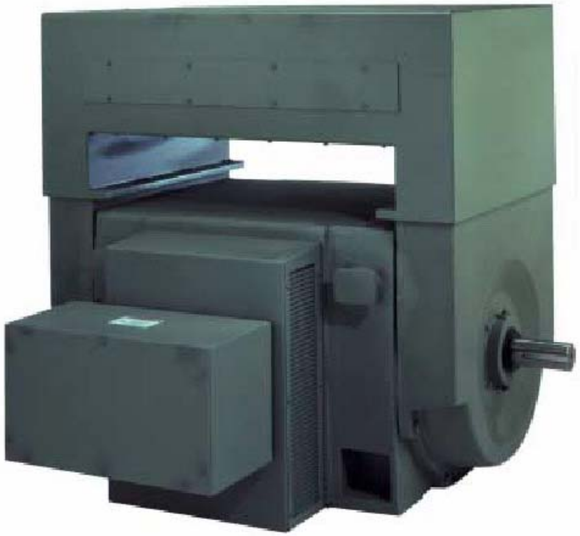
Motors for Municipal Pumping

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

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

Table 12-12
Full load efficiency of Premium Efficiency motors

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

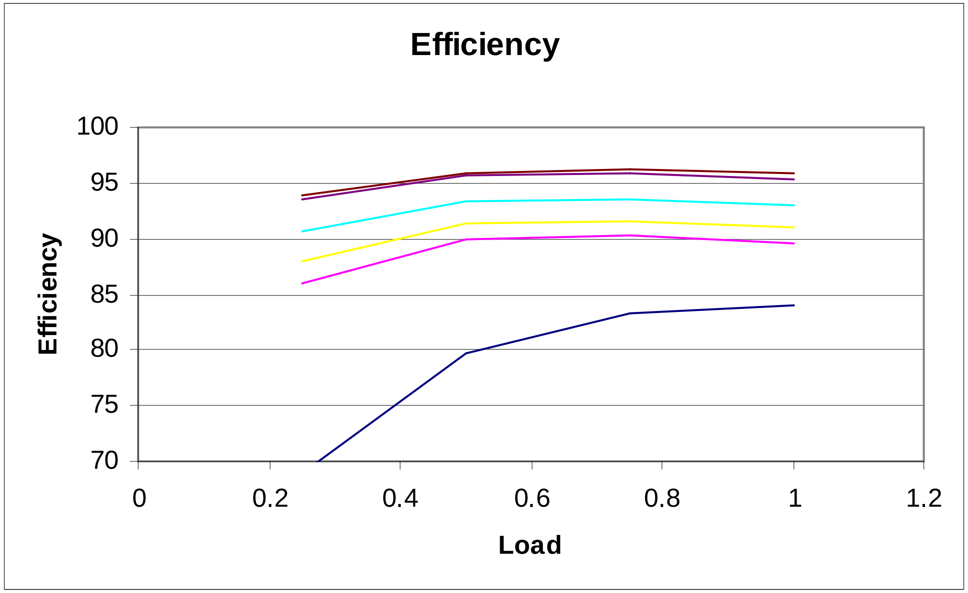
- Air Gap
- Rotor diameter and length
- Core material
- Stator winding – wire size
- Cooling requirements

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

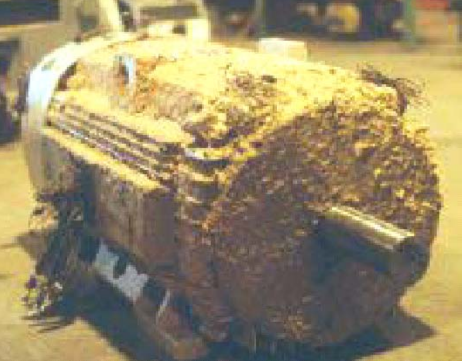
- Starting Torque
- Breakdown Torque
- Starting Current (and inrush)
- Efficiency

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:

