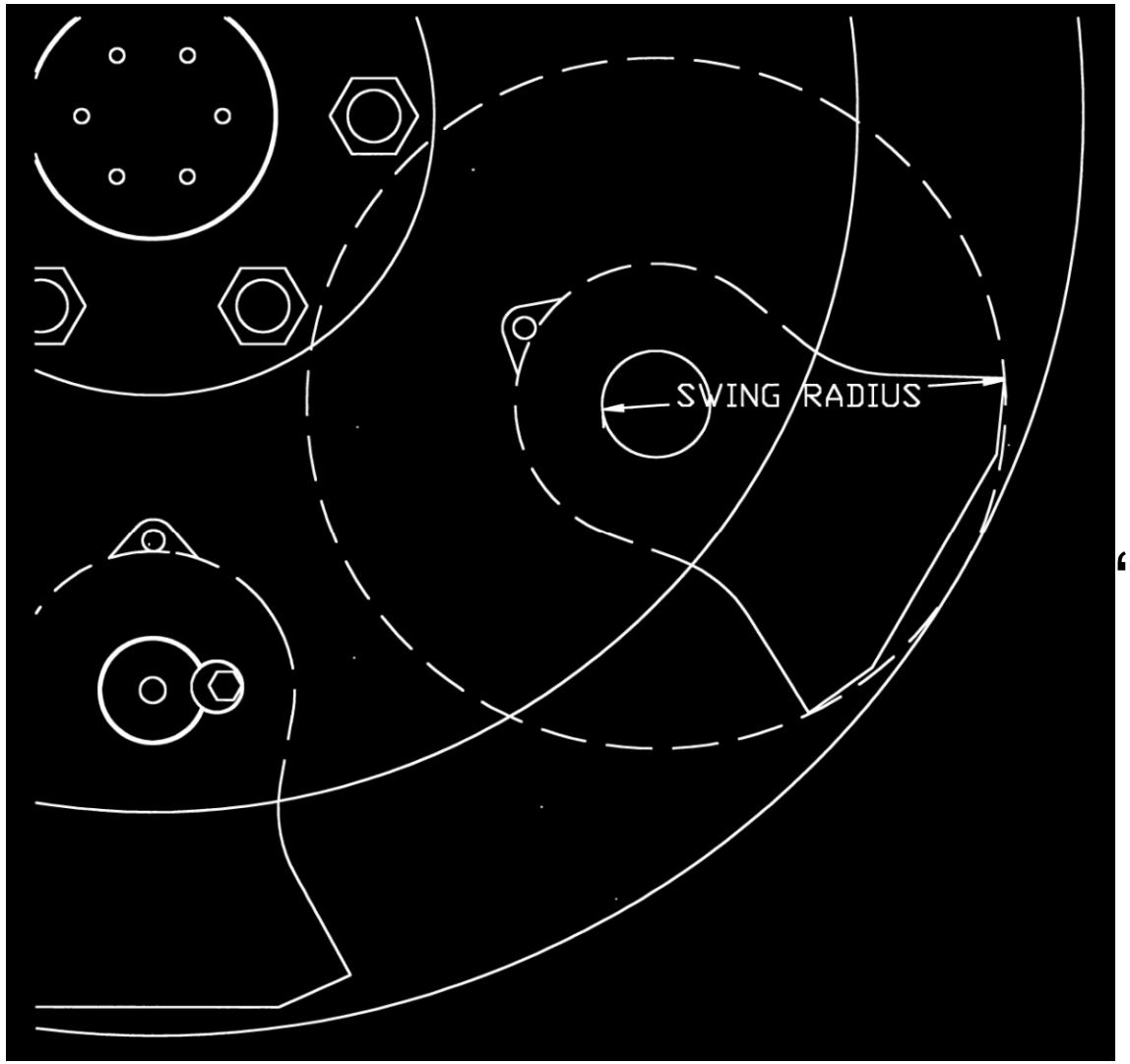
Shredder Types and Sizes

“Hammer Swing Diameter”



