AC Motor Rotors in Detail

In depth review of AC motor Rotor construction and design

AC Motor Rotors in Detail

- Overview/Objectives:
  - Rotor Material and Construction Options
  - Rotor Components in Detail
  - Rotor Shaft and Endplate Details
  - Motor Bearing Types and Uses

Motor Rotor

- Rotor Highlights and Considerations
  - Material
    - Copper Bar
    - Cast Aluminum
  - Ducted or Solid
  - Bar Shape / Slot Design
  - Balance Tolerance

Motor Rotor – Material Considerations

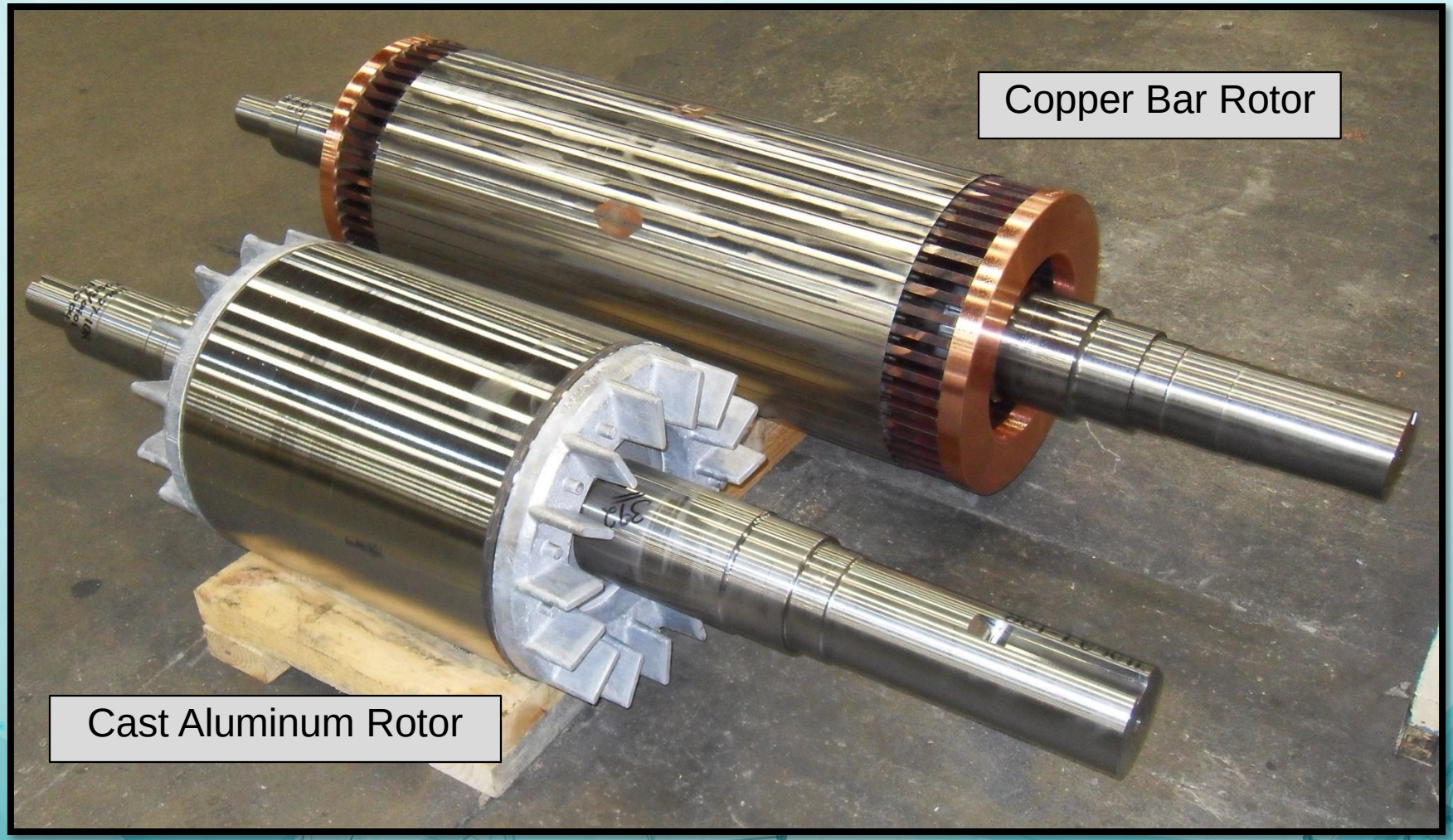
Cast Rotor

- Rotor bars are formed during casting. Therefore, they are in direct contact with laminations
- Less expensive
- Lighter weight
- Internal fans are part of the casting

Bar Rotor

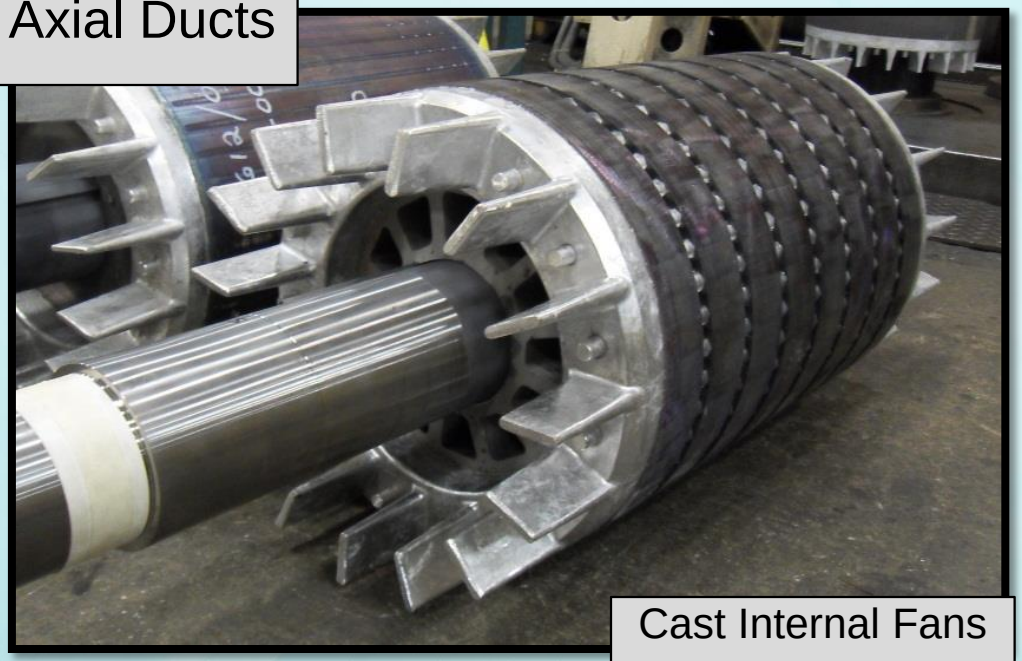
- Rugged Construction
- More Expensive
- Repairable
- Multiple Alloys = Different Speed/Torque Characteristics
- Better for high start applications

Motor Rotor – Solid Rotors

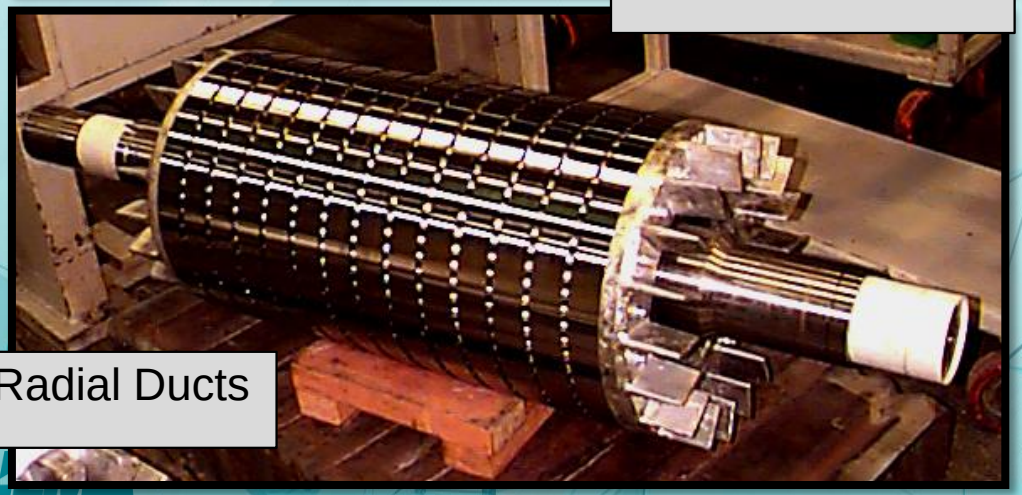


Motor Rotor – Cast Ducted Design

Axial Ducts



Cast Internal Fans

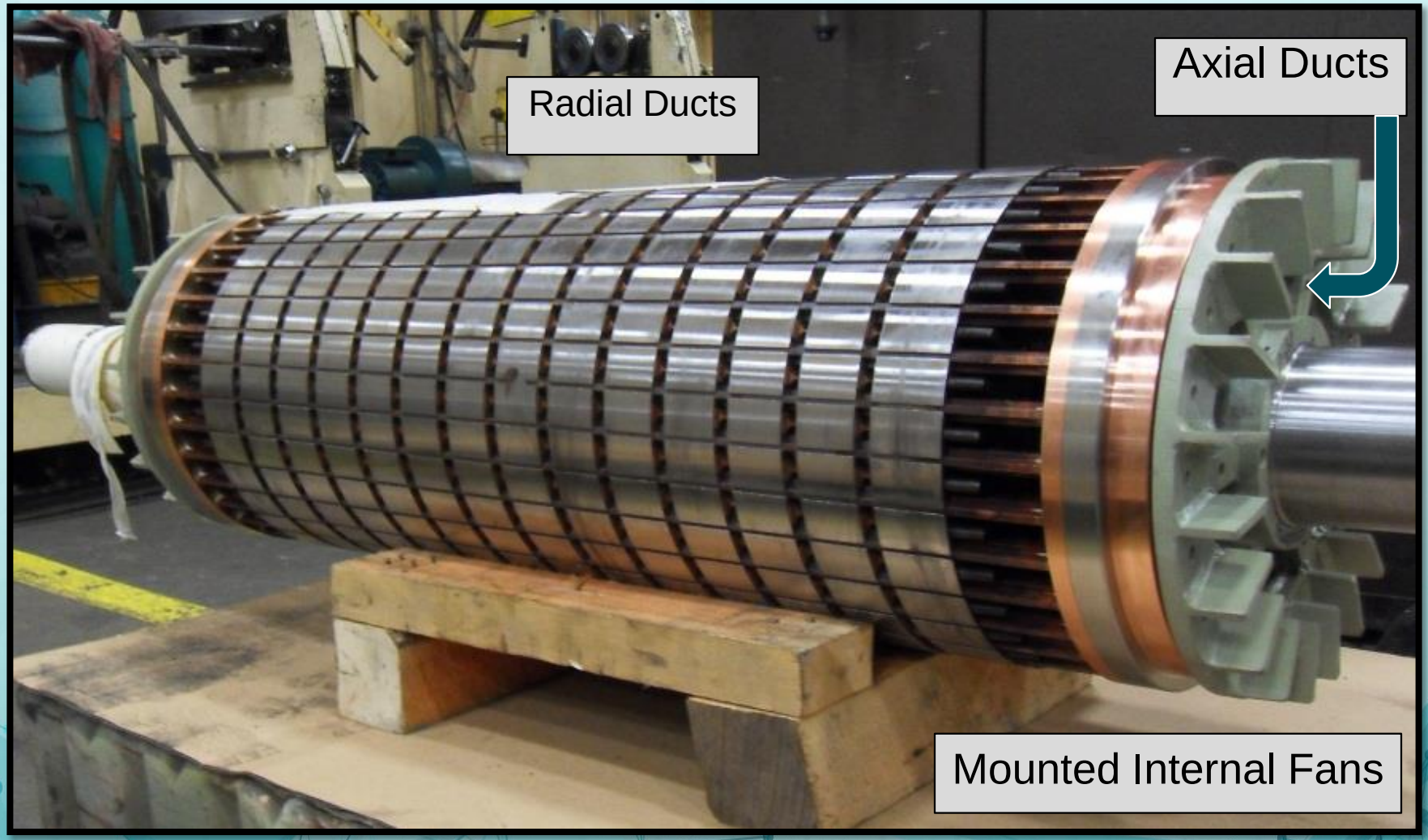


Radial Ducts

Notice:

- Integral cast fans
- Integral cast end rings
- Integral balance sprues
- Axial passages thru rotor
- Radial paths thru rotor laminations

Motor Rotor – Bar Ducted Design



Cast Rotor Construction

Cast Rotor Construction

- Rotor laminations and molds used to form the end rings and integrally cast fans are placed in a preheated oven.

