

Motors for Municipal Pumping

Low Voltage to about 250HP

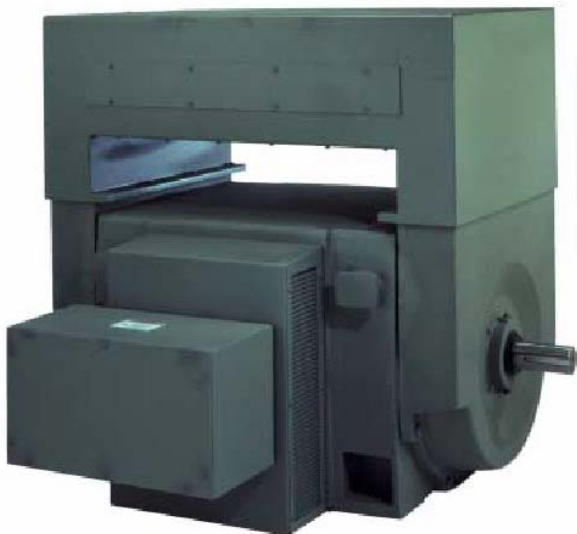
Medium Voltage, 2300 volts or 4160 volts

Vertical and Horizontal

- Enclosures
- Efficiency Standards – MG-1 Premium / Normal
- History of Efficiency – How we got here
- Physics of Efficiency (fiction and truth)
- Motor repair effect efficiency
- Motor testing – normal / guaranteed efficiency

Dennis Bogh – GE Motors

Enclosures



History of Efficiency

Old U frame

Old T frame

EPACT 92 - Effective October 24, 1997

Signed by George Bush as a group of amendments

Three phase, integral horsepower, squirrel cage induction motors

NEMA frame, single speed, mfg after 10-24-1997, sold in USA

Does not cover special purpose motors

Verticals, High Slip, Submersible

EPACT 92 became the NEMA MG-1 table 12-11, Energy Efficient

Efficiency Standards

From NEMA MG-1, 2003

Includes bearing losses, but not thrust loss

Table 12-11
Full load efficiency of Energy
Efficiency motors

Table 12-12
Full load efficiency of Premium
Efficiency motors

HP	Normal Efficiency	Minimum Efficiency
5	87.5	85.5
50	93.0	91.7
150	95.0	94.1
200	95.0	94.1

HP	Normal Efficiency	Minimum Efficiency
5	89.5	87.5
50	94.5	93.6
150	95.8	95.0
200	96.2	95.4

Physics of Efficiency



Loss	Typical - four pole machine
Stator I^2R	35 – 40%
Rotor I^2R	15 – 20%
Core Loss	15 – 20%
Stray Load Loss	10 – 15%
Friction & Windage	5 – 10%

Air Gap
Length
Diameter
Active material

Efficiency – Designer's choice

There are standard designs and they fit most requirements

Efficiency is largely controlled by

- Air Gap

- Rotor diameter and length

- Core material

- Stator winding – wire size

- Cooling requirements

Within this structure, the motor has to meet the NEMA criteria

- Starting Torque

- Breakdown Torque

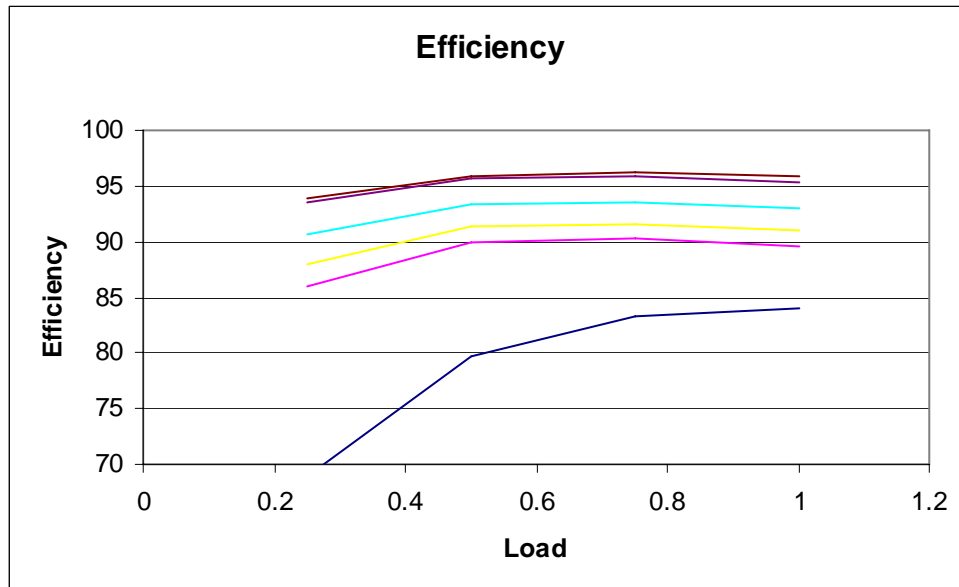
- Starting Current (and inrush)

- Efficiency



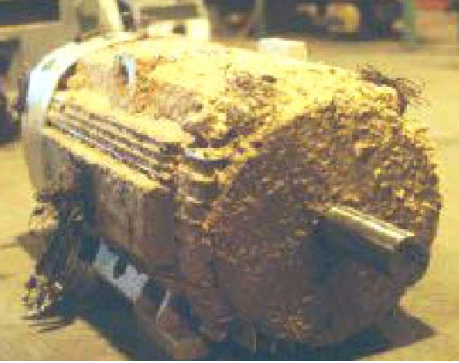
More on Efficiency

A motor that is lightly-loaded is more efficient than one that is overloaded
Most low voltage motors are optimized between 75% and 100% load