Shredder Types and Sizes

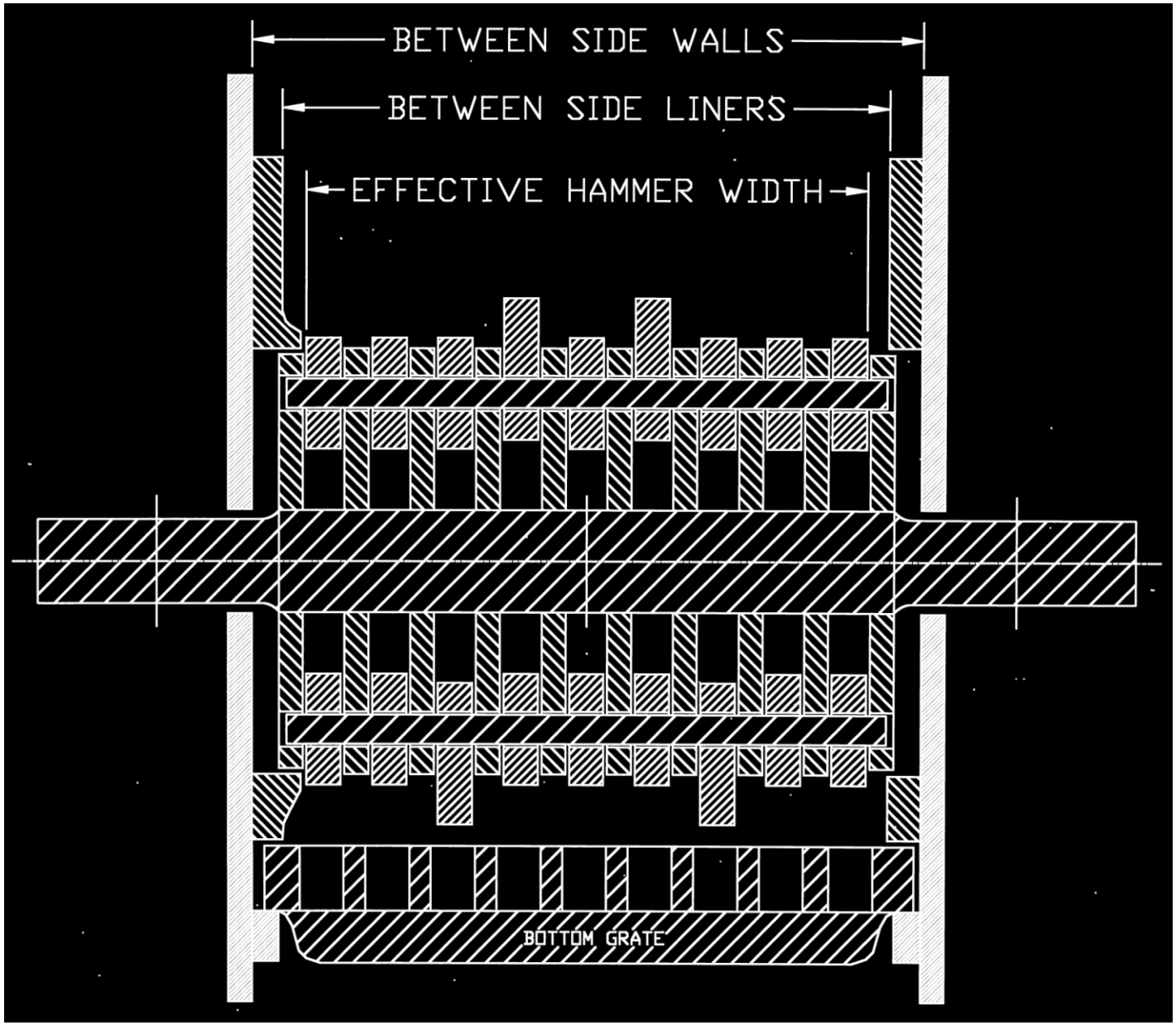
Hammer Swing Diameter



Hammer
“swing radius”

Shredder Types and Sizes

“Shredder Nominal Width”