Preheating helps ensure quality castings by reducing the stresses and voids that would occur due to temperature variations between the molten aluminum and the tooling.

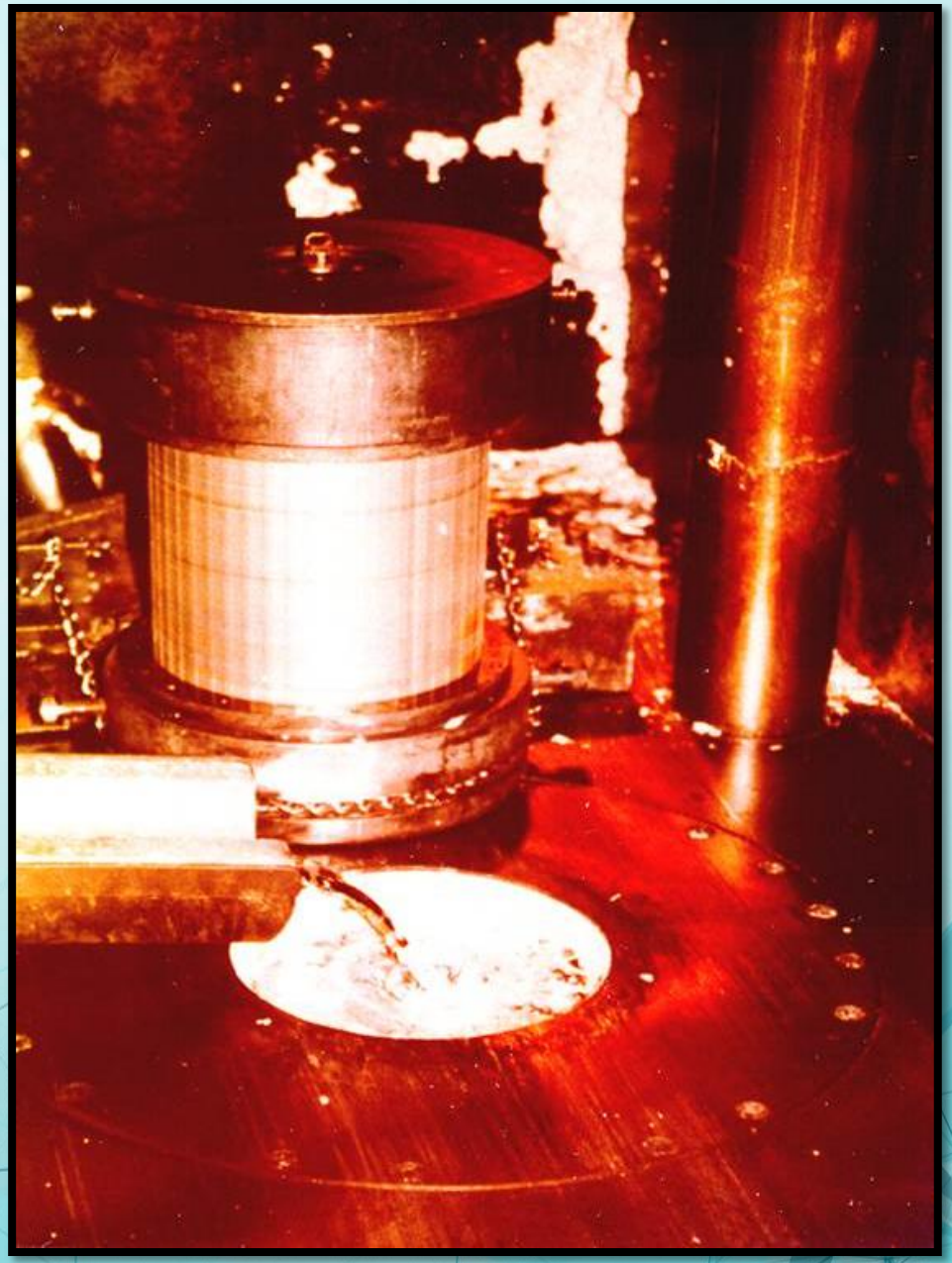
Cast Rotor Construction

- Laminations and molds are stacked on an arbor to form a tooling assembly

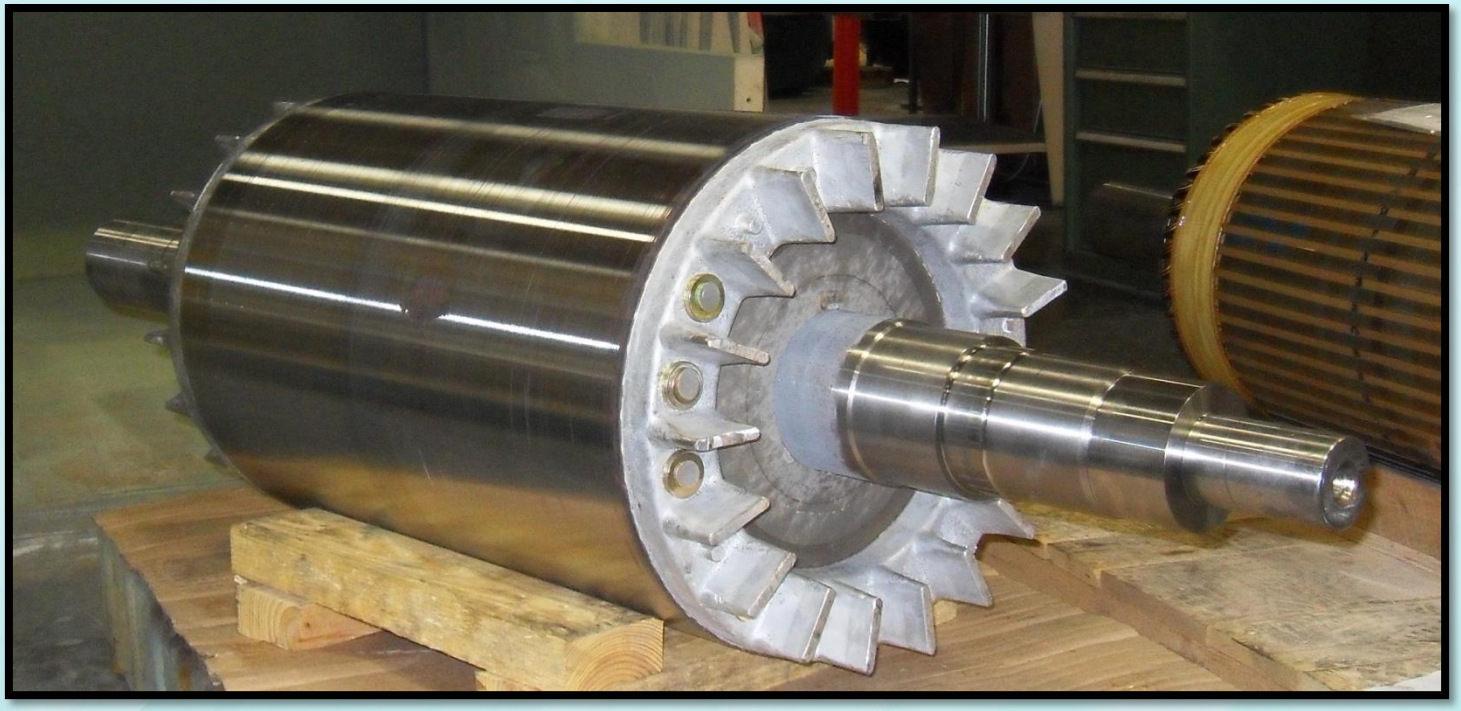
- Laminations are rotated during the punching operation to make sure that any thickness variations in the steel are evenly distributed along the length of the rotor.

Cast Rotor Construction

- Molten aluminum at over 1200 °F is poured into the shot well in the bottom of the casting machine.
- The tooling assembly is then placed over the well and pressed together.
- The casting machine door is closed and the aluminum is injected into the tooling assembly.
- Vent holes in the mold (near the top) allow for escape of gases.



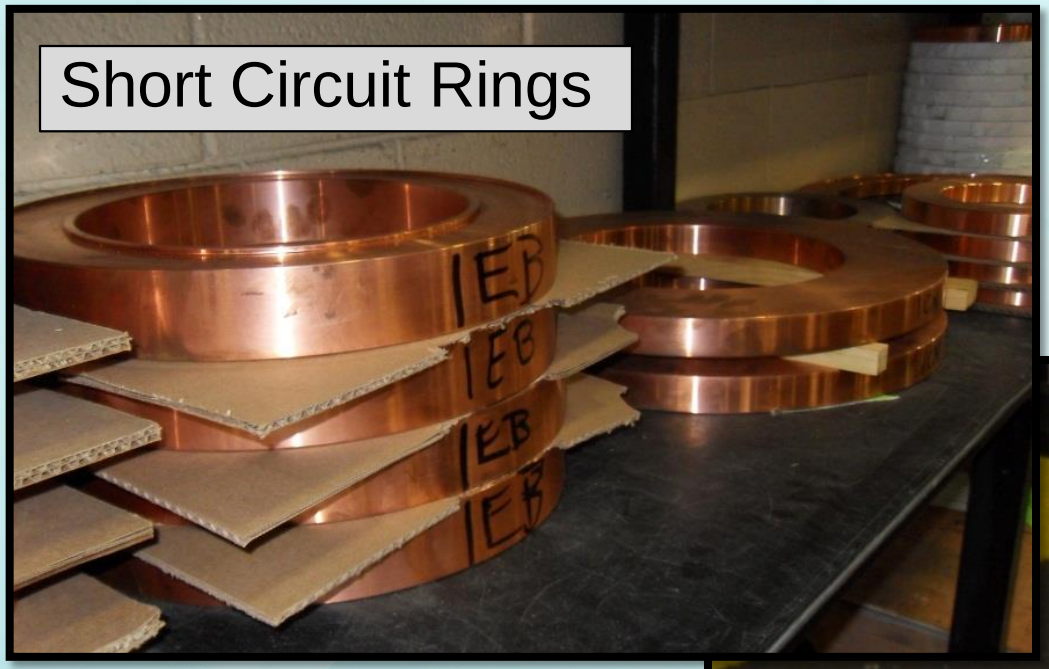
Cast Rotor Construction

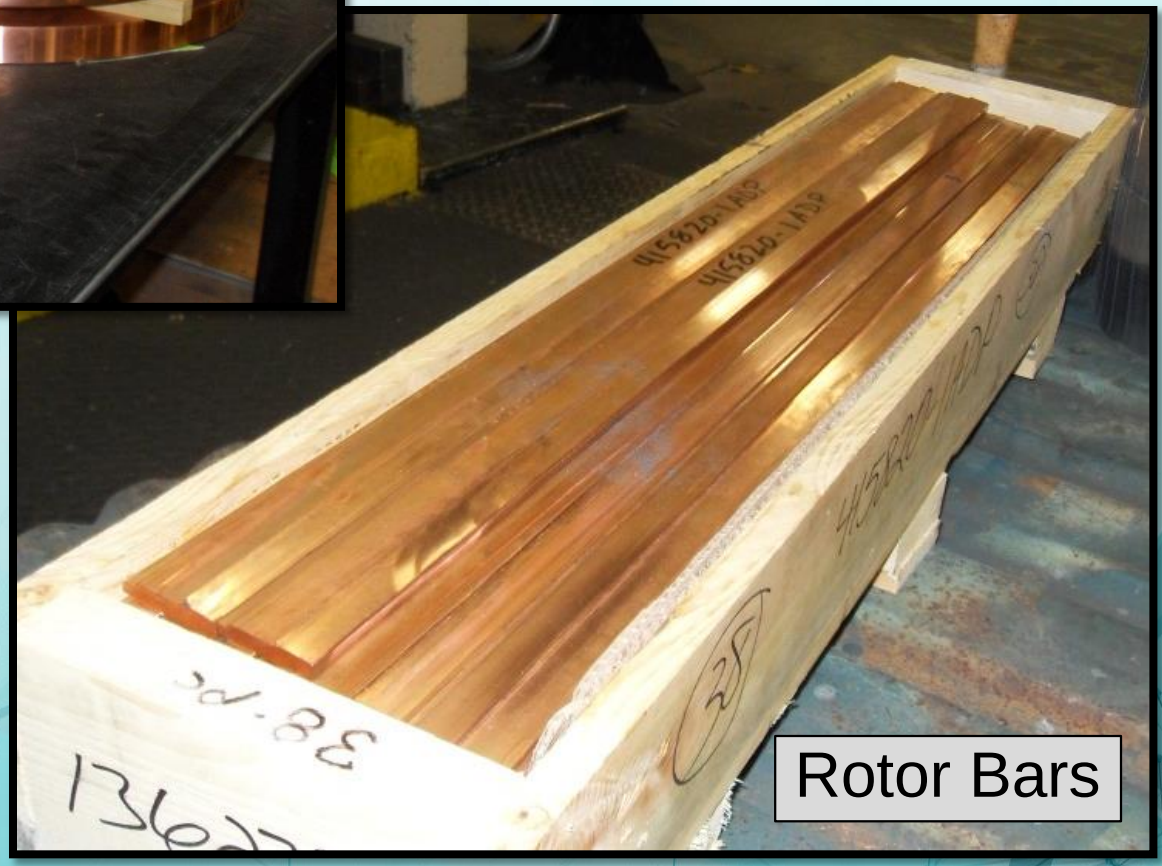


- The tooling assembly is removed from the casting machine and the lower and upper molds are removed.
- At this point the core is now held together by the bars and endrings which are cast into one continuous piece.
- The extra aluminum or flashing is then removed from the rotor by using a file or hand grinder.

