Electric motors overview

Presented by

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Emerson Motor Technologies

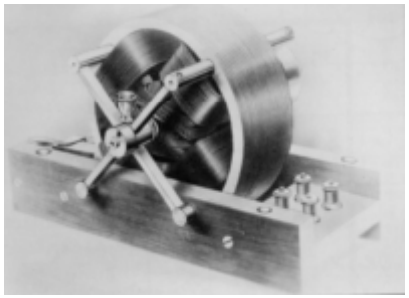
Agenda

- Motor introduction
- Motor applications
- Electric Motor life cycle costing
- Efficiency and Motor Repairs
- Emerging Motor Technologies

AC Induction Motor

This is the most common place motor.

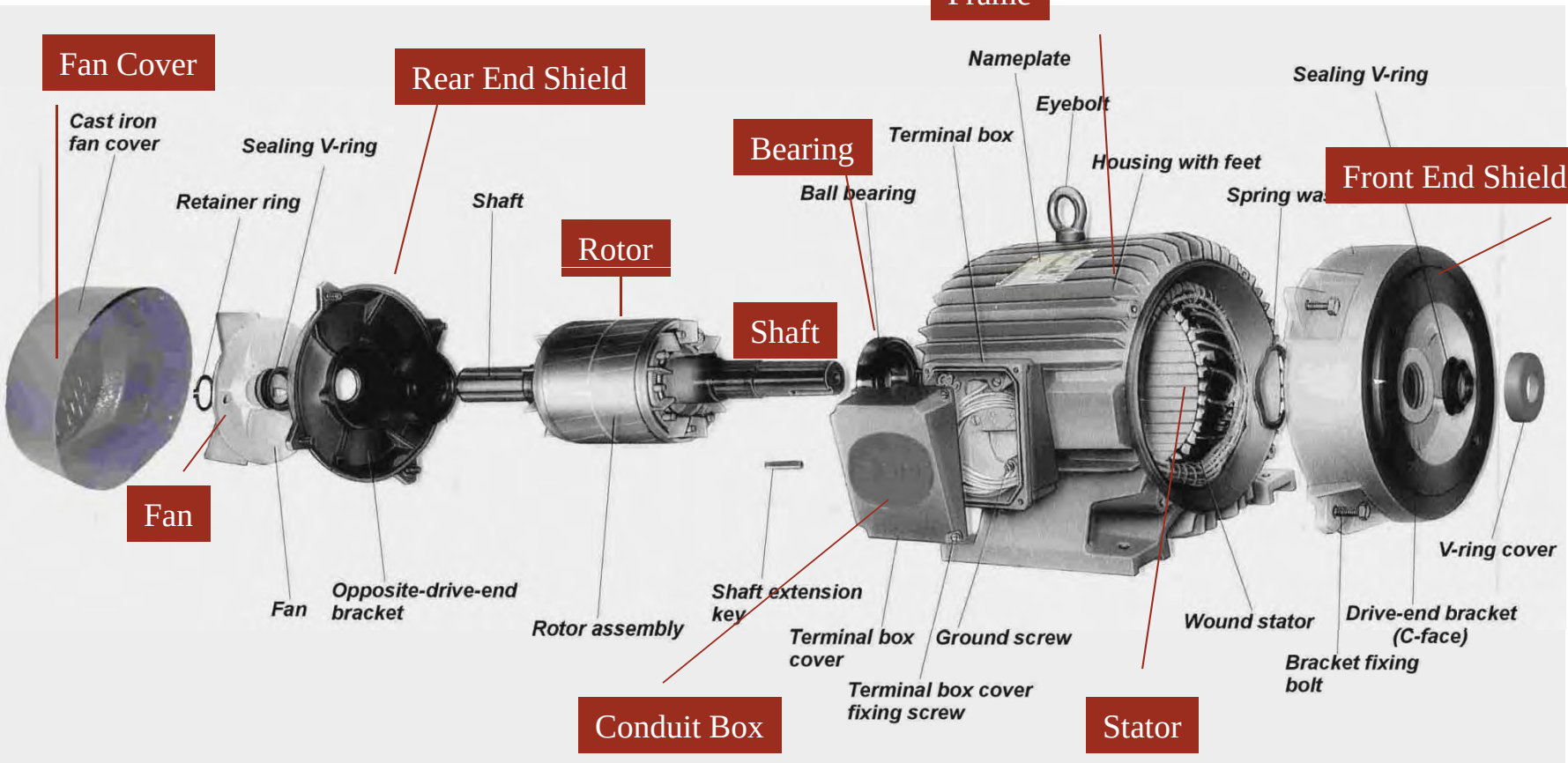
First Induction Motor, 1888 Inventor Nikola Tesla



