Electric Motors: Repair or Replace?

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Introduction

- Perennial plant maintenance questions:
  - Is it better to repair or replace an electric motor that has failed?
  - Will a repaired motor retain its efficiency?
- We will answer the above, and provide:
  - Better understanding of key criteria to consider when facing this decision
  - Details about EASA Accreditation Program for electric motor repair

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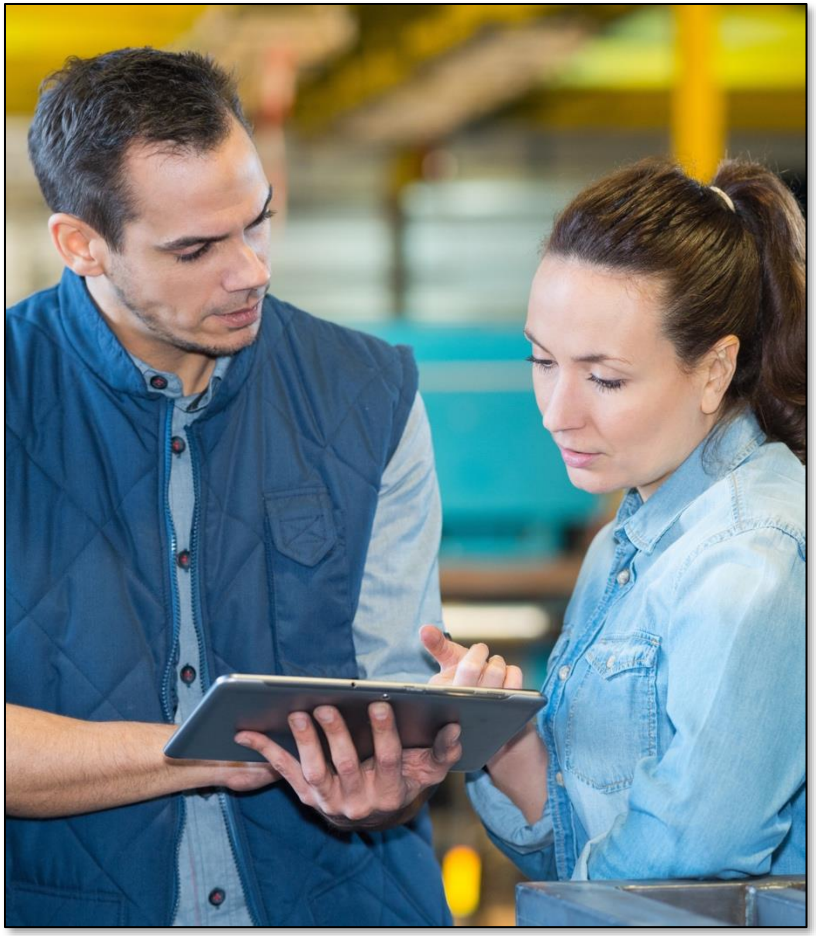
Repair/replace decision-making process

- Well-informed decisions involve many criteria
  - Suitability for application
  - Condition of stator core and rotor
  - Efficiency rating; lifecycle costing
  - Availability of funds and replacement motor
  - If it's not an EPAct (IEC IE2) or NEMA Premium® (IEC IE3), is ROI of replacement acceptable?
- Specific applications may add unique criteria
- Flowchart on next slide provides overview of process