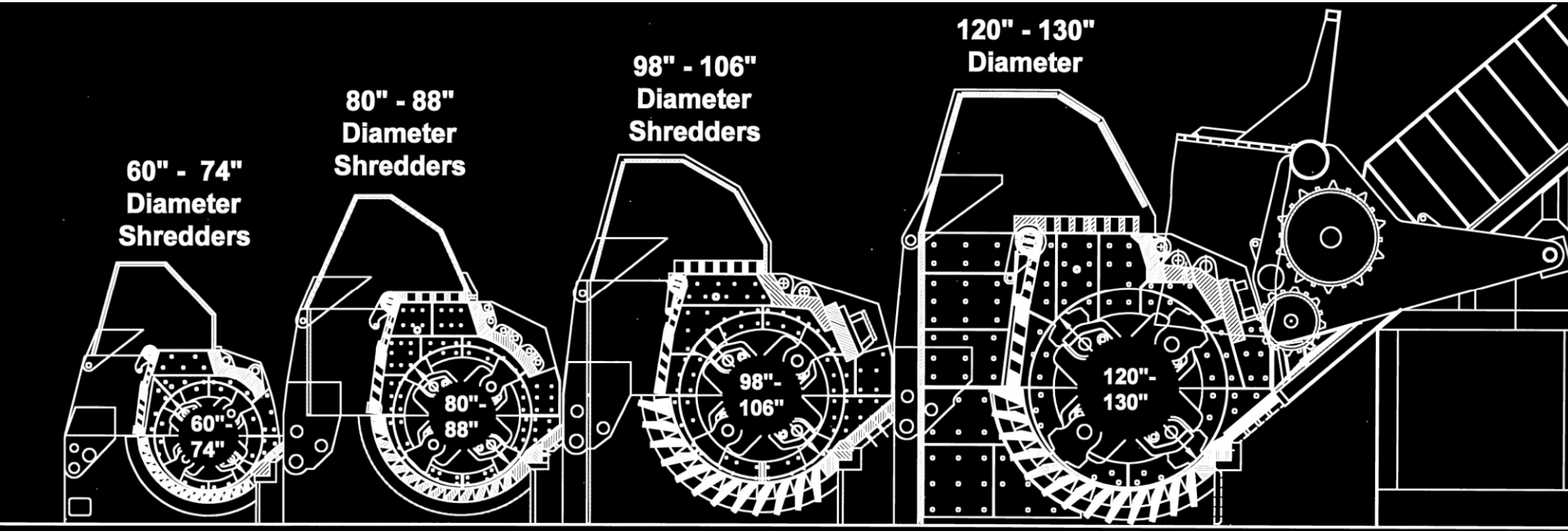
Shredder Performance and Capabilities

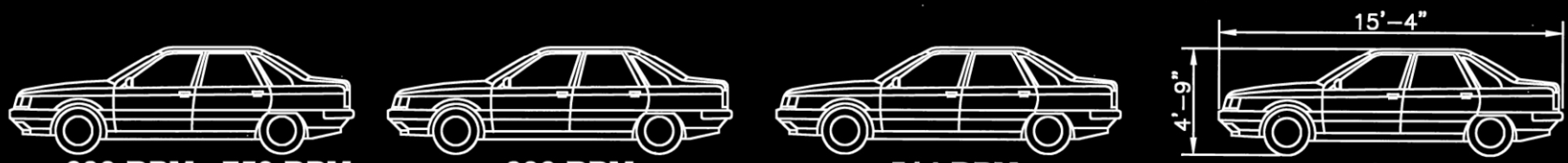
- Shredder Size
  - Determines maximum usable HP
  - Determines maximum hammer weight
  - Determines maximum inertia
- Horsepower
- Hammer weight
- Rotor Inertia
- Importance of "FULL BOX SHREDDING"
- Other factors

Horsepower Range:
1,000HP – 10,000HP

Daily Production:
200 tons – 3,000 tons

Industry Available Shredder Sizes
60”Ø to 130”Ø





600 RPM - 750 RPM	600 RPM	514 RPM	450 RPM
1,000 HP - 2,500 HP	2,500 HP - 5,000 HP	3,500 HP - 6,000 HP	4,000 HP - 10,000 HP
20 TPH - 55 TPH	50 TPH - 150 TPH	100 TPH - 200 TPH	170 TPH - 400 TPH
180 Lbs - 300 Lbs	330 Lbs - 450 Lbs	420 Lbs - 650 Lbs	800 Lbs - 1,200 Lbs
(Hammer weight)	(Hammer weight)	(Hammer weight)	(Hammer weight)
40 - 60 HP / TPH	35 - 50 HP / TPH	30 - 40 HP / TPH	25 - 35 HP / TPH

Shredder Performance and Capabilities

- Horsepower
  - For a given size shredder, horsepower is the primary determining factor of throughput
  - More horsepower gives more throughput (until "saturation" occurs)
- Hammer weight
  - The weight of the hammer, inside a given size shredder, determines the "types of scrap" that can be "effectively" processed in the shredder

  - Note: These are generalized statements, as there are many other relevant factors.

Shredder Performance and Capabilities

- Hammer weight (cont.)
  - The combination of hammer weight and hammer speed determine the maximum "Striking Force" of a hammer in a shredder
  - "Striking Force" A.K.A. Kinetic Energy
  - Maximum striking force (Kinetic Energy KE) is a function of hammer weight and its velocity (KE = 1/2mv^2, m=mass of hammer, v=velocity of hammer)
- Hammer design
  - CG of hammer, width and shape of hammer

Shredder Performance and Capabilities

- Rotor Inertia
  - Having a higher inertia rotor reduces the RPM loss when a “surge of scrap” enters the shredder
  - Shredder size affects the inertia of the rotor by the “square” of the diameter of the rotor
  - Average Inertia values:
    - 60” shredder inertia = 35,000 lbsft^2
    - 80” shredder inertia = 180,000 lbsft^2
    - 98” shredder inertia = 400,000 lbsft^2
    - 120” shredder inertia = 1,200,000 lbsft^2
  - The higher the inertia the closer to 100% motor utilization that can be achieved