1894 Induction Motor. World's largest when new. 65 HP

Today

Motor parts



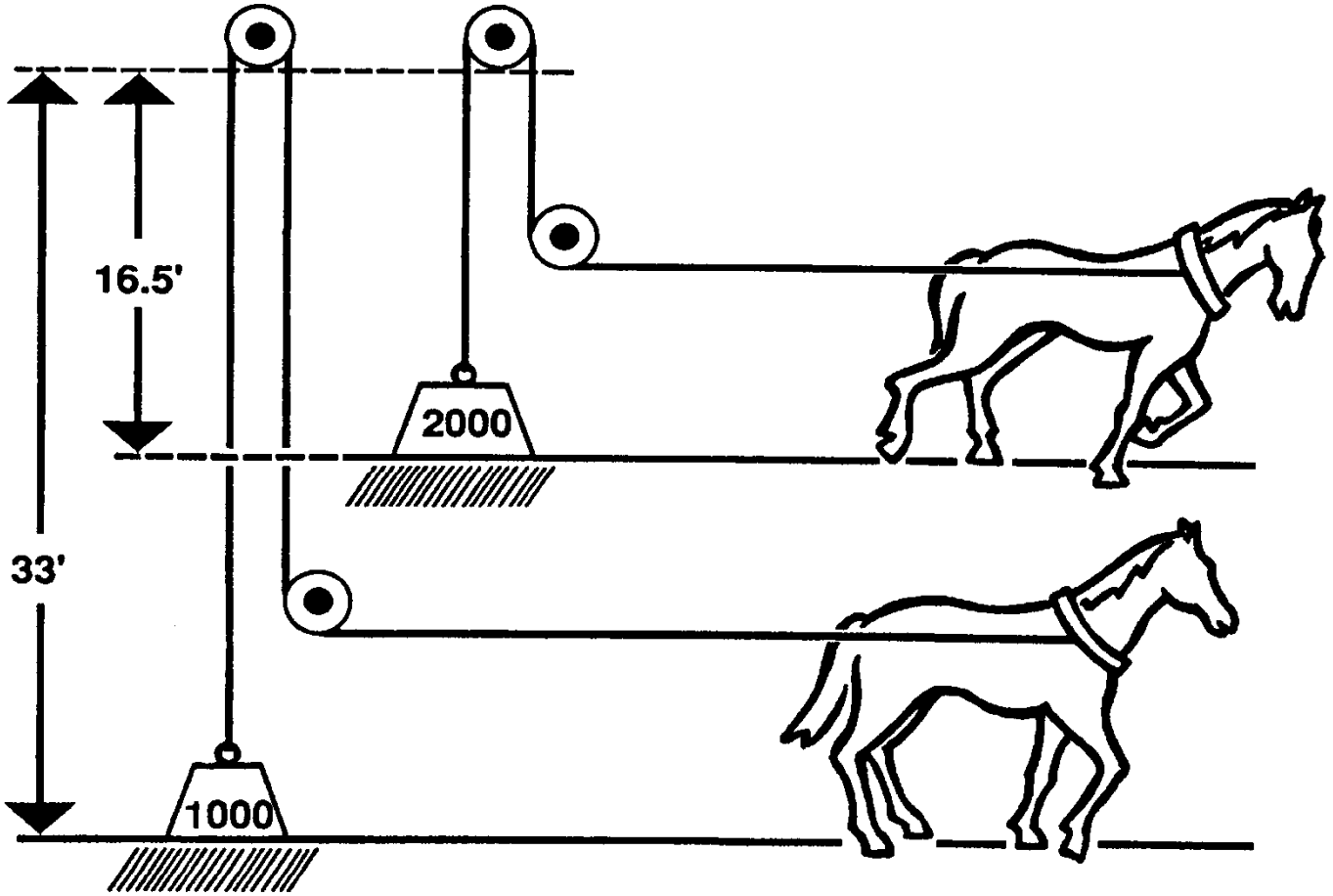
Industry Standards

- National Electrical Manufacturers Association (NEMA)
- Underwriters' Laboratories (UL))
- Canadian Standards Association (CSA) (ACNOR)
- International:
  - International Electrotechnical Commission (IEC)
  - Commission Électrotechnique Internationale (CEI)
  - Japanese International Standard (JEC)

- Institute of Electrical and Electronics Engineers(IEEE)

1 HP

1 HORSEPOWER = 33,000 lbs-ft. Per minute



Motor Selection –Typical information

HP	Always defined	Standardized
Frequency	60 HZ or 50HZ	May be defined from the requested speed
Speed	Defined in RPM or	Defined if Customer provides number of poles of the motor and power supply frequency.
Voltage	To be specified by end user or consultant	Customer specification