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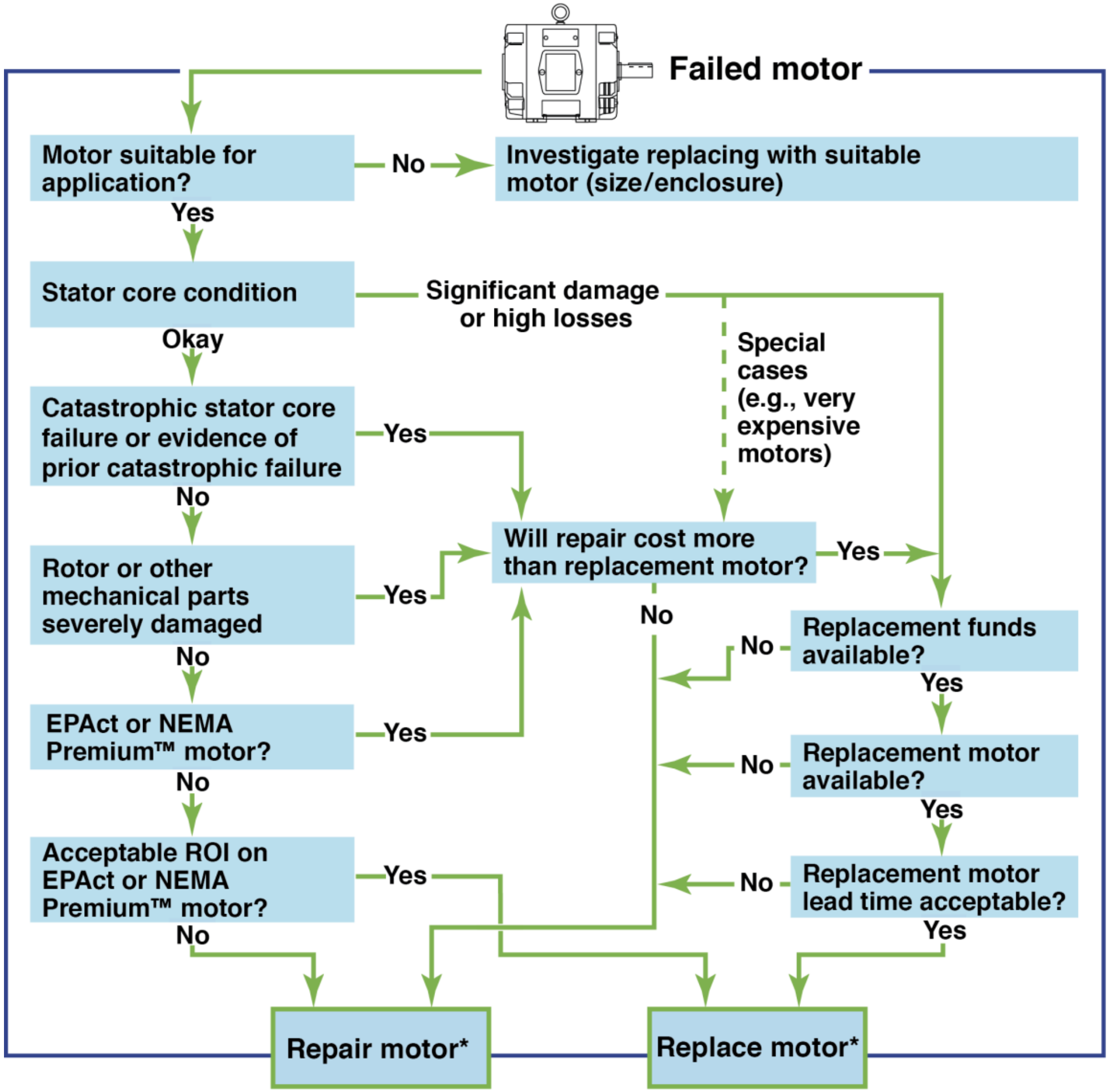
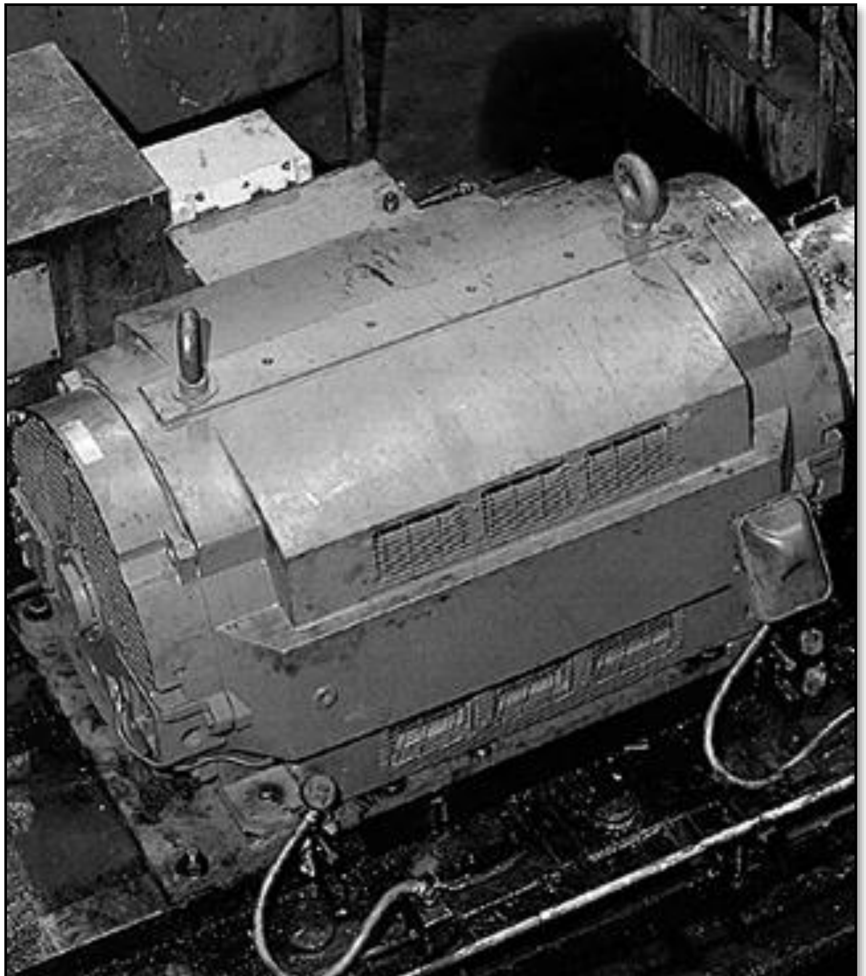
Repair/replace decision flowchart