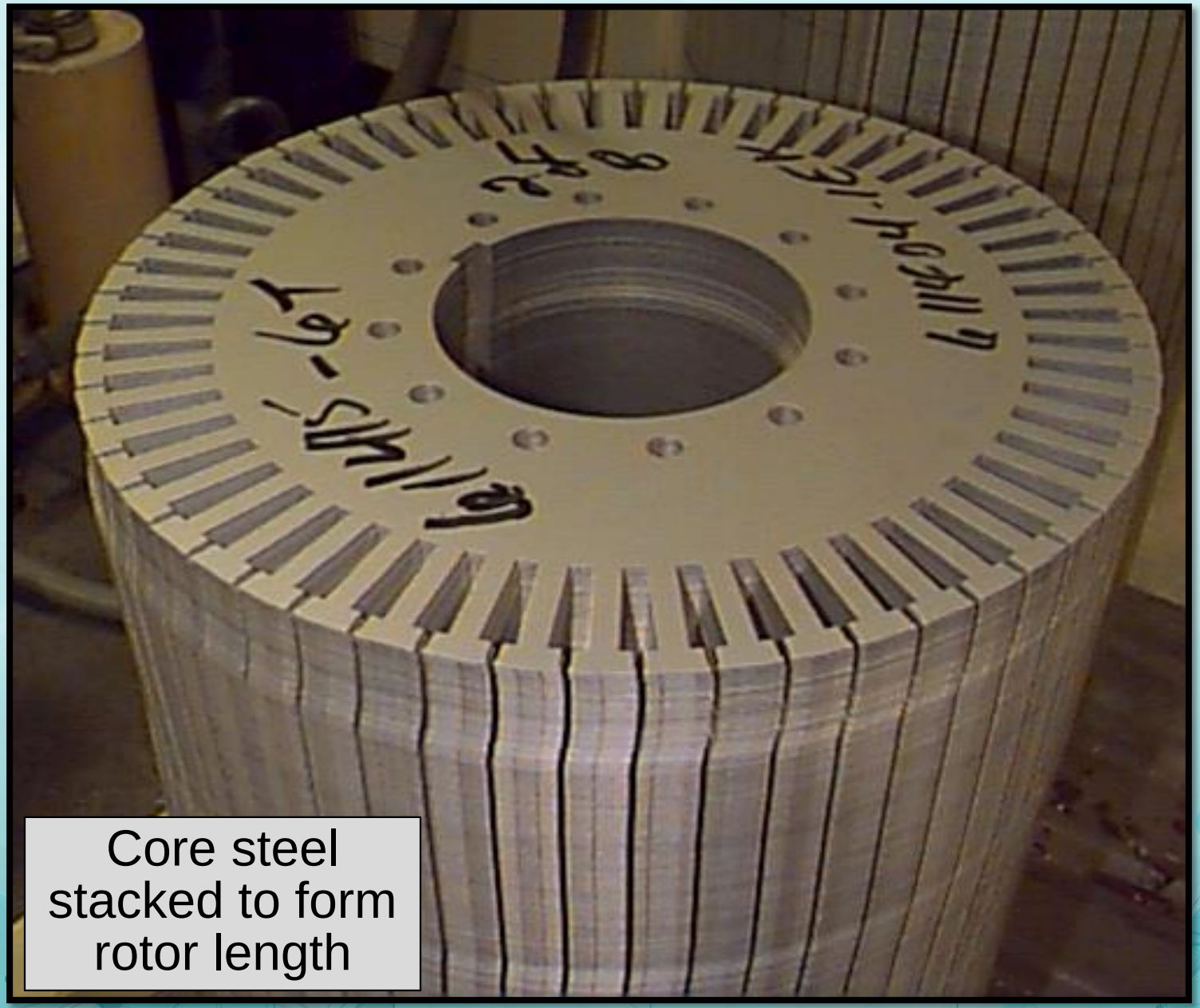
Copper Bar Rotor Construction

Copper Bar Rotor Construction



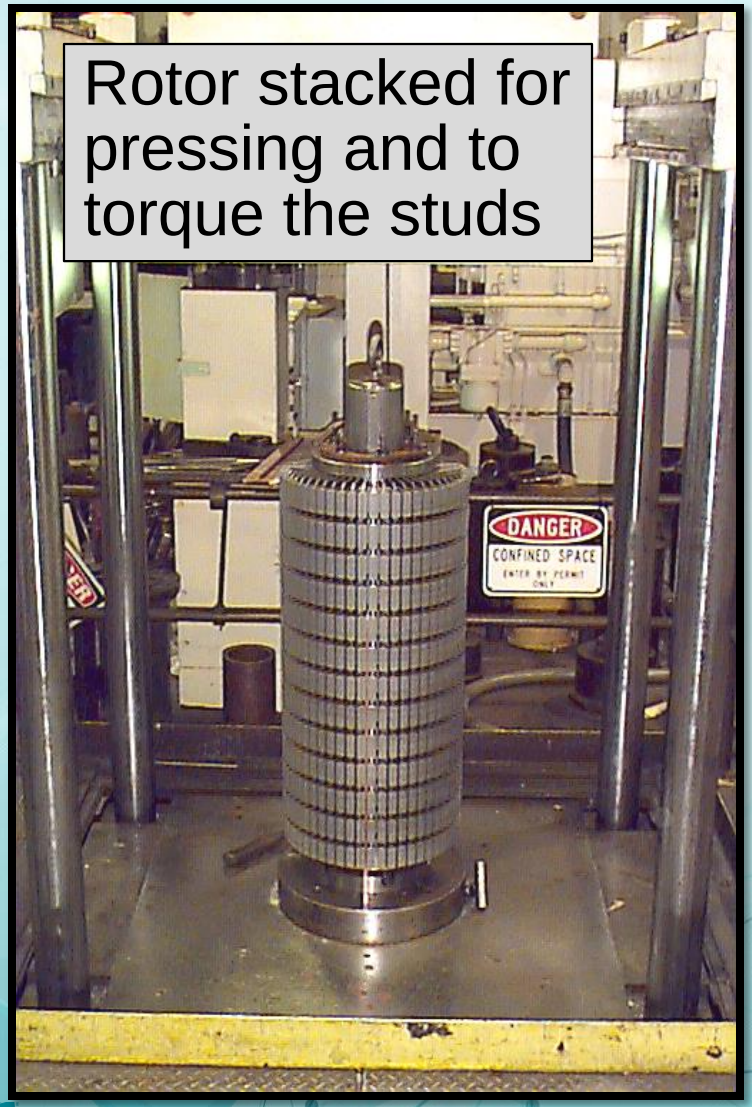


Copper Bar Rotor Construction



Core steel stacked to form rotor length

Copper Bar Rotor Construction



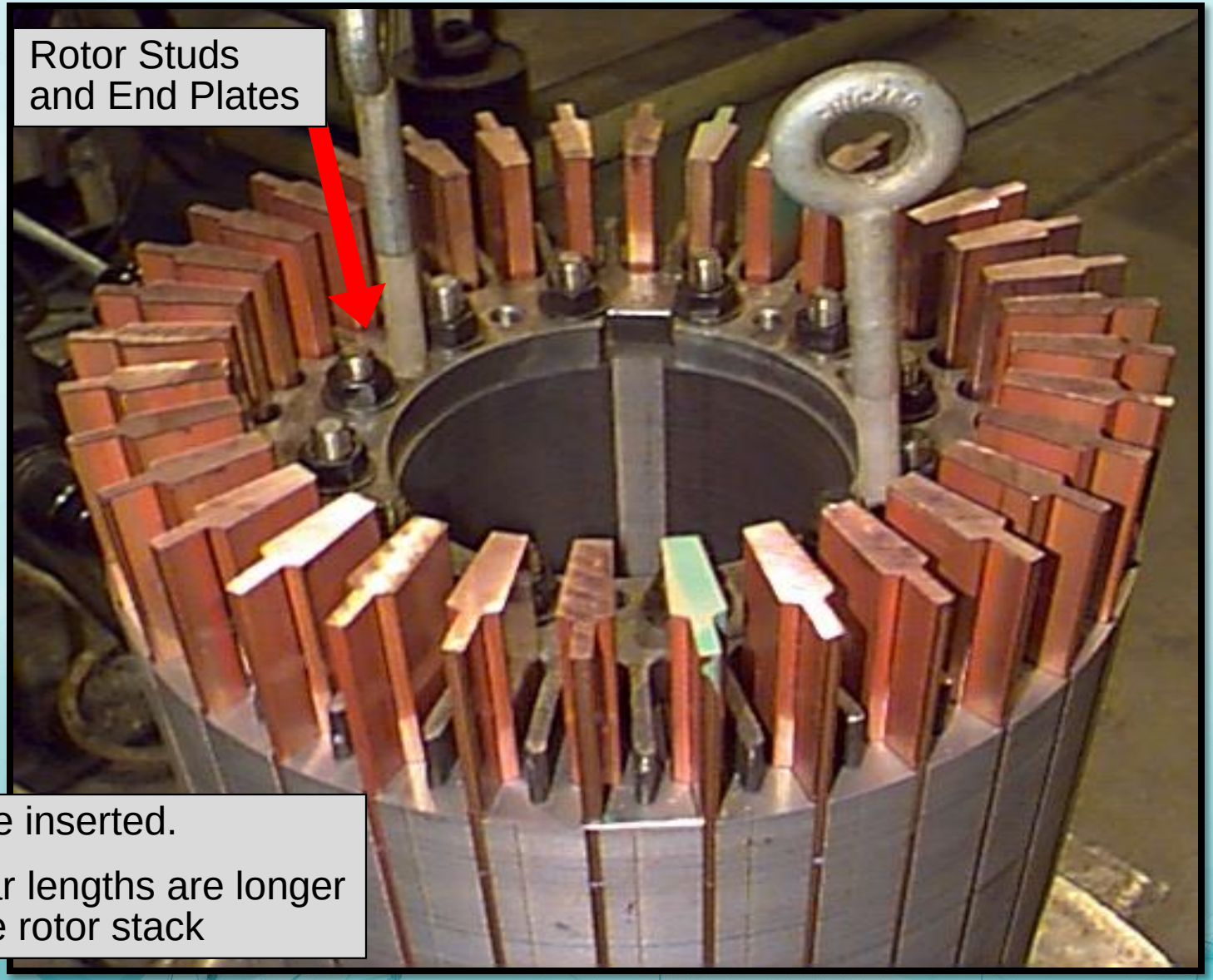
Rotor stacked for pressing and to torque the studs