# of phase	Assumed	**575v** Always Three Phase. **230/460v** Always Three Phase **230v** May be Three or single Phase !!! **115/230v** Always single Phase **115v** Always single Phase
Protection/ enclosure	To be specified by end user or consultant	

Motor Selection – Typical Information

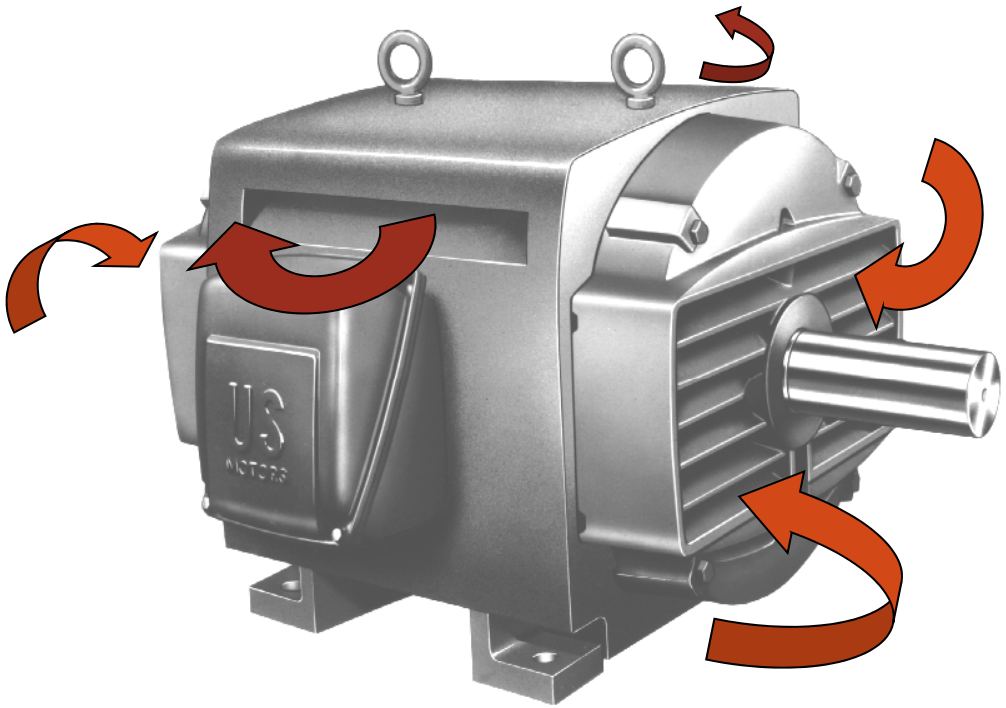
Criteria	*Standard By Default*	*Comments*
Environment (Enclosure)	TEFC (horizontal)	If otherwiset, the customer should specify ODP or Explosion-proof..etc..
Mounting	Horizontal Footed F1	Defined by the the letter(s) following the frame size: Ex: 56, 182**T,** 286**T.** If customer specify feet and flange the motor frame will change : Ex: 56**C**, 182**TC**, 286**TC**.
Efficiency	High Efficiency (for 60HZ)	Motor legislated by NRCan (National Resources Canada) or Epact in the USA (California NEMA Premium)
Motor Coupled to Load	Direct	If a belt pulley coupling is required Above 75 HP Roller Bearing may be required.