* Other considerations include increased reliability, life expectancy, and benefits of additional features, upgrades or modifications.

Review application



Suitable for application?

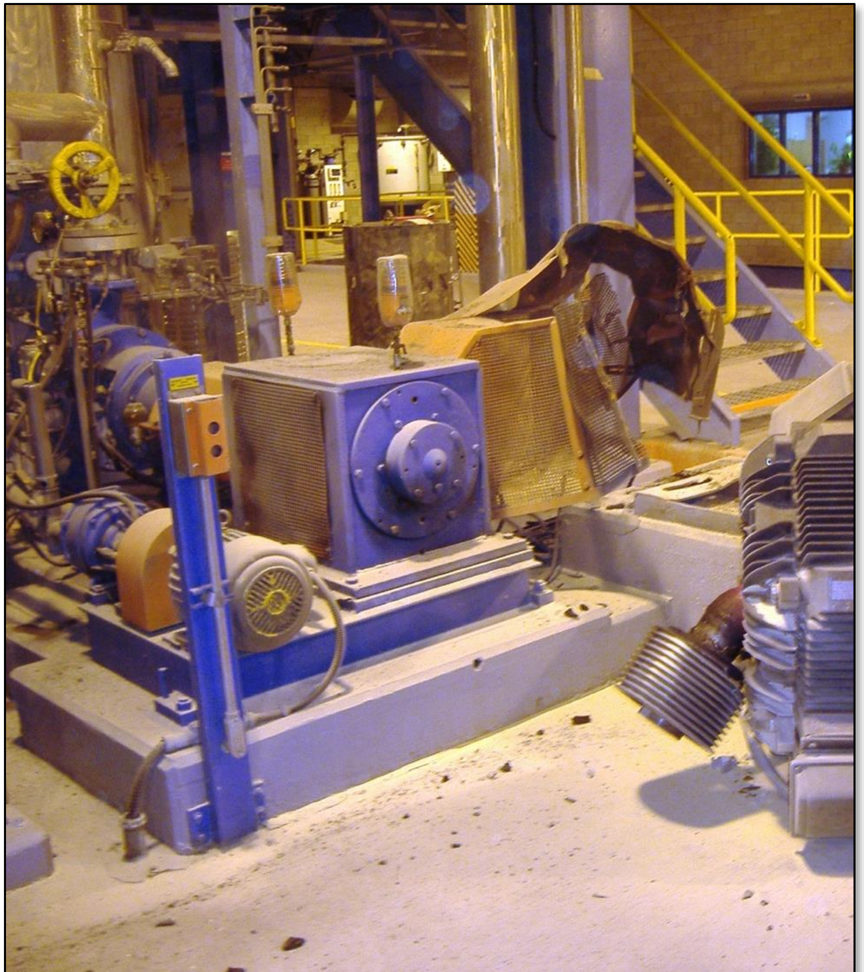
Example
Open enclosure may not be practical for paper mill

- Airborne moisture & debris
- <u>Better choice</u>
  Totally-enclosed, fan-cooled (TEFC) replacement, but add:
  - Weep/drain holes
  - Space heaters

Review application

- Reassess application as part of repair/replace decision
  - Processes and duty cycles can change over time
- Even better approach
  - Assess all critical applications prior to failure as part of a motor management plan

Multiple decision points



Consider these decision points simultaneously:

- Is the present failure catastrophic?
- Is there evidence of a prior catastrophic failure?
- Is the rotor damaged?
- Are other mechanical parts severely damaged?
- Is it an EPAct (IE2) or NEMA Premium® (IE3) motor?