Shredder Performance and Capabilities

- Maintaining “full box shredding”
  - Higher efficiency
  - Higher throughput
  - Improved density
  - Longer casting life
  - Improved NF liberation
  - Reduced long bars
  - Improved downstream performance

Shredder Performance and Capabilities

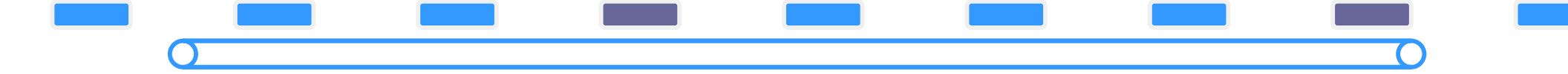
- Primary reasons for not maintaining “full box shredding”
  - Lack of material in feed ramp
    - Gaps on infeed
    - Motor underutilized
  - Material flow issues into shredder
  - Feed roll issues
    - Worn teeth
  - Hammer condition (material difficult to feed)

Shredder Performance and Capabilities

Shredder Performance and Capabilities

Shredder Performance and Capabilities

Infeed conveyor moving at 60 feet per at 150 tons per hour



Infeed conveyor moving at 120 feet per at 150 tons per hour

If your shredder operator is rarely stopping the infeed conveyor, then the input rate into your shredder is being set by the crane operators. Only by training the crane operators to load the infeed with no gaps to an agreed upon depth can the shredder operator control the input rate into the shredder by speeding up, slowing down or stopping the infeed.

Shredder Performance and Capabilities

- Other Factors
  - Shredder internal configuration
  - Feed roll system and condition
  - Feed ramp/anvil condition
  - Material being processed/density output
  - Grate design/sizing
    - Percent opening
    - Discharge angle

Shredder Improvements

- In an effort to operate as competitively and as safely as possible, every shredding operation needs to be continually evaluating and asking several key questions:
  - Does our shredder have the appropriate safety equipment installed?
  - Is our shredder producing at the appropriate throughput rate for our shredder size, output density and horsepower?
  - Is the reliability of our shredder where it needs to be?

Shredder Improvements

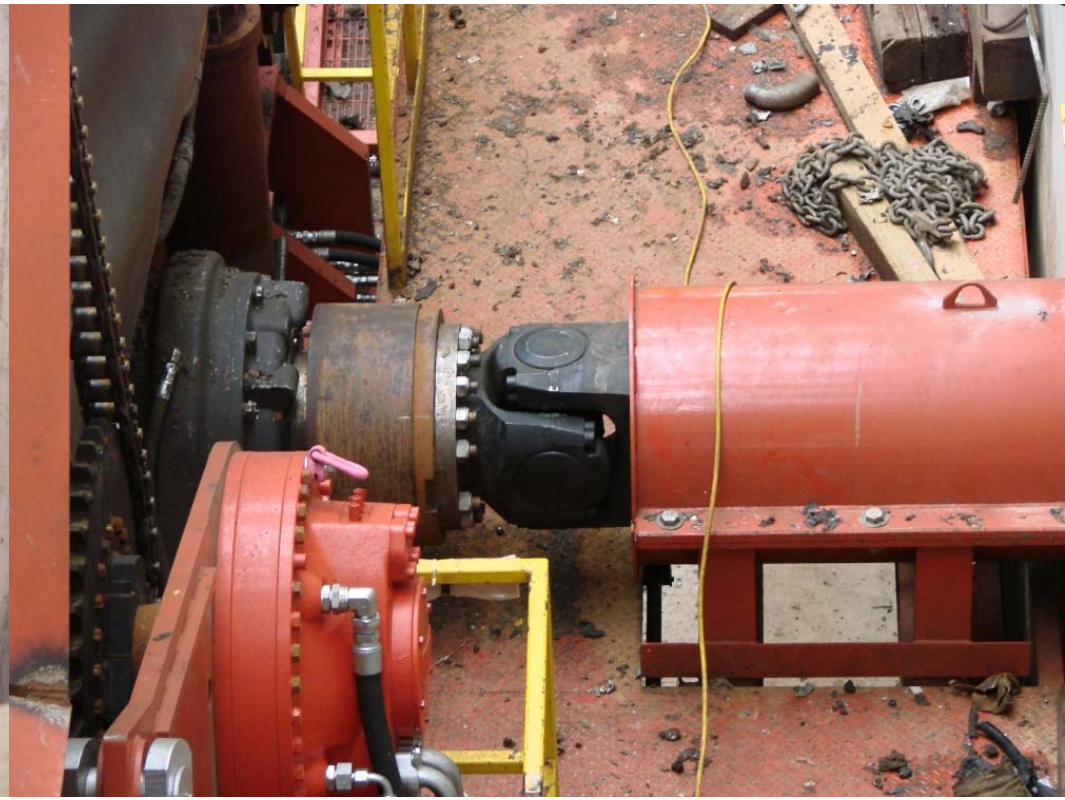
- Drive shaft guarding
- Infrared camera
- Grate configuration
- Rotor / hammer configuration
- Feed roll system
- Automated feed control system
- Infeed conveyor
- Water injection and foam injection
- Spring box replacement
- Belt scales