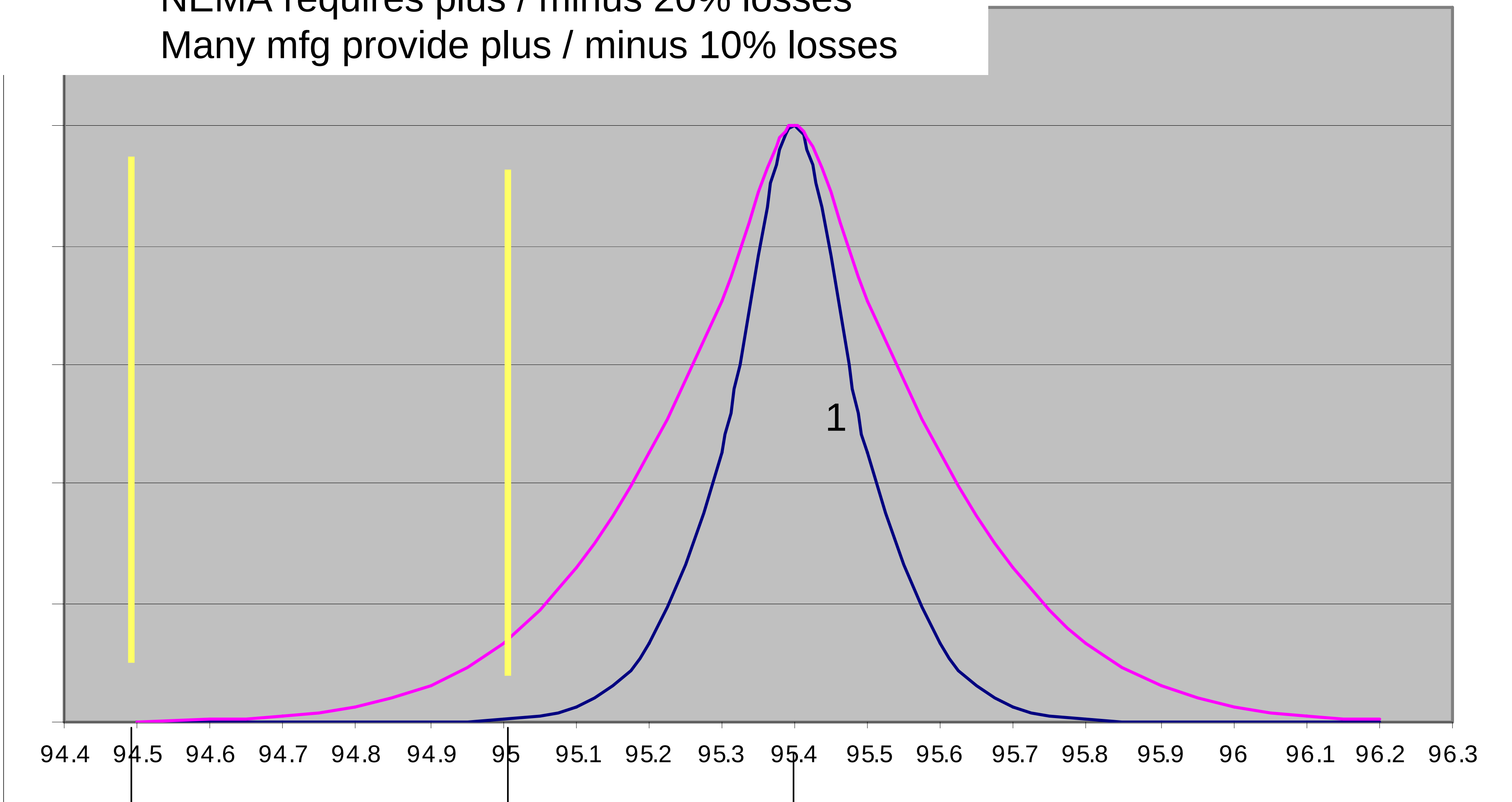
- Careful burn-out. Today burn-out should not increase core loss
- Winding configuration. Some windings are tough to duplicate

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.