Catastrophic failure — present

- Evaluate cost of repair vs. replacement
- Catastrophic failures typically do considerable damage to:
  - Stator core
  - Windings
  - Other motor parts, including:
    - Rotor
    - Shaft and bearings
    - End brackets
- Replacement may be most economical option (especially if suitability for application is questionable)

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Catastrophic failure — prior

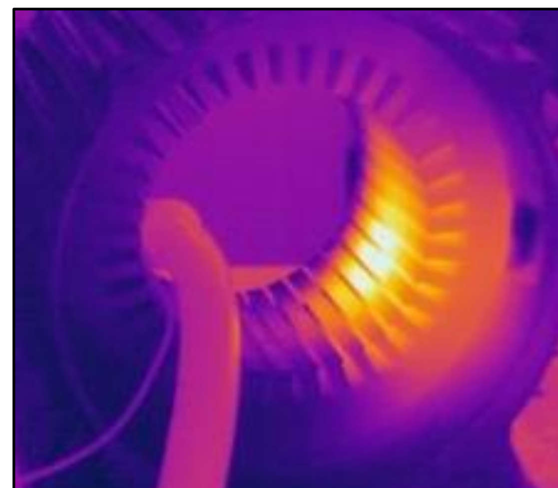
Evidence of prior catastrophic failure may be apparent only after motor disassembly, e.g.:

- Damaged stator core laminations
- Damaged rotor core
- Damaged rotor bars or end rings
- Bent shaft that has bent again

Stator core condition

If failed motor suits application:

- Assess condition of stator core
  - Is damage significant?
  - Did motor exceed rated temperature rise before it failed (e.g., due to high core losses)?
- If core damage is significant, may be more economical to buy new motor
  - Repair of seriously degraded stator core can be expensive
  - Unless motor has special features affecting replacement price or availability



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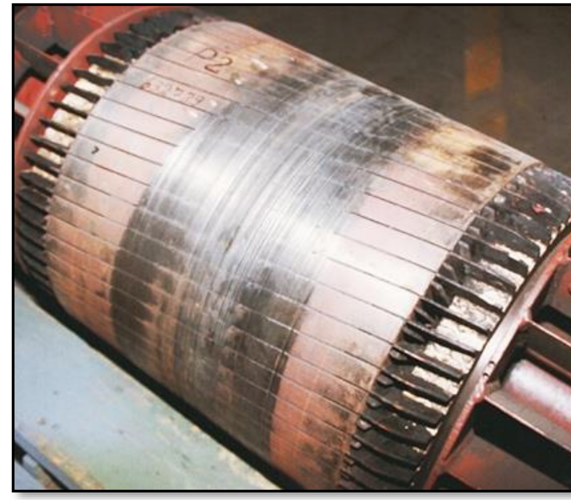
Rotor condition

If failed motor suits application:

- Assess condition of rotor
  - Is damage significant?
  - Did motor exceed its rated temperature rise before it failed (e.g., due to high core losses)?
- If rotor damage is significant, may be more economical to buy new motor
  - Repair of seriously degraded rotor can be expensive
  - Unless motor has special features affecting replacement price or availability



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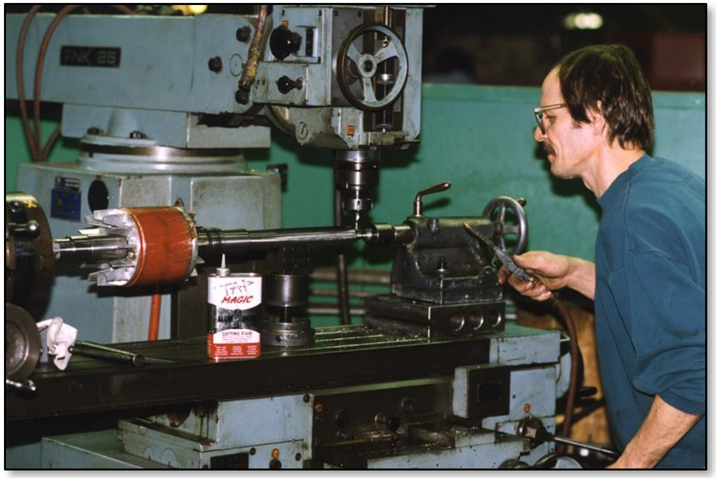
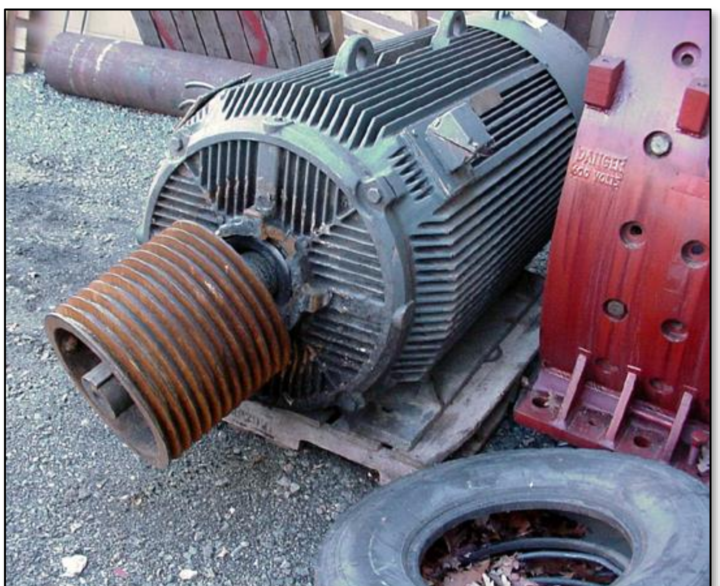
Mechanical parts condition