Shredder Improvements

- Drive shaft guarding
  - Drive shafts can fail due to several reasons
    - Fatigue/age
    - Overloading
    - Misalignment
    - Lack of lubrication
  - A drive shaft guard reduces the risk of significant damage that can be caused during a driveshaft failure

Shredder Improvements

Drive shaft guarding

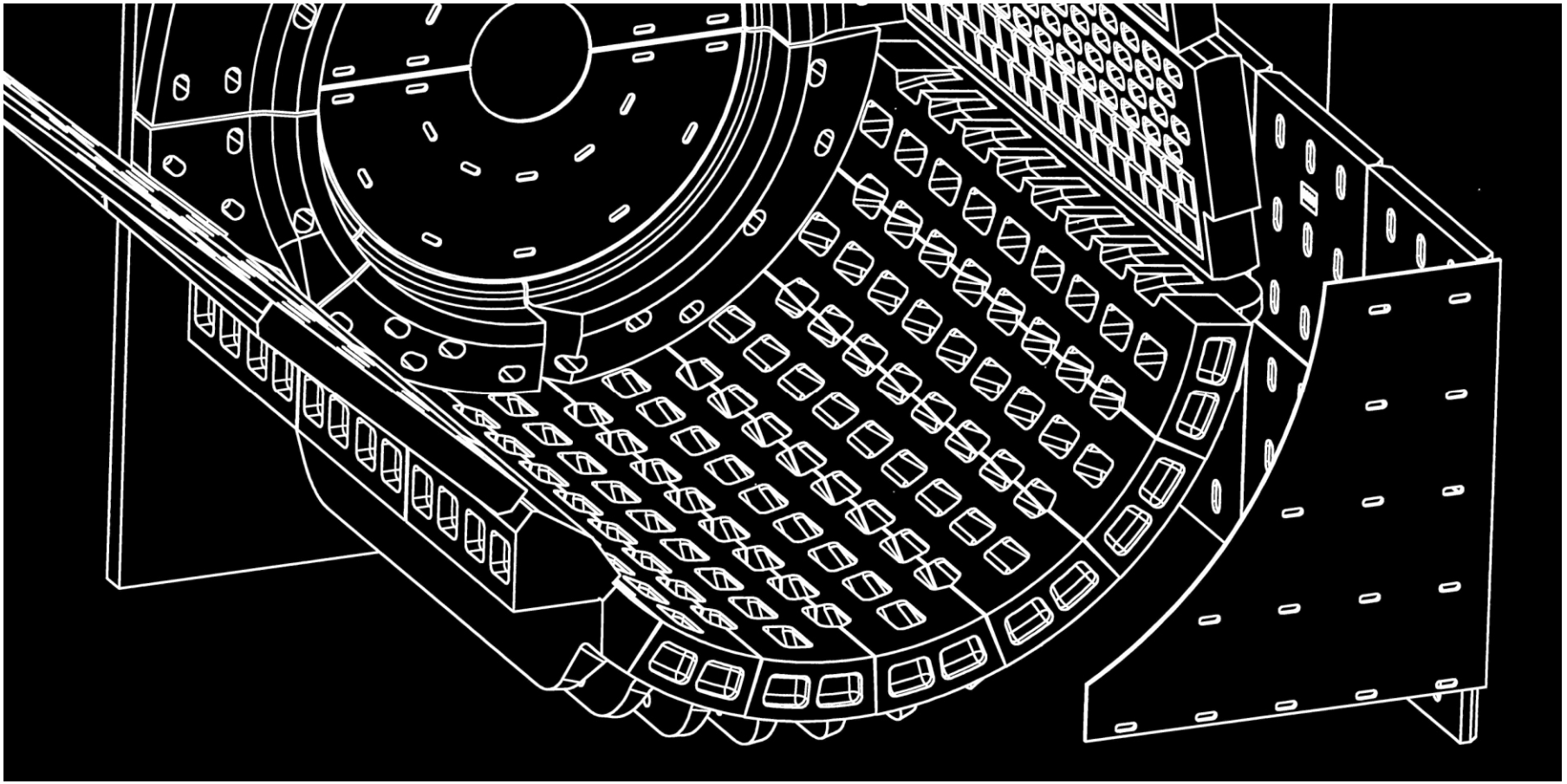


Shredder Improvements

Infrared camera

Shredder Improvements

- Grate configuration
  - Choosing and installing the appropriate grate sizing and type is instrumental to throughput, density and non-ferrous liberation