Rotor Core Assembly

Copper Bar Rotor Construction

Inserting Bars

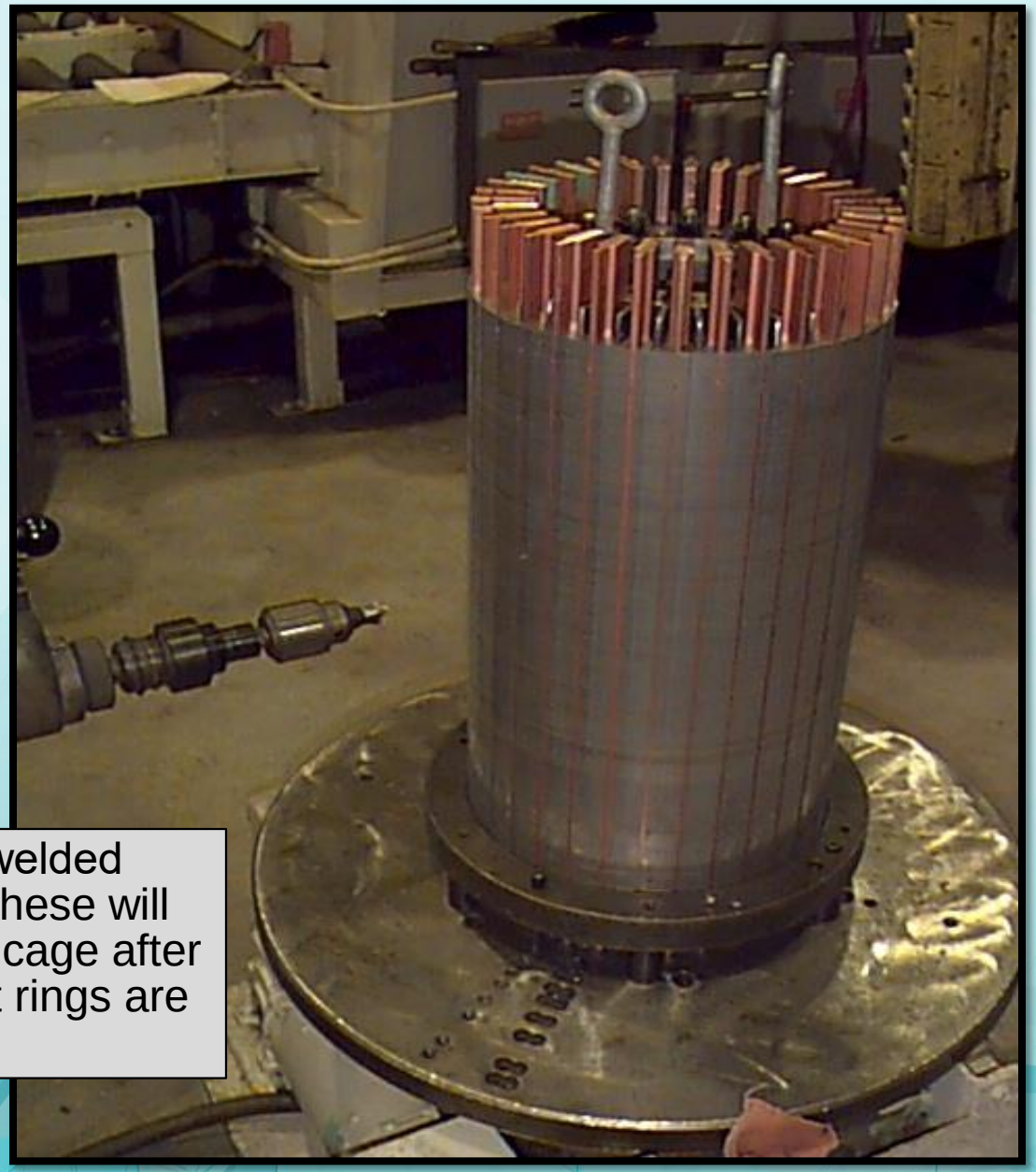
Copper Bar Rotor Construction



Bars are inserted.

Note bar lengths are longer than the rotor stack

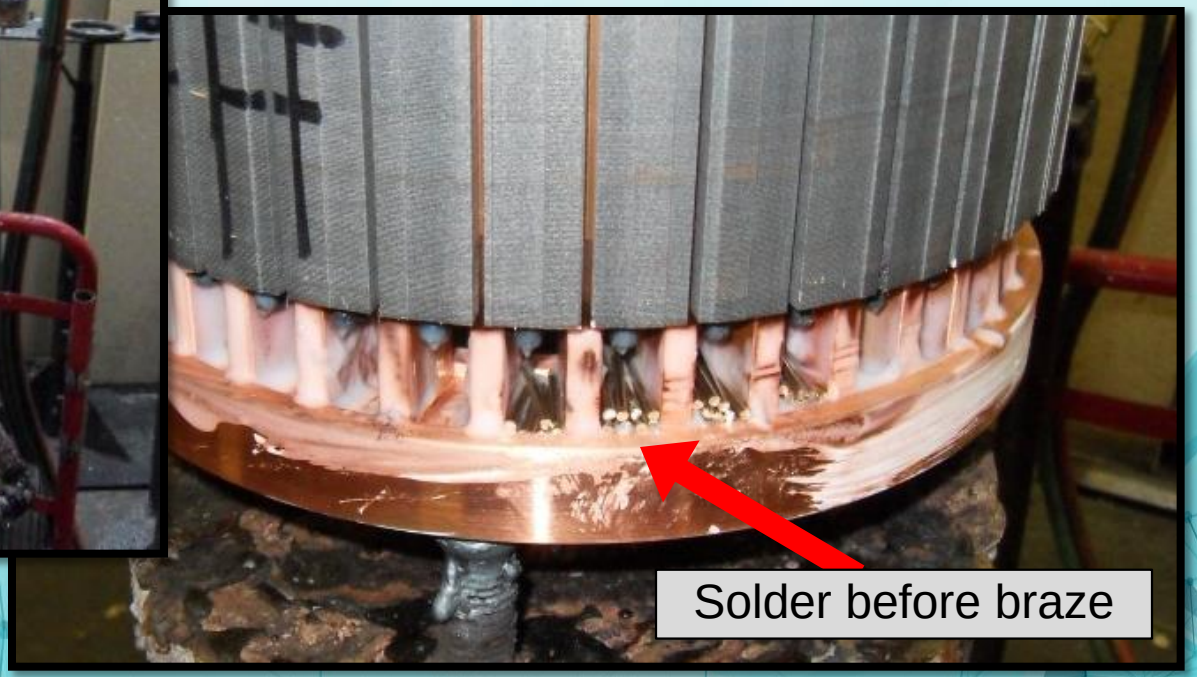
Copper Bar Rotor Construction



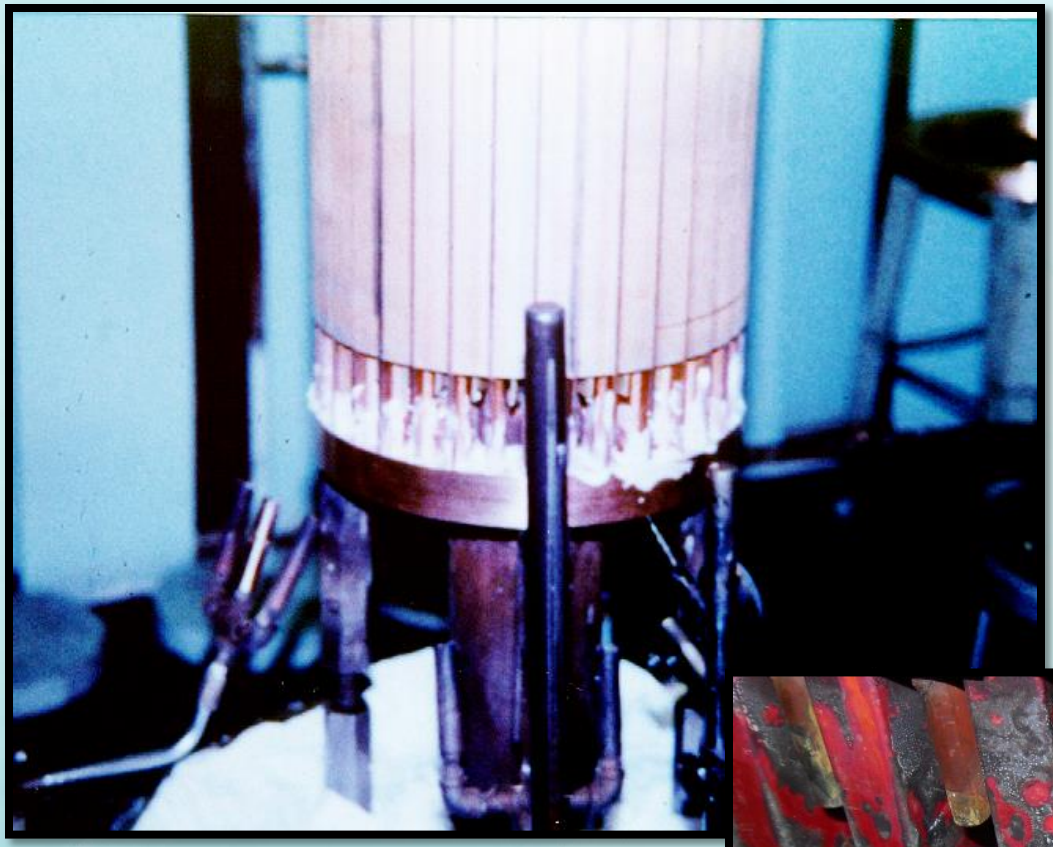
6-8 “Pins” are welded into the rotor. These will help locate the cage after the short circuit rings are brazed on.

Copper Bar Rotor Construction

- Silver Solder and Flux installed between bars.
- A machine cuts each piece of solder to the same length from a spool of material.
- The same number of solder pieces are placed between each bar.