Motors operate at plus and minus 10% voltage, but not as well as at rated voltage
Voltage unbalance can quickly reduce motor efficiency

Motor Repair



See EASA standards

Generally OK for motors > 100 HP or specialty motors

Expect ~60% of new motor price for repair

Then a tough decision on life already used

Opportunity to improve efficiency

Opportunity to improve process

Most companies discard motors < 50 HP

Some companies discard motors < 100 HP

Watch for:

Careful burn-out. Today burn-out should not increase core loss

Winding configuration. Some windings are tough to duplicate



It can't be welded back

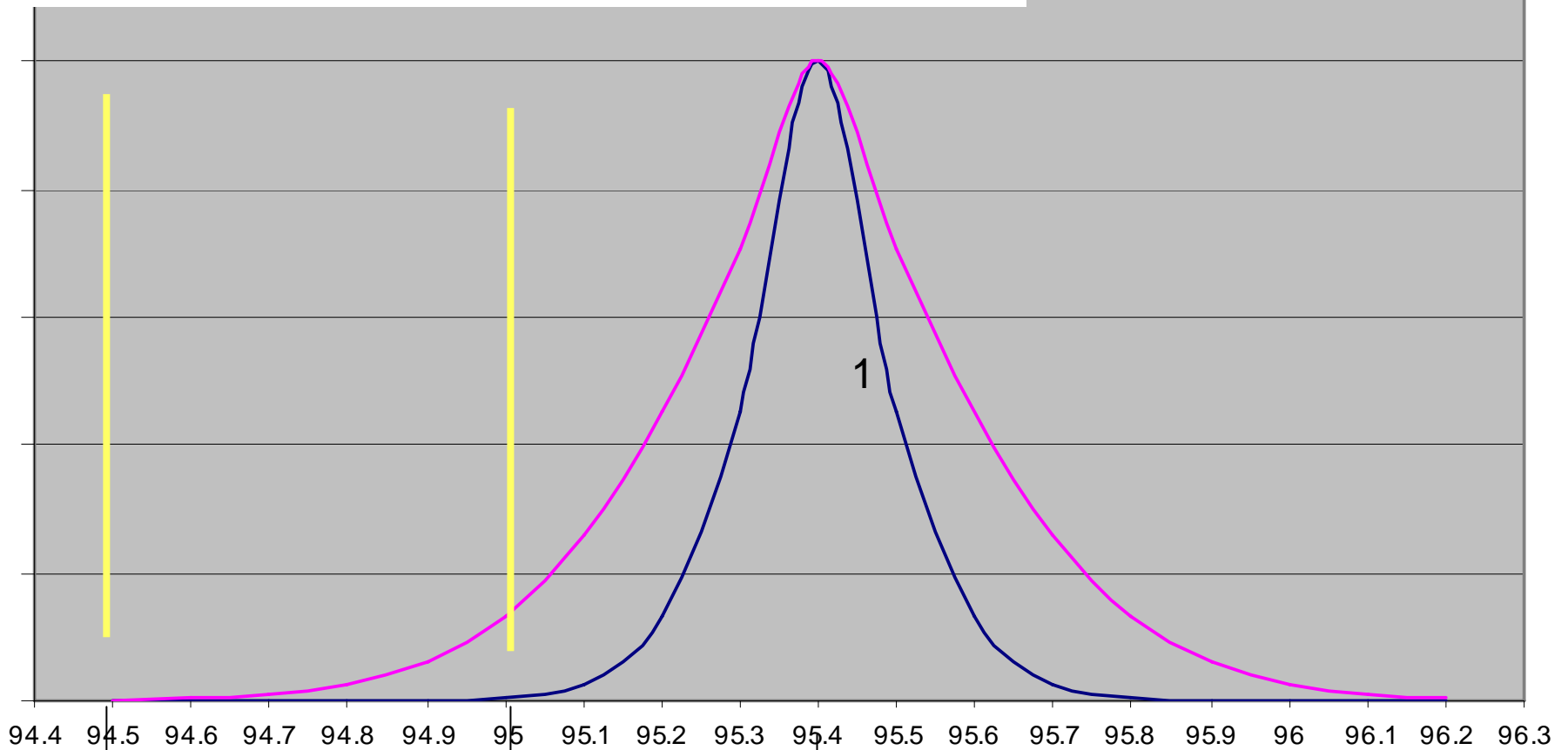
Losses

IEEE 112 method B for most motors

Based on dyno measurements

NEMA requires plus / minus 20% losses

Many mfg provide plus / minus 10% losses



← 1 band →

10% losses

← 2 bands →

20% losses

Efficiency Testing

IEEE 112 method B for most motors

- Based on dyno measurements

- NEMA requires plus / minus 20% losses

- Many mfg provide plus / minus 10% losses

IEEE 112 method E for vertical motors where bearing construction requires

- Load on vertical bearings is not part of normal motor losses

Also, but little used IEC (add about 0.8%)

In the field it is tough to know the load sufficiently well to do accurate testing.

There are lots of prediction methods that give reasonable indication of efficiency

- We can measure stator resistance accurately

- We can measure rotor speed accurately – slip vs. load constant

- Uncoupled run → friction and windage and core loss are found

Dr. Wallace at OSU tested some of the in-situ measurement techniques and found them “satisfying”. Some within 2% of losses over a broad range.