Shredder Improvements

- Feed roll assembly
  - Single vs Double
  - 36x36, 36x60
  - Hydraulic vs electric

Shredder Improvements

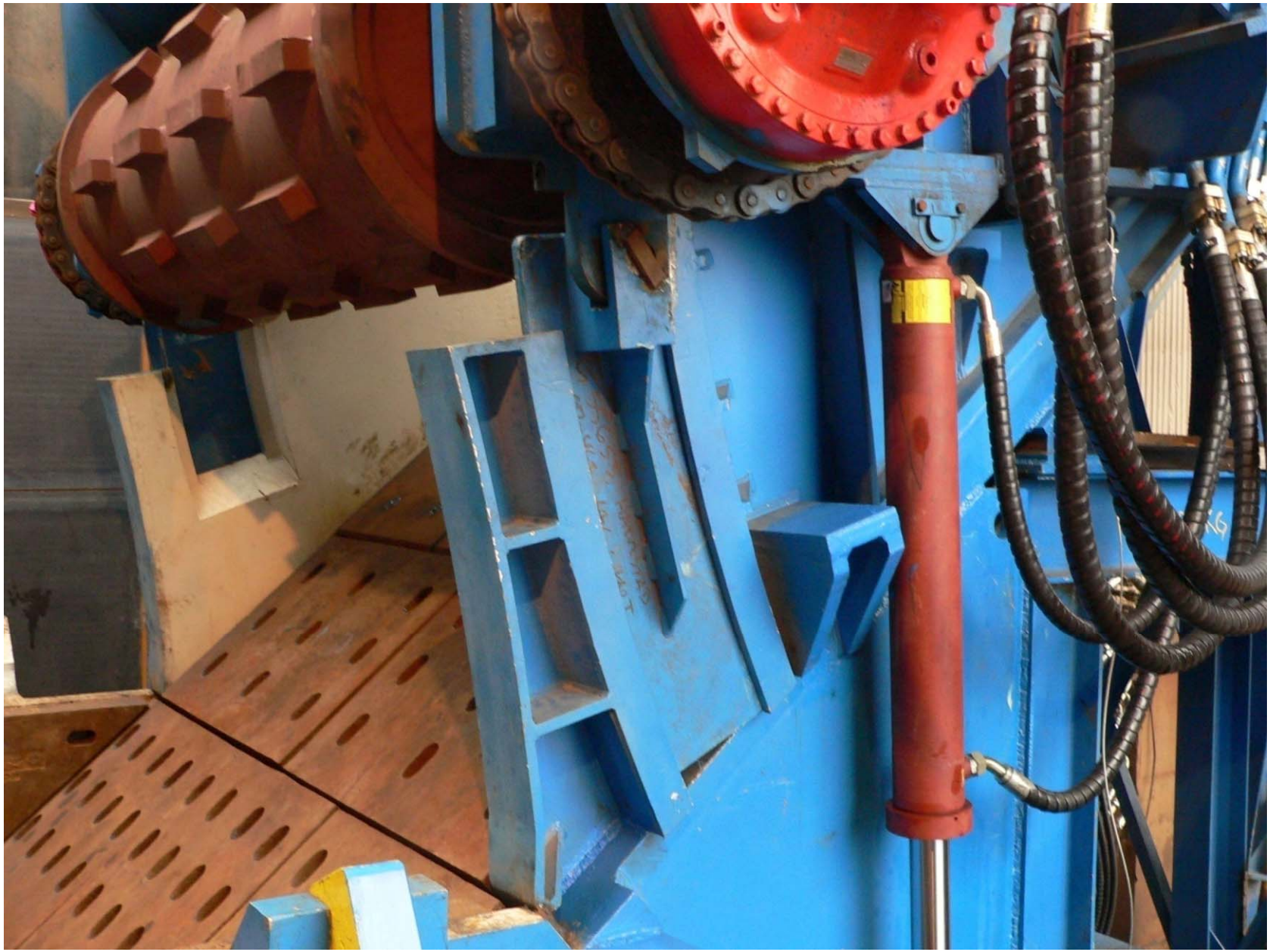
- Feed roll assembly

Shredder Improvements

- Feed ramp side wall condition

Shredder Improvements

- Feed roll slide plates



Shredder Improvements

- Automated feed control system
  - Adjusts feed roll speed and height automatically based on shredder and motor loading conditions
  - Several operating parameters can be monitored
    - Motor load (RPM, % of FLA)
    - Feed roll height
    - Pressure or amps turning feed roll
    - Rotor speed “rate of change”
  - Automatically pause the infeed conveyor

Shredder Improvements

Automated feed control system benefits:

- Higher average throughput
- More consistent flow through downstream
- Operators are easier to train
- Fewer occurrences of a plugged shredder
- Much less stress on the shredder operator allowing him to focus on other situations with the shredder and in the yard

Shredder Improvements

- Infeed conveyor
  - Track pad replacement
  - Drive sprocket replacement
  - Removal of excess catenary sag
  - Support rail repair/replacement

Shredder Improvements

Water and Foam injection

- Increase effectiveness in dust and odor suppression
- Highly effective in capturing shredder emissions (particulates, hydrocarbons, VOC's, blue smoke)
- Reduced frequency and intensity of shredding chamber explosions
- Significantly less water consumption in shredding process
- Reduced Waste disposal weight/cost by reduced moisture content
- Moisture reduction improves downstream separation and non ferrous metal recovery

Shredder Improvements

- Belt scales
  - Load cell on idler type
    - Requires mechanical installation
    - Requires specific conveyor profile
    - Excellent accuracy when calibrated
  - Electronic type
    - Uses CT's (current transformers) on conveyor motor leads
    - Requires motor load to increase with rate of flow increase
    - Good accuracy, and reliable when installed on suitable conveyor

Tracking Shredder Performance

- Every yard should be tracking downtime and daily production, either manually or automatically.
- In an effort to be continually improving; benchmarking and comparing old and new information is the only way to keep your yard improving and not deteriorating
- Making intelligent decisions about where to apply your available resources (Money, Time, People)

Tracking Shredder Performance

- Collecting, storing, and reporting daily processing information is critical to the “Continuous improvement” process

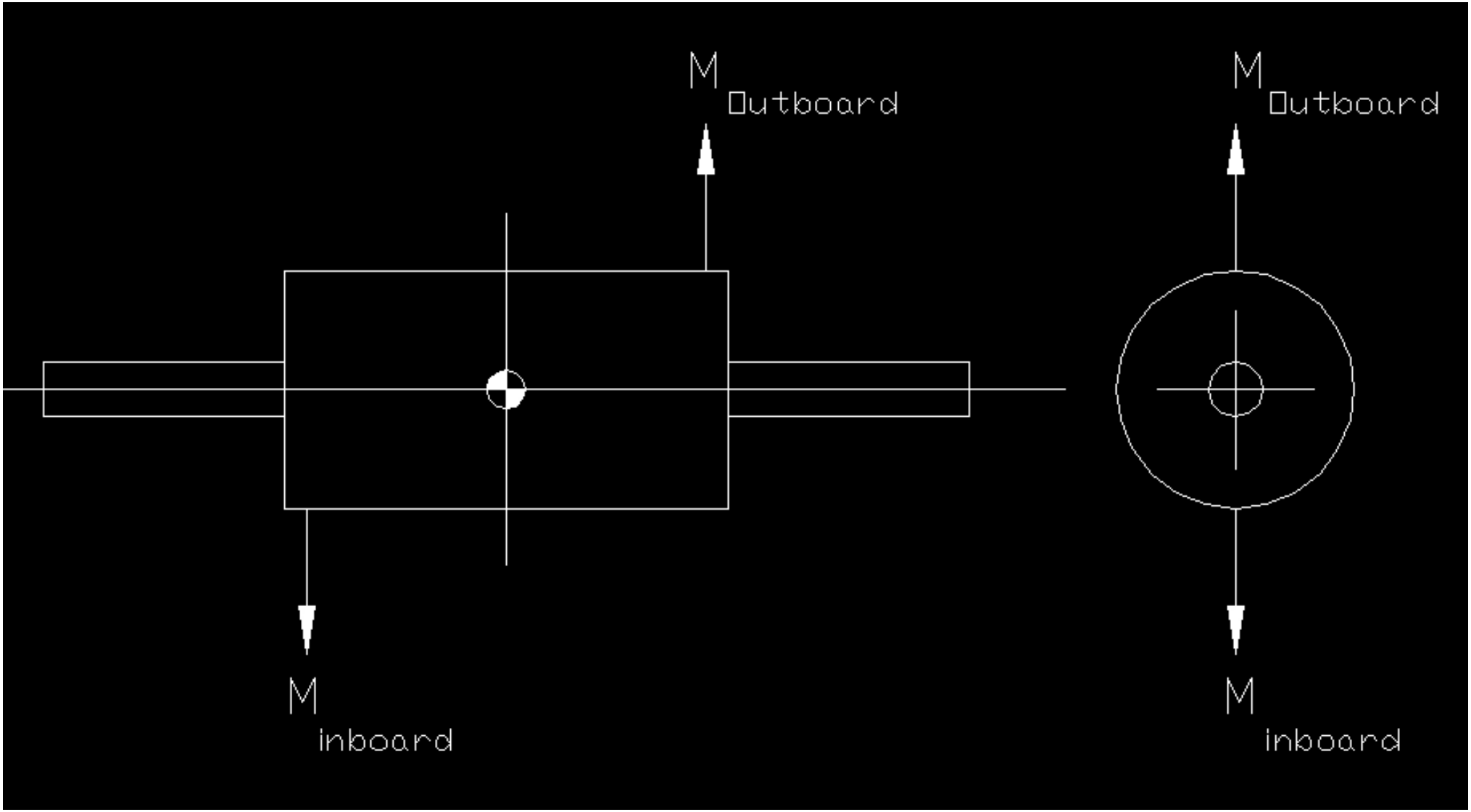
- This should include, but is not limited to:
  - Start time
  - End time
  - Tons produced
  - Lost time with reasons