In doubt, ask the engineer or end user!

Criteria	*Standard by Default*	*Comment*
Ambient Temperature	40°C	Some motors may have to operate in higher ambient temperature. Re-rating/sizing available
Altitude	0 to 3300 ft (1000m)	A specific application may be higher than3300 Ft. De-rating /sizing available
Nema Design Letter	Design B	If a specific application is mentioned, select the adequate motor (Chipper, Crusher..)
Operating Cycle Time	S1 (Continuous)	Some applications may require only intermittent duty (S230mn…)

ODP

- Open Drip Proof **(ODP)**
  - The ODP motor has a free exchange or air with the ambient.Drops of liquid or solid particles of a certain size do not interfere with the operation at any angle from 0 to 15° downward from the vertical.

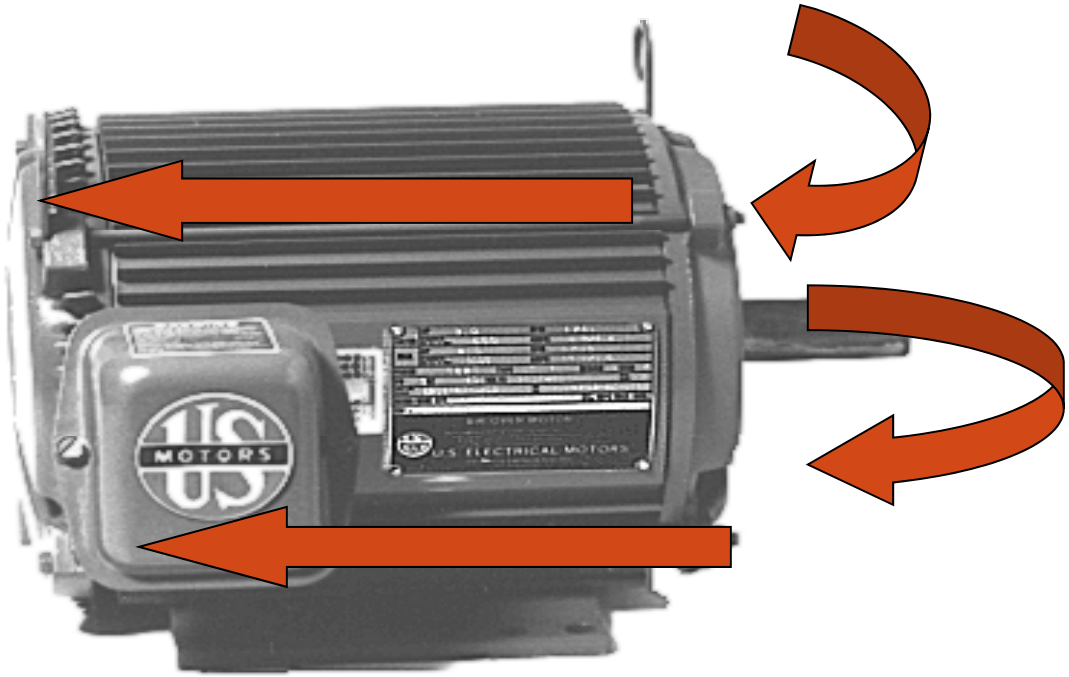


TEFC

- Totally Enclosed Fan Cooled **(TEFC)**
  - The TEFC type enclosure prevents free air exchange but still breathes air. A fan is attached to the second shaft and pushes air over the frame during operation to help in the cooling process.

TENV-TEAO

- Totally Enclosed Non-Ventilated **(TENV-TEAO)**
  - The TENV enclosure does not utilize a fan for cooling - but is used in situations where air is being blown over the motor shell for cooling.