Shaft, frame, bearing housing or other mechanical parts may be damaged beyond repair

- Making new shaft may be economical option
- Cost of buying new may make replacing motor the logical choice (unless motor is very large or has special features)

Root cause failure analysis

- Identify and address underlying causes of failure to prevent reocurrence(s)
- Applies to both repair and replace

EPAct (IE2) or NEMA Premium® (IE3) motor

Transition in repair/replace decision process

- Factors to this point have shaped process for over a half-century
- Whether to replace a failed motor with a more energy-efficient model is an important consideration

EPAct (IE2) or NEMA Premium® (IE3) motor

Higher efficiency motors

- Those covered by earlier U.S. federal regulations (EPAct 1992) — equivalent to IEC motors labeled IE2
- NEMA Premium® motors covered by newer U.S. federal regulations (EISA 2007) — equivalent to IEC motors labeled IE3

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EPAct (IE2) or NEMA Premium® (IE3) motor

Repair considerations for higher efficiency motors

- Same as for older standard efficiency models
- Efficiency and reliability can be maintained by qualified service centers that
  - Follow good practices of **ANSI/EASA AR100** and EASA's ***Good Practice Guide to Maintain Motor Efficiency***
  - Participate in EASA's Accreditation Program

EPAct (IE2) or NEMA Premium® (IE3) motor ROI

Consider return on investment (ROI) of a higher efficiency replacement before repairing a lower efficiency motor

Examples

- NEMA Premium® (IE3) in place of EPAct (IE2) motor
- EPAct (IE2) in place of older standard efficiency motor

Factors

- Expected life of motor or process
- Hours of operation
- Energy costs

Verify that replacement is higher efficiency than motor being replaced

EPAct (IE2) or NEMA Premium® (IE3) motor ROI

- If analysis favors replacement, determine if cost fits within budget
- If not, best option may be good practice repair (if it costs less than a new motor)

Next decision: Motor availability

- Motors such as those under EISA rules are usually stock items
- Larger motors or those with special features often have delivery times up to several months