- Many of the downtime and production monitoring systems have the ability to text or e-mail alarms or “out of range” conditions to the appropriate management
- End of shift production summary’s can also be texted or e-mailed to the appropriate individuals
- Forecasting the production and necessary shredding hours at the beginning of each month allows for some planning by the buyers and maintenance crew. At the end of the month it is easy to review the actual vs. scheduled production.
- Some systems support the collection and comparison of data from several different shredders in one corporate organization.

Analysis Tools - Reports

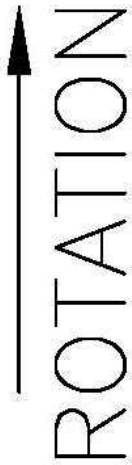
- What you do with all this information is much more important than the information itself
- Supplies the information needed to justify what equipment needs to be fixed or replaced as a priority
- Provides an invaluable tool for recognizing and rewarding good yard operation and management
- Creates a permanent record of production, and yard efficiencies that are often lost and forgotten

Avoiding the “Couple Unbalance”



Avoiding the “Couple Unbalance”

This arrangement is Unbalanced



	SPACE 1	SPACE 2	SPACE 3	SPACE 4	SPACE 5	SPACE 6	SPACE 7	SPACE 8	SPACE 9	SPACE 10	
PIN A						○					1
PIN B				○			○				2
PIN C		330							320		2
PIN D					○						1
PIN E			○					○			2
PIN F	320									330	2

Pin C total weight = 650

Pin E total weight = 650

Avoiding the “Couple Unbalance”

This arrangement is Balanced

ROTATION

	SPACE 1	SPACE 2	SPACE 3	SPACE 4	SPACE 5	SPACE 6	SPACE 7	SPACE 8	SPACE 9	SPACE 10	
PIN A											1
PIN B											2
PIN C		320							330		2
PIN D											1
PIN E											2
PIN F	320									330	2

Pin C total weight = 650

Pin E total weight = 650

Bolt Torque Table

* * * THIS INFORMATION IS FOR REFERENCE ONLY * * *

Always follow the equipment manufacturers bolt replacement and tightening procedures

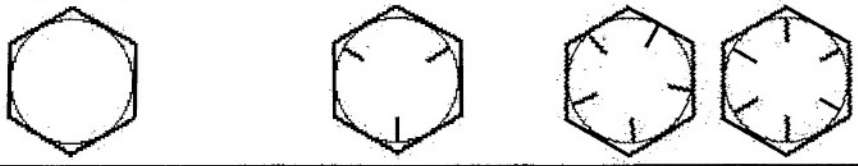
Tightening torque and resulting tension is dependant upon the nut/bolt/surface friction

Using Stover (deformed) nuts, or nylock nuts will reduce the final bolt tension at a specified torque

Torque values below assume the "as manufactured" light oil residue only (no corrosion/damage)

Using a low friction "anti-seize" lubricant and torque values below can lead to over torqued or broken bolts

Follow manufacturer's instructions for tightening liner bolts and rotor "tie rods"



	DIA-Pitch	Unmarked (36-60 ksi)	Grade 3 to 5 (90-105 ksi)	Grade 6 to 8 (130-150 ksi)
1	1/2"-13	45	75	100
2	5/8"-11	90	140	200
3	3/4"-10	150	250	350
4	7/8"-9	200	350	500
5	1"-8	180	475	700
6	1"-12	210	500	750
7	1 1/4"-7	375	800	1,200
8	1 1/4"-12	400	900	1,500
9	1 1/2"-6	650	1,400	2,300
10	1 1/2"-12	700	1,600	2,500
11	1 3/4"-5	1,000	2,300	3,500
12	2"-4.5	1,500	3,400	5,500
13	2"-12	1,700	3,800	6,000
14	2 1/2"-4	3,000	6,500	11,000
16	2 3/4"-4	4,000	9,400	15,000
18	3"-4	5,500	12,000	20,000
20	4"-4	13,000	30,000	48,000

Thank You For Your Time !

Questions and Answers

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