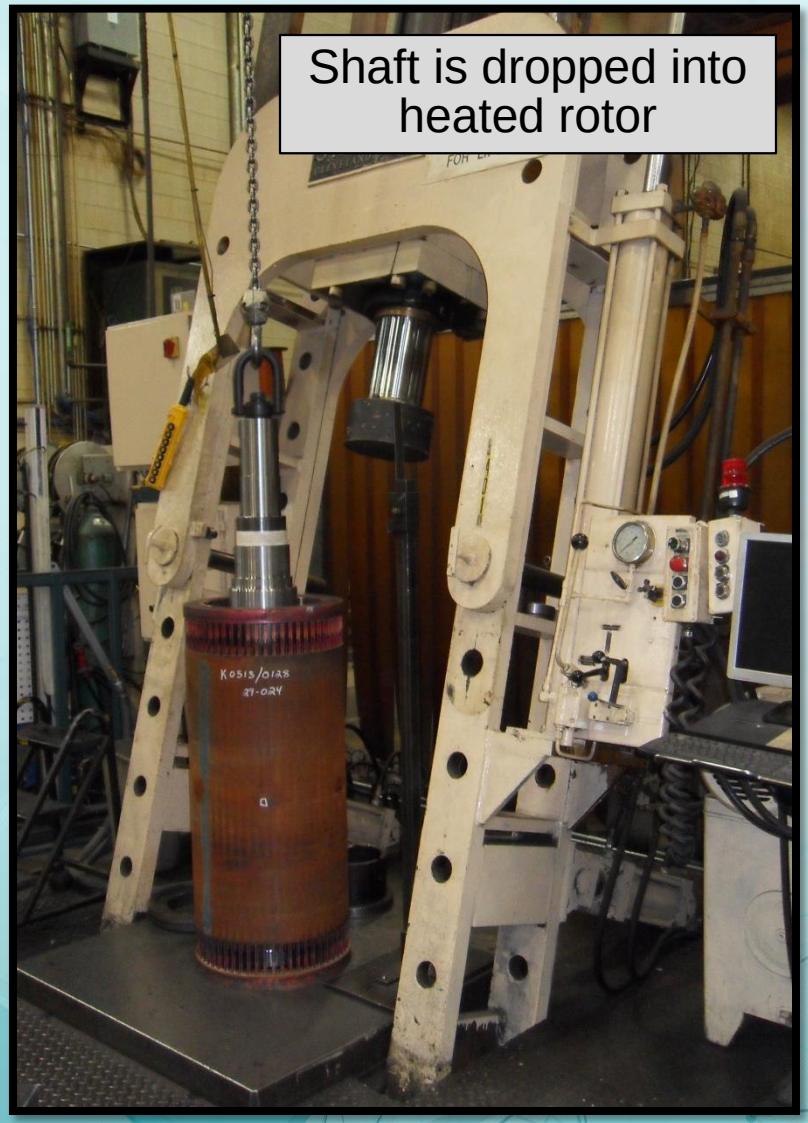
Copper Bar Rotor Construction

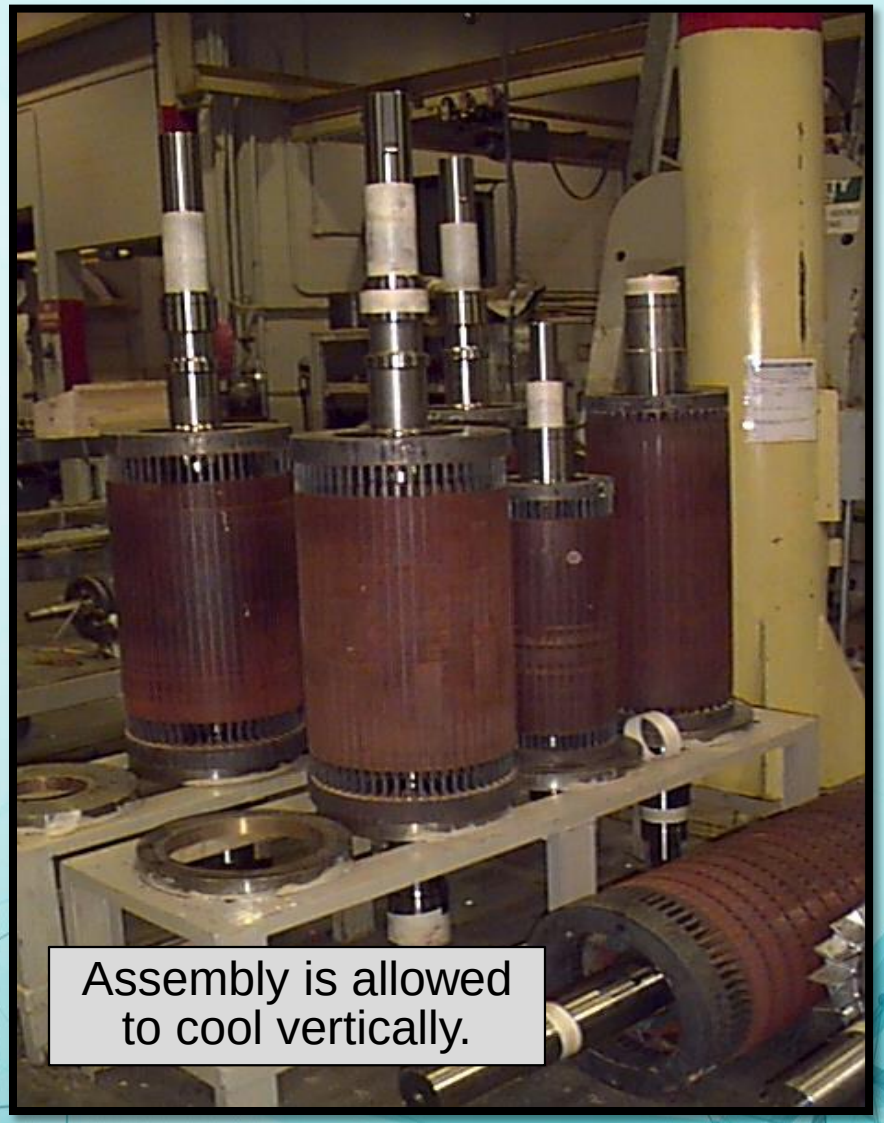


Solder after braze

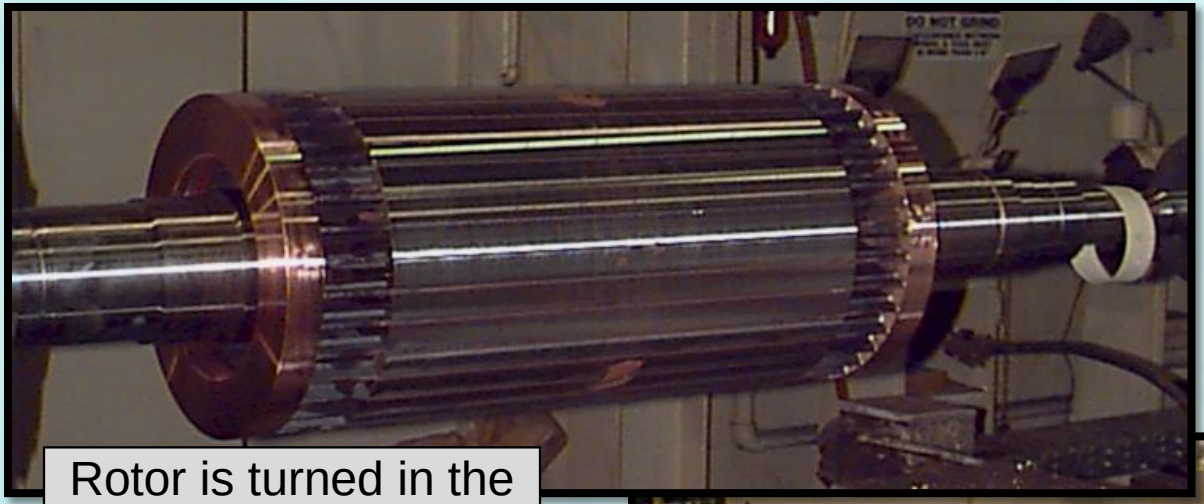
Rotor/Shaft Construction

Rotor/Shaft Construction

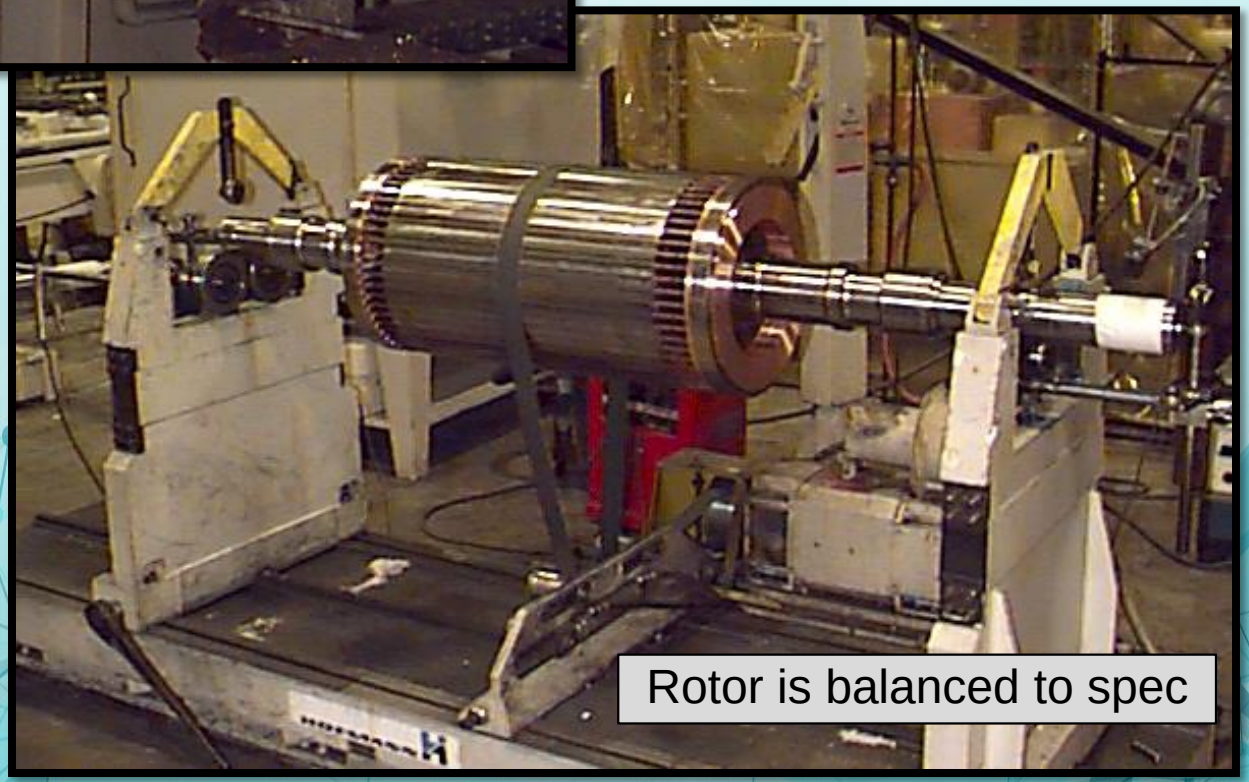




Rotor/Shaft Construction

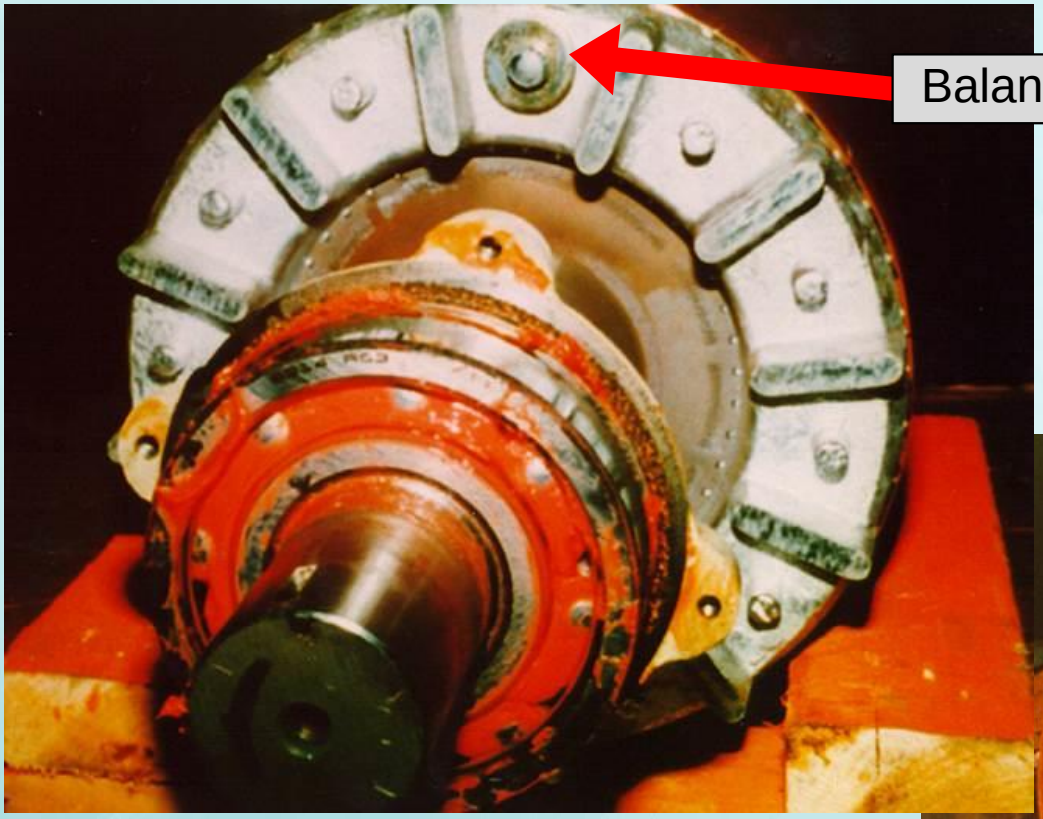


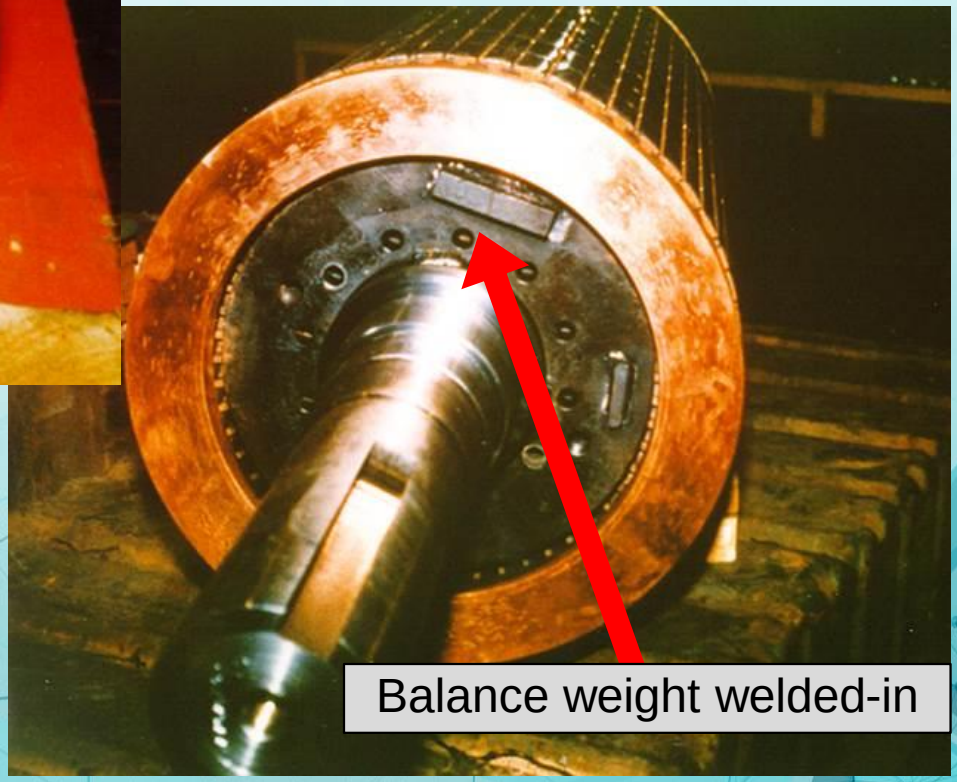
Rotor is turned in the lathe to size



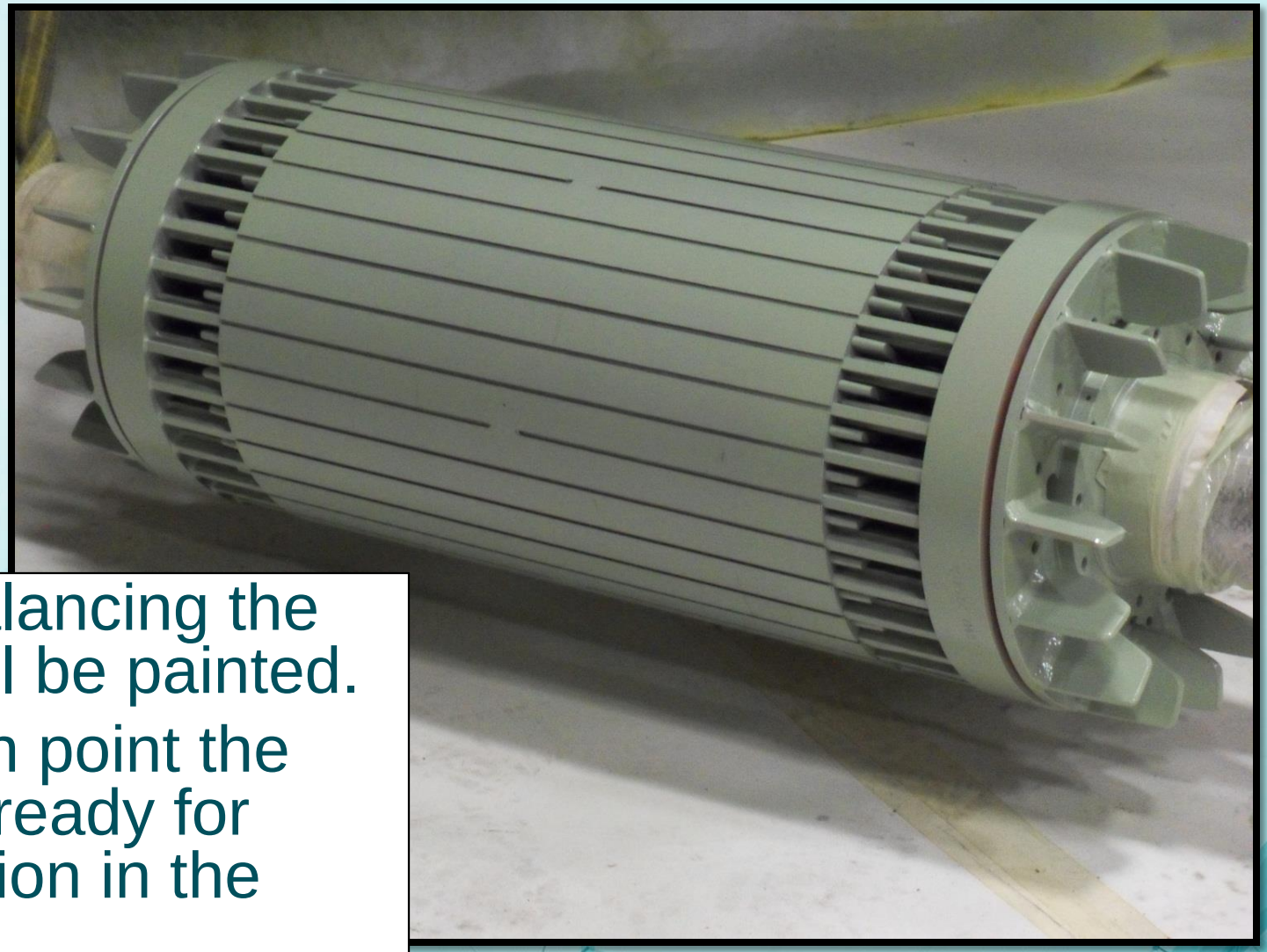
Rotor is balanced to spec

Rotor/Shaft Balance





Rotor/Shaft Construction



- After balancing the rotor will be painted.
- At which point the rotor is ready for installation in the motor.

Motor End Plates

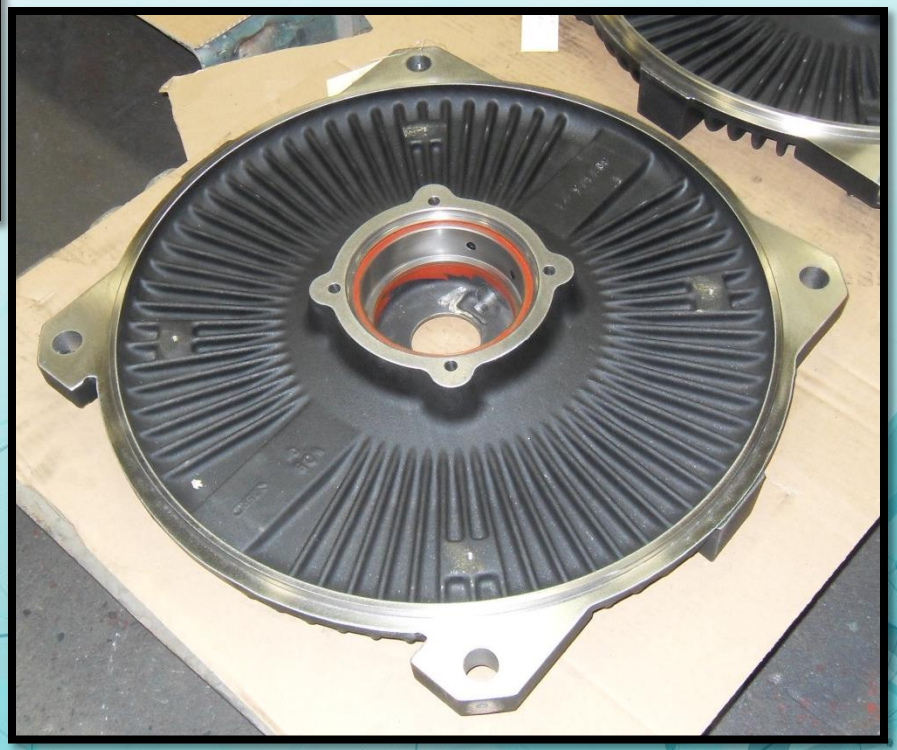
Motor End Plates

- Typical construction materials:
  - Cast Iron
  - Ductile Iron
  - Fabricated Steel

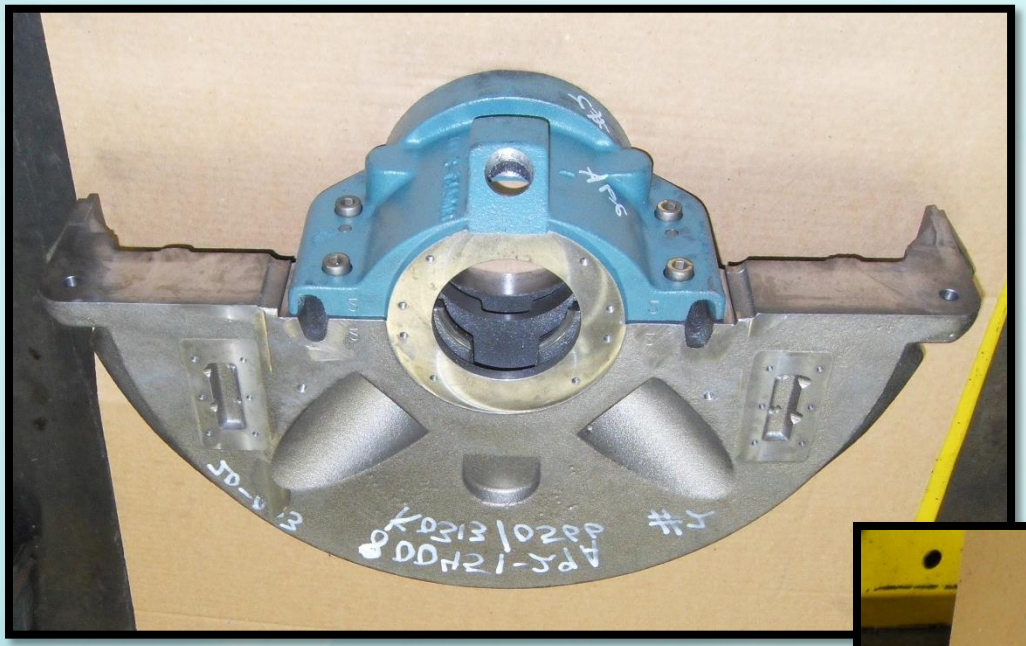
Also, known as:

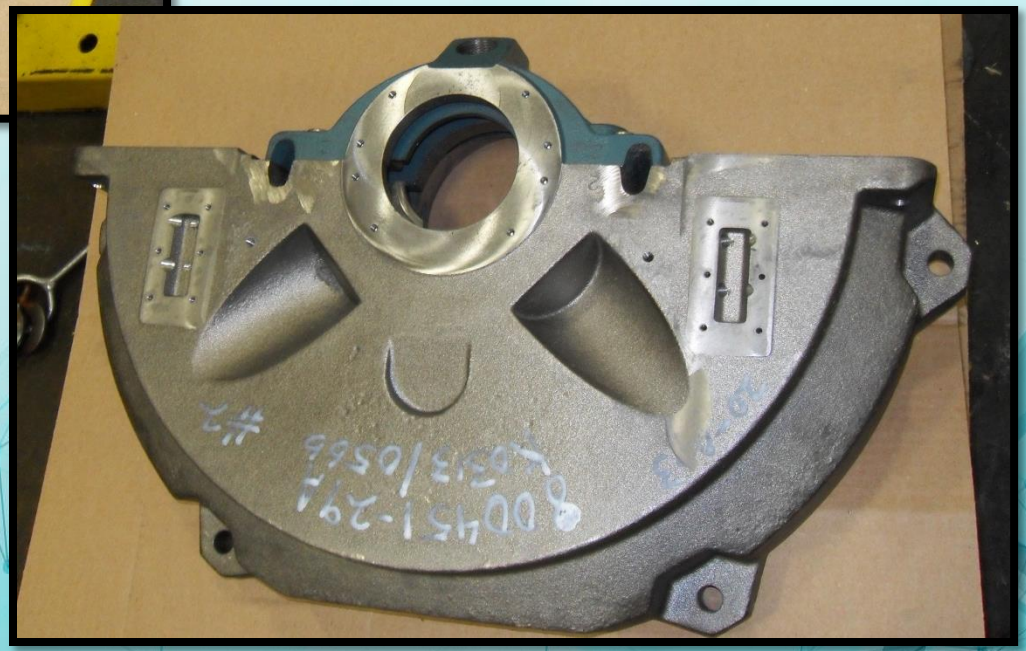
- “End bells”
- “Brackets”
- “Cartridges”

Motor End Plates – A/F



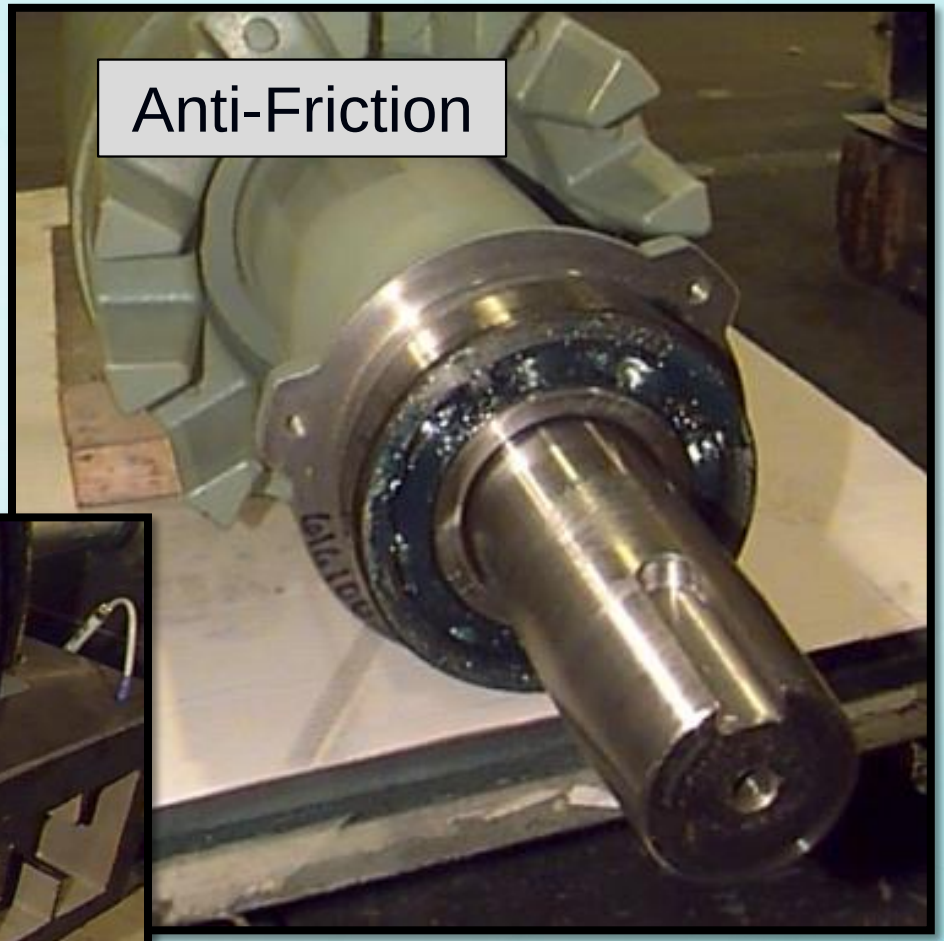
Motor End Plates – Sleeve Brgs



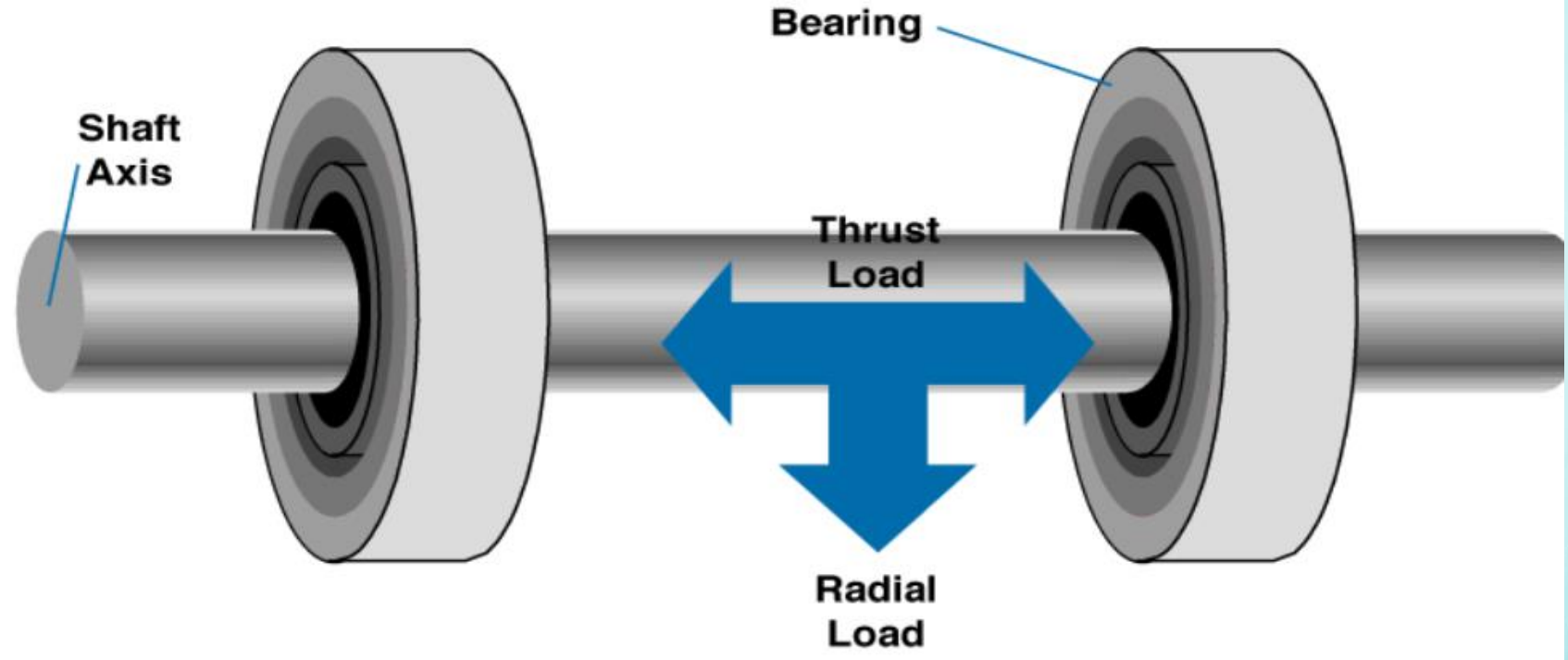


Motor Bearings

Motor Bearings

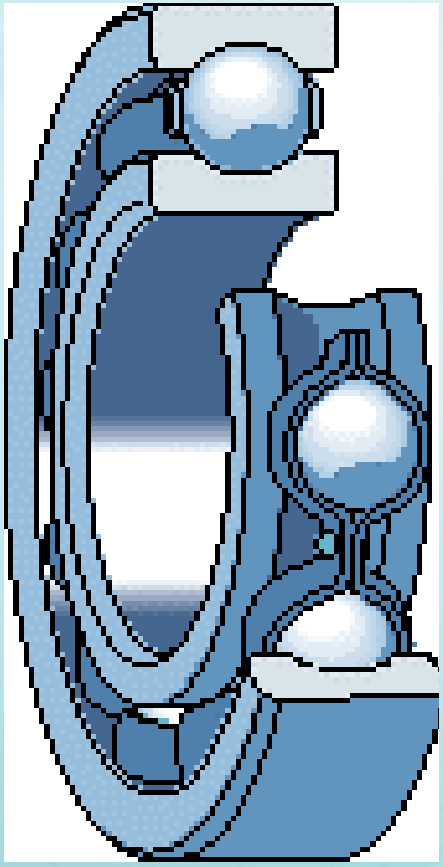


Purpose of Motor Bearings



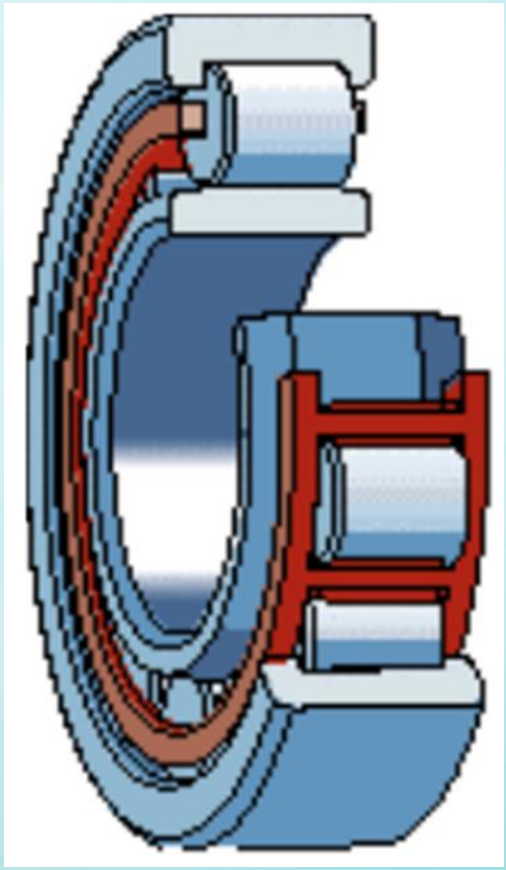
- Support and locate the rotor
- Keep the air-gap small and consistent
- Transfer loads from the shaft to motor frame

Anti-friction Bearings



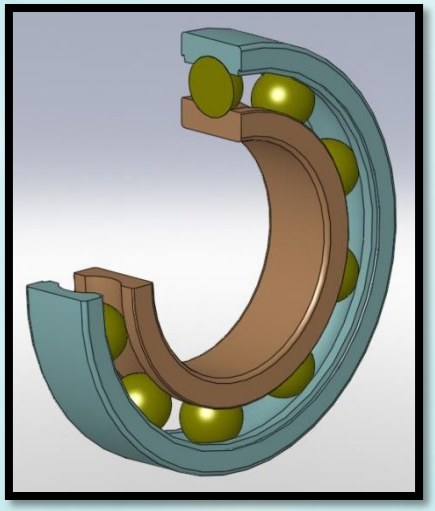
Deep Groove Ball

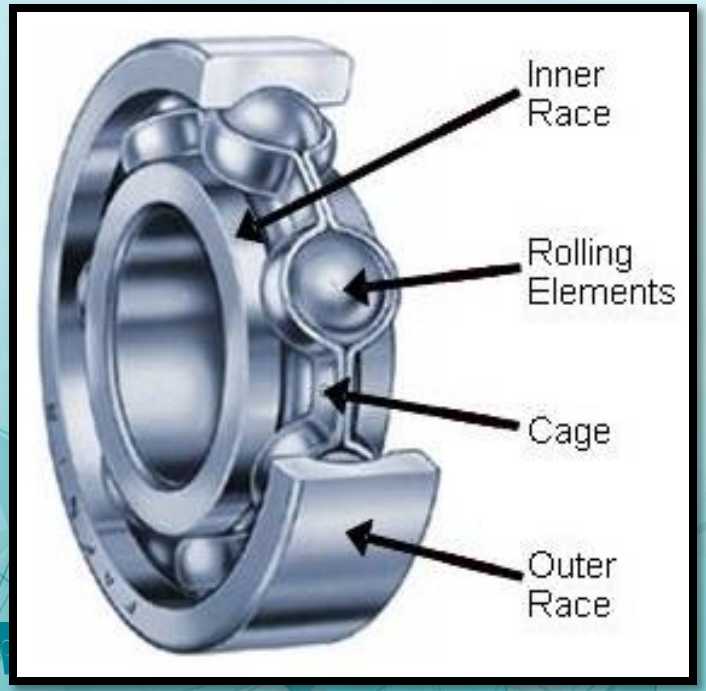
Angular Contact



Cylindrical Roller

Deep Groove Ball Bearing

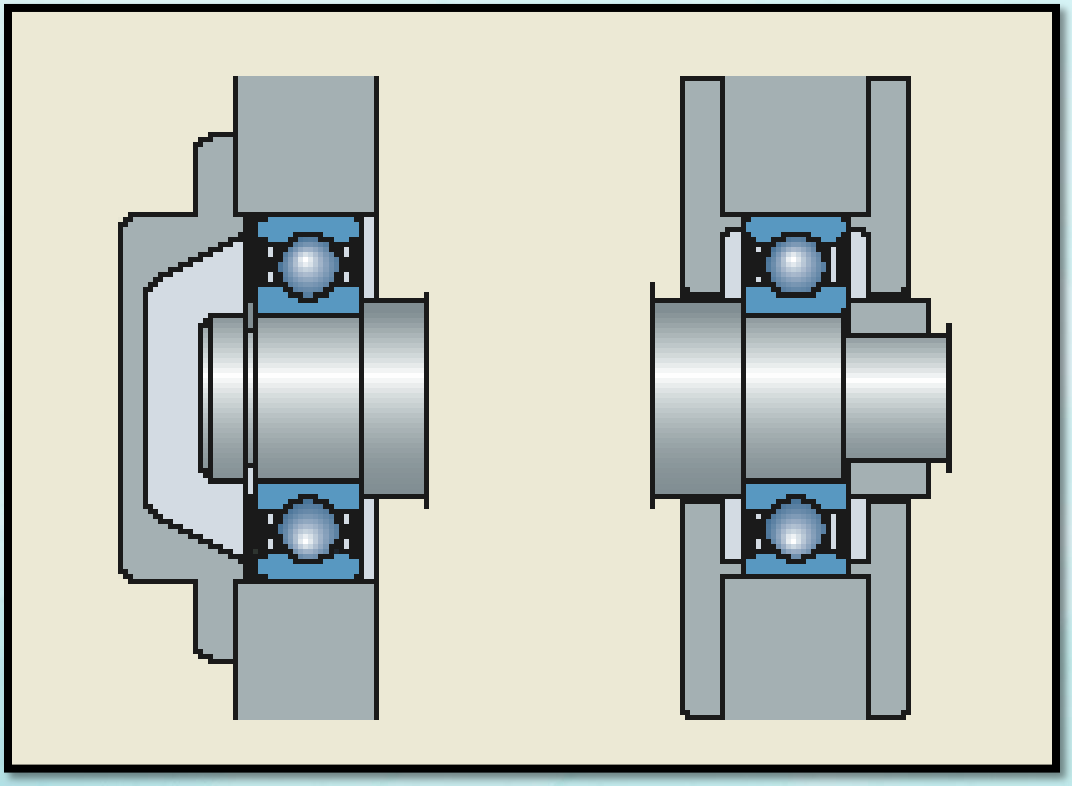




- Common bearing type
- High speed and quiet running capabilities
- Moderate radial and axial loading capability
- Low minimum radial loading required
- Economical

	Geometry	***Point of Contact***
Ball		

Anti-Friction Bearing Mounting



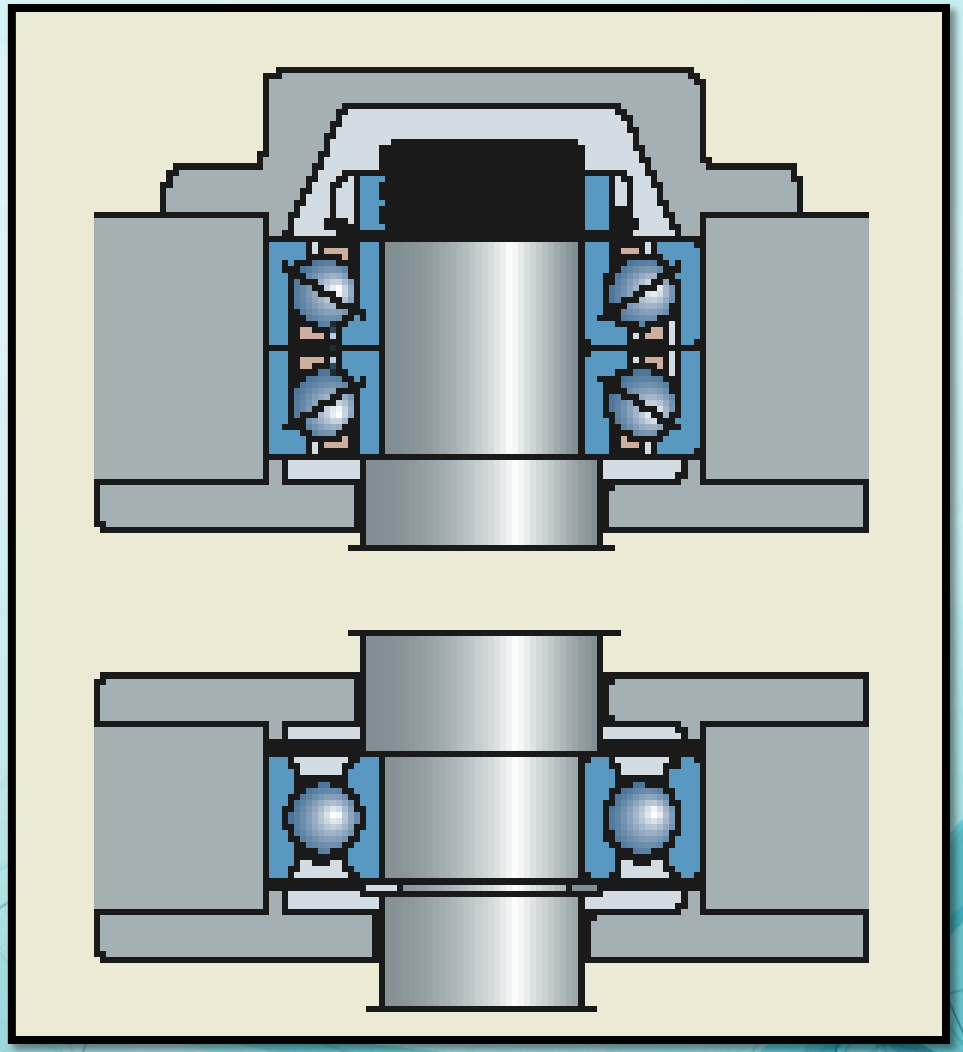
- Two Deep Groove Ball Bearings
- Fixed and Free (Expansion) setups
- Snap Rings or Locknuts with shaft shoulders

Angular Contact Ball Bearings

- High axial load and combined load capability
- Good high speed capability
- Low friction
- Usually used vertical motors
- Low minimum load requirements
- Used in pairs for reversing axial loads

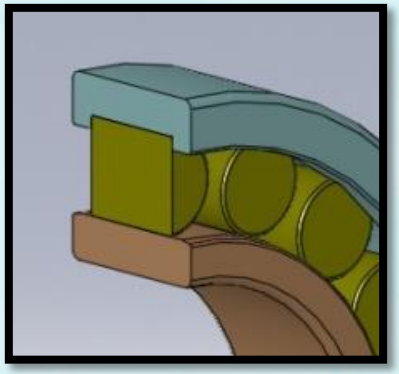
Vertical Motor Brg Arrangement

- Paired angular contact thrust bearings on ODE.
- Ball guide bearing on DE.
- Moderate axial loads in both directions with back to back (duplex) arrangement.
- Heavy axial load in one direction with tandem arrangement

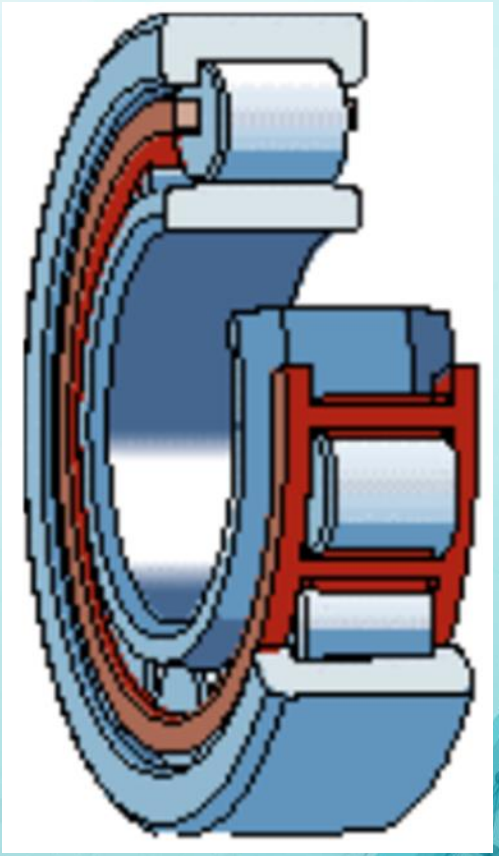


Cylindrical Roller Bearing

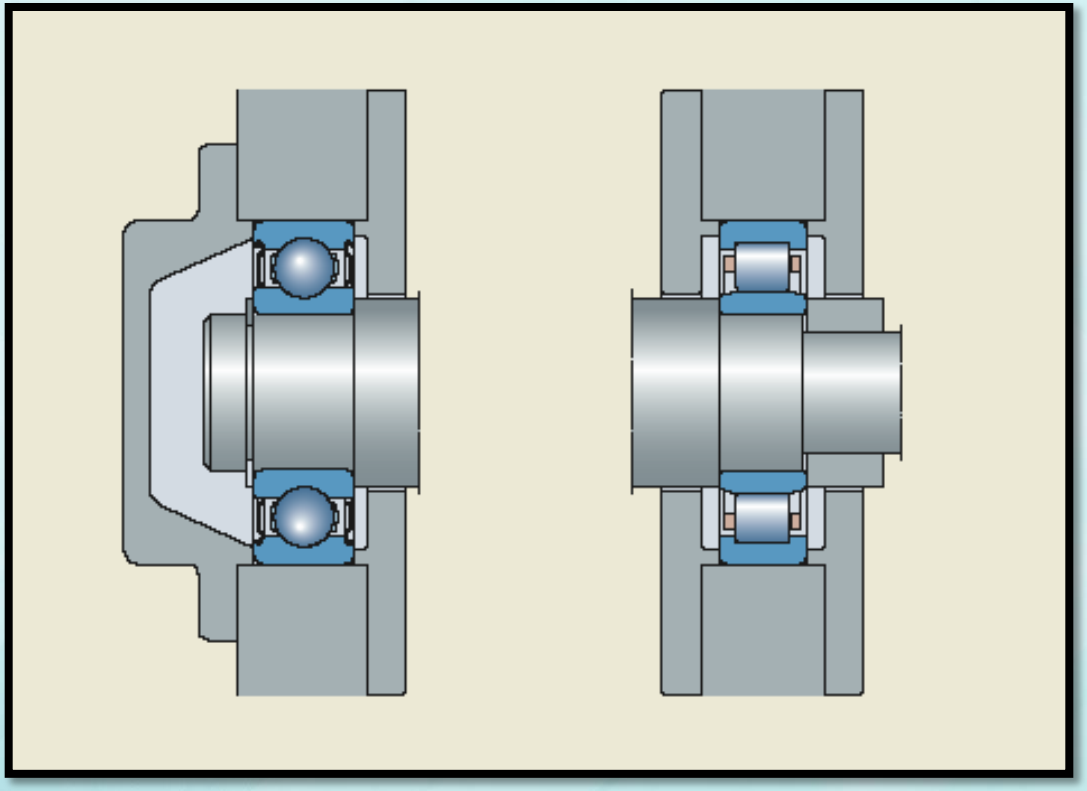
	Geometry	Point of Contact
Cylindrical Roller		



- Axially free bearing design (internally)
- Opposite drive end bearing must be held captive with retainer
- Heavy radial load capability
- Minimum radial load required greater than ball bearings
- Speed limitations could exist



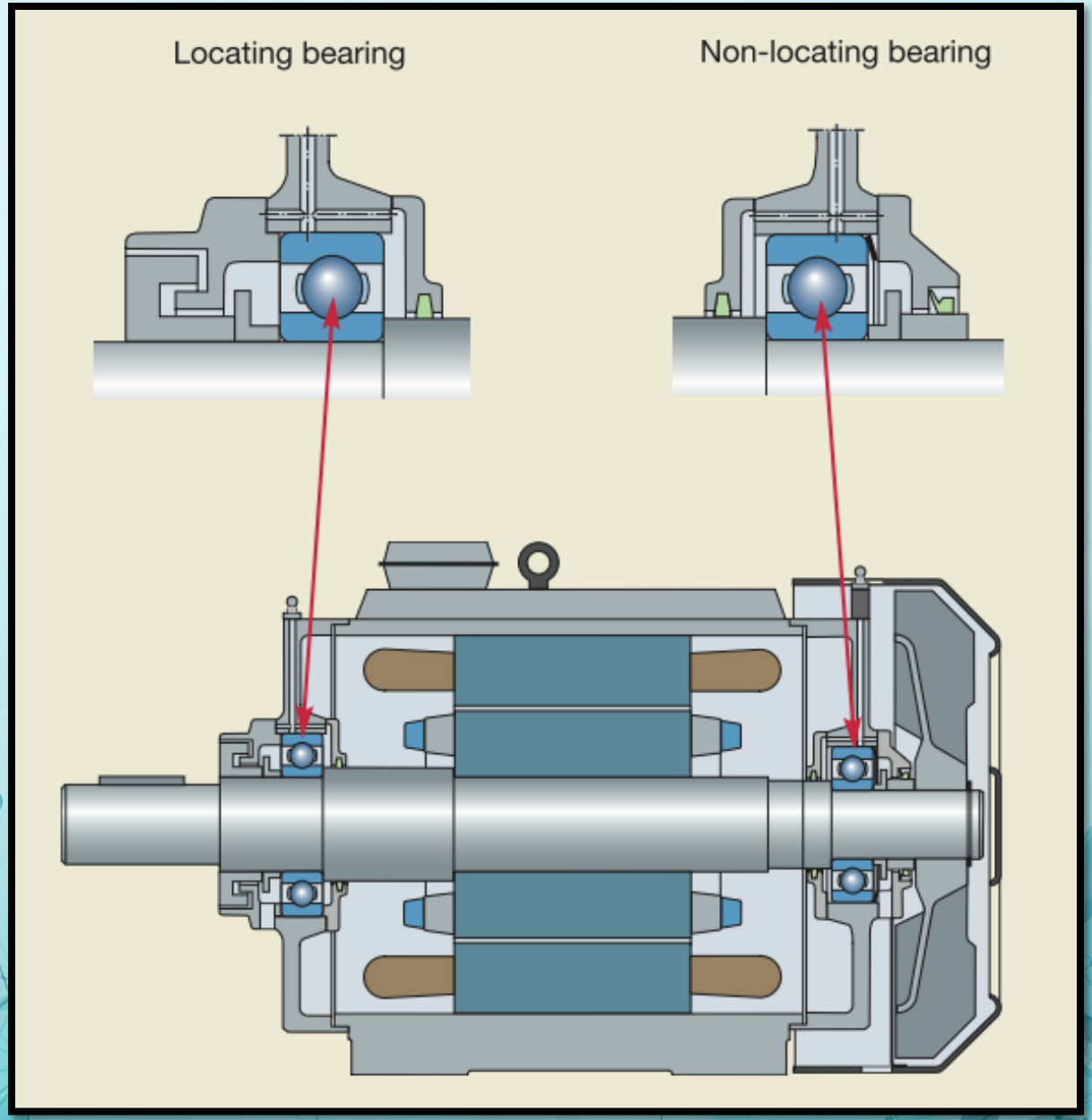
Anti-Friction Bearing Mounting



- Roller bearing on drive end
- Ball bearing on non-drive end
- The locating bearing is the non-drive end

Typical NEMA Motor Bearing Arrangement

- Why?
  - Drive End is fixed (locating)
  - Opposite drive end is allowed to float
  - Allows for shaft expansion when motor is running



Quiz

- What are the two most common rotor types?
- What are the two most common types of bearings?
- Why are some end bearings allowed to float?

- Cast rotor and Copper Bar rotor
- Sleeve and Anti-Friction
- To allow for heat expansion