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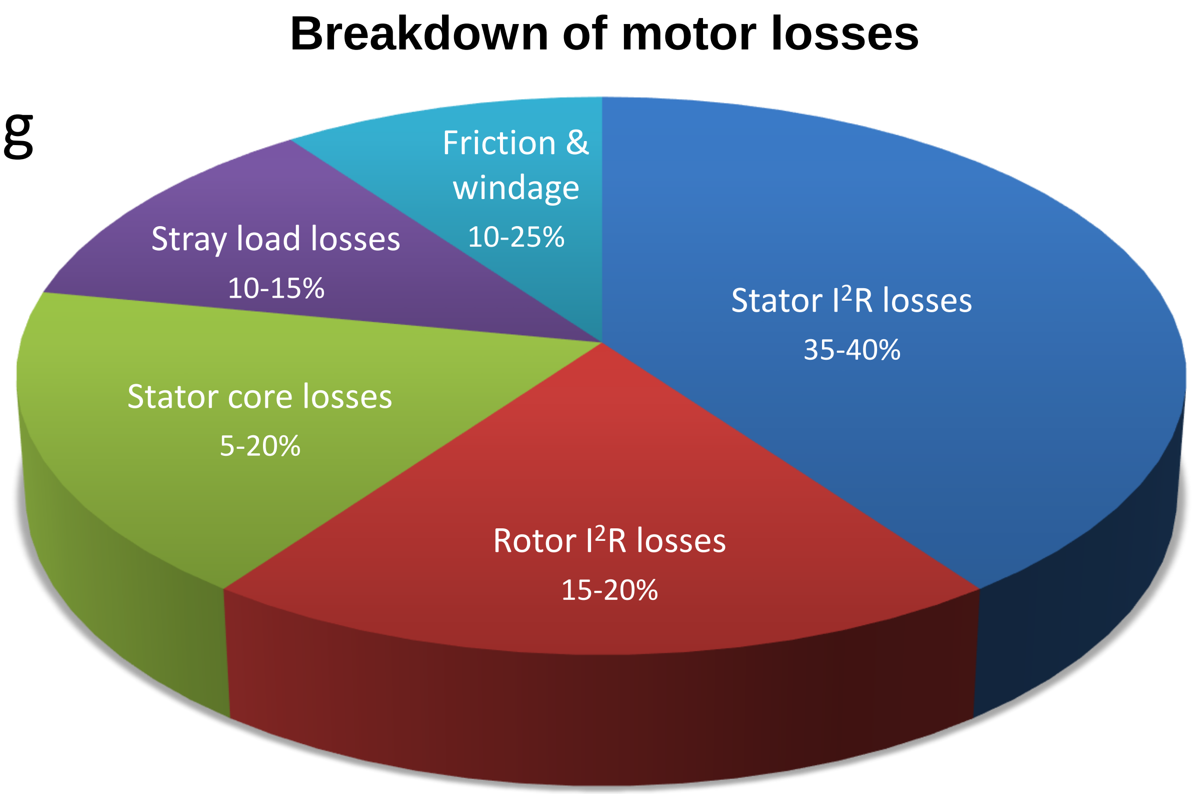
Next decision: Motor availability

If delivery time exceeds your requirements

- Qualified service centers usually can provide a good practice repair of original motor in far less time
- Service centers may be able to add special features to a stock higher efficiency motor, e.g.:
  - Convert it to a C-face or D-flange mounting
  - Modify the output shaft

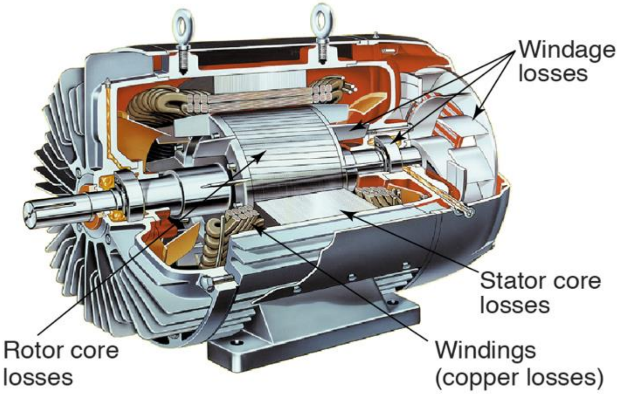
Motor efficiency

Manufacturers improve motor efficiency by reducing losses, primarily through design changes



Motor efficiency

Ways manufacturers improve efficiency

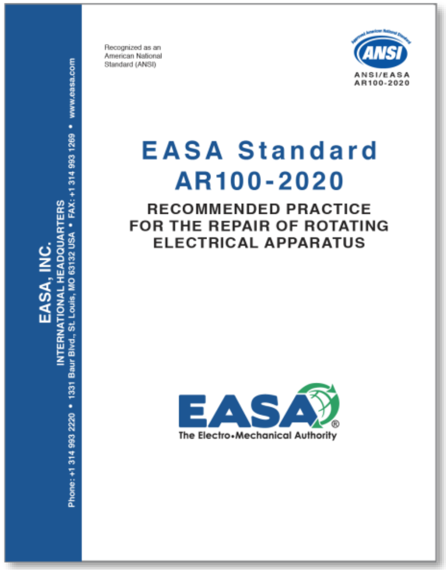


- Some high efficiency models have longer stator and rotor cores (reduces core losses)
- Some have more copper wire area in windings (reduces copper losses)
- Fans of totally enclosed, fan-cooled (TEFC) designs
  - Use smallest fan that keeps winding within design temperature limit
  - Minimizes power diverted to windage

Repaired motor efficiency

Service centers that follow good practices provide repairs with a proven record of maintaining the efficiency of standard and higher efficiency motors

- Good practices found in ANSI/EASA ***AR100 Recommended Practice for the Repair of Rotating Electrical Apparatus***
- And more specific recommendations in EASA's ***Good Practice Guide to Maintain Motor Efficiency***
- Download both free at easa.com/energy

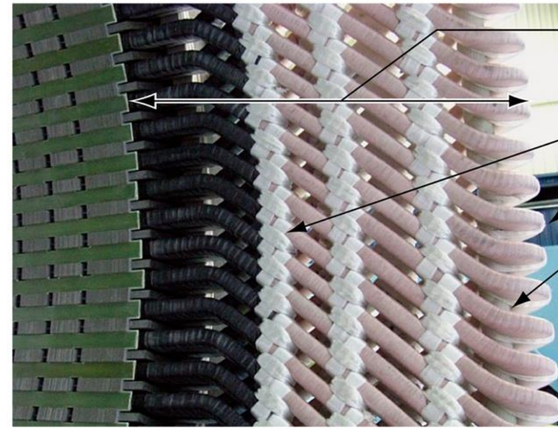


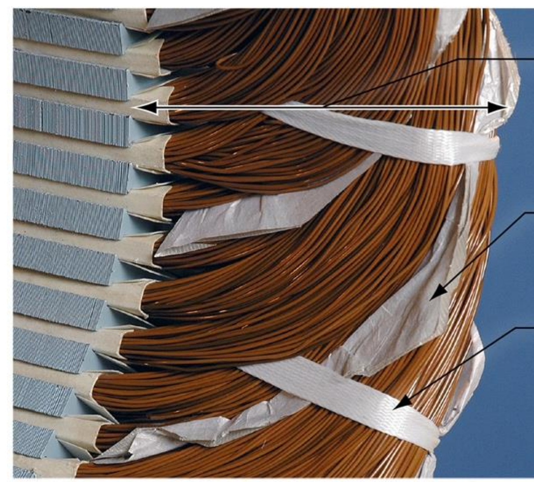
Repaired motor efficiency

Good repair practices identified by the two documents include:

- Ensuring that overall length of turns in winding does not increase (more resistance increases loss)
- Increasing wire area when slot fit allows it (lower resistance reduces losses)

These steps maintain or may reduce winding copper (I^2R) losses





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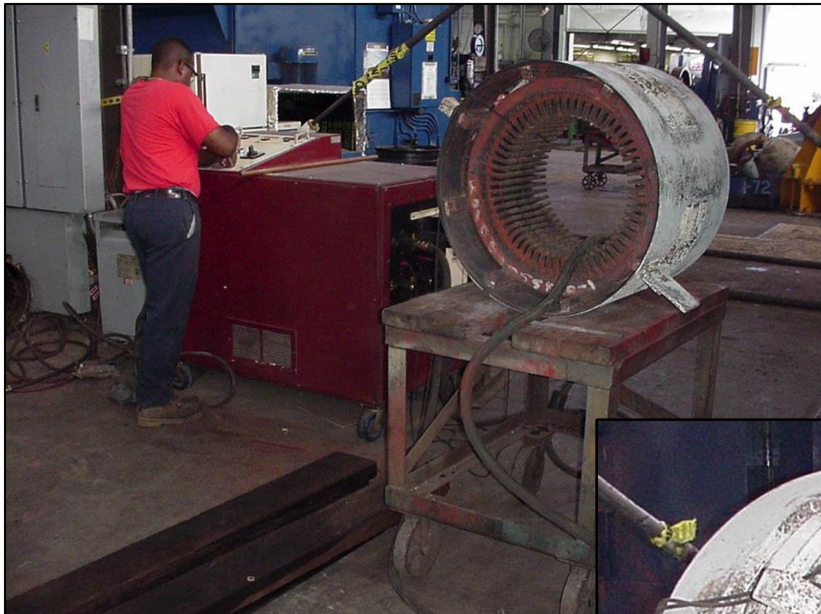
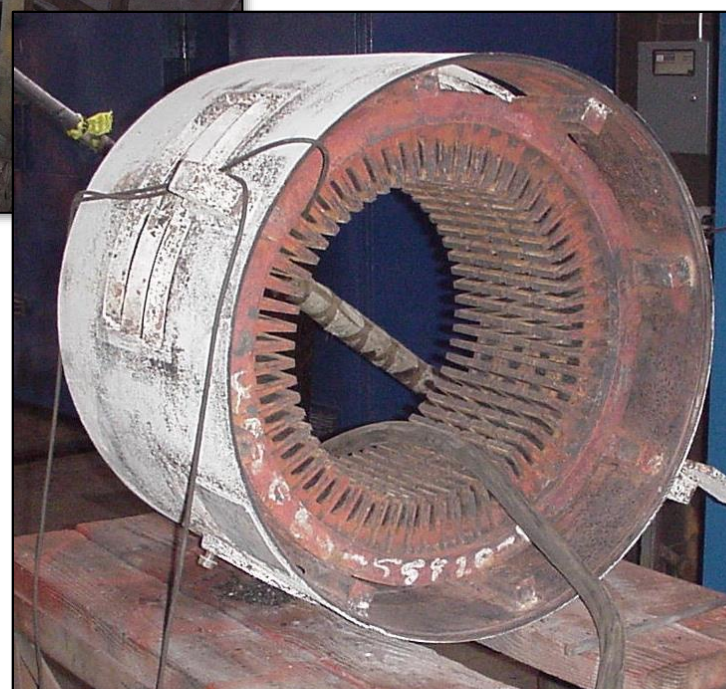
Rewinding good practices



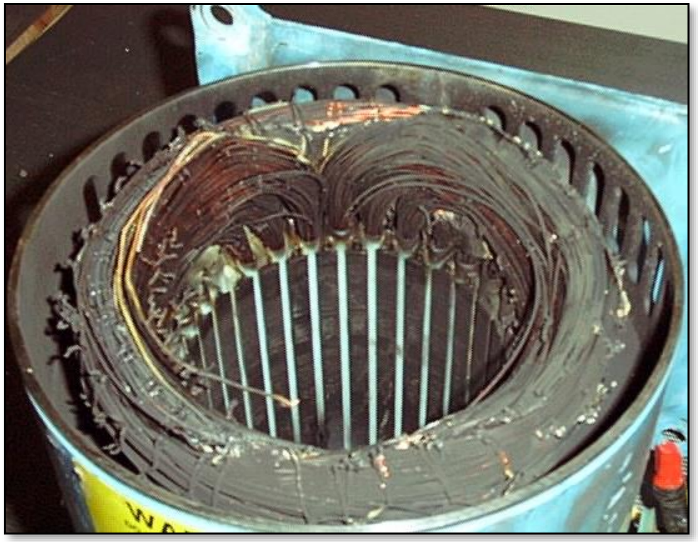
- Test for core losses before and after winding removal
- Repair or replace a defective core

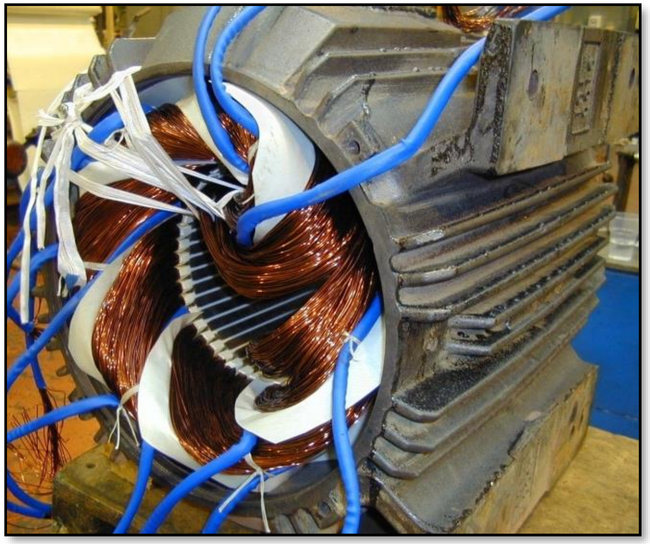


Rewinding good practices

Maintain efficiency by

- Copy-rewinding or improving winding pattern (e.g., concentric to lap)
- Using same or shorter average length of turns





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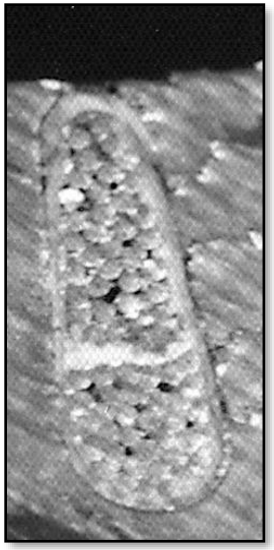
Rewinding good practices

Opportunity to improve efficiency by

- Increasing slot fill (reduces heating)
- Using larger winding coil wire area (reduces I^2R losses)



Wire Size: AWG 17
Bare Dia. = 0.0453

Wire Size: AWG 16
Bare Dia. = 0.0508

Testing good practices

- Measure and compare winding resistance lead-to-lead
- No-load testing
  - Check exact operating speed
  - Measure no-load current and compare to full-load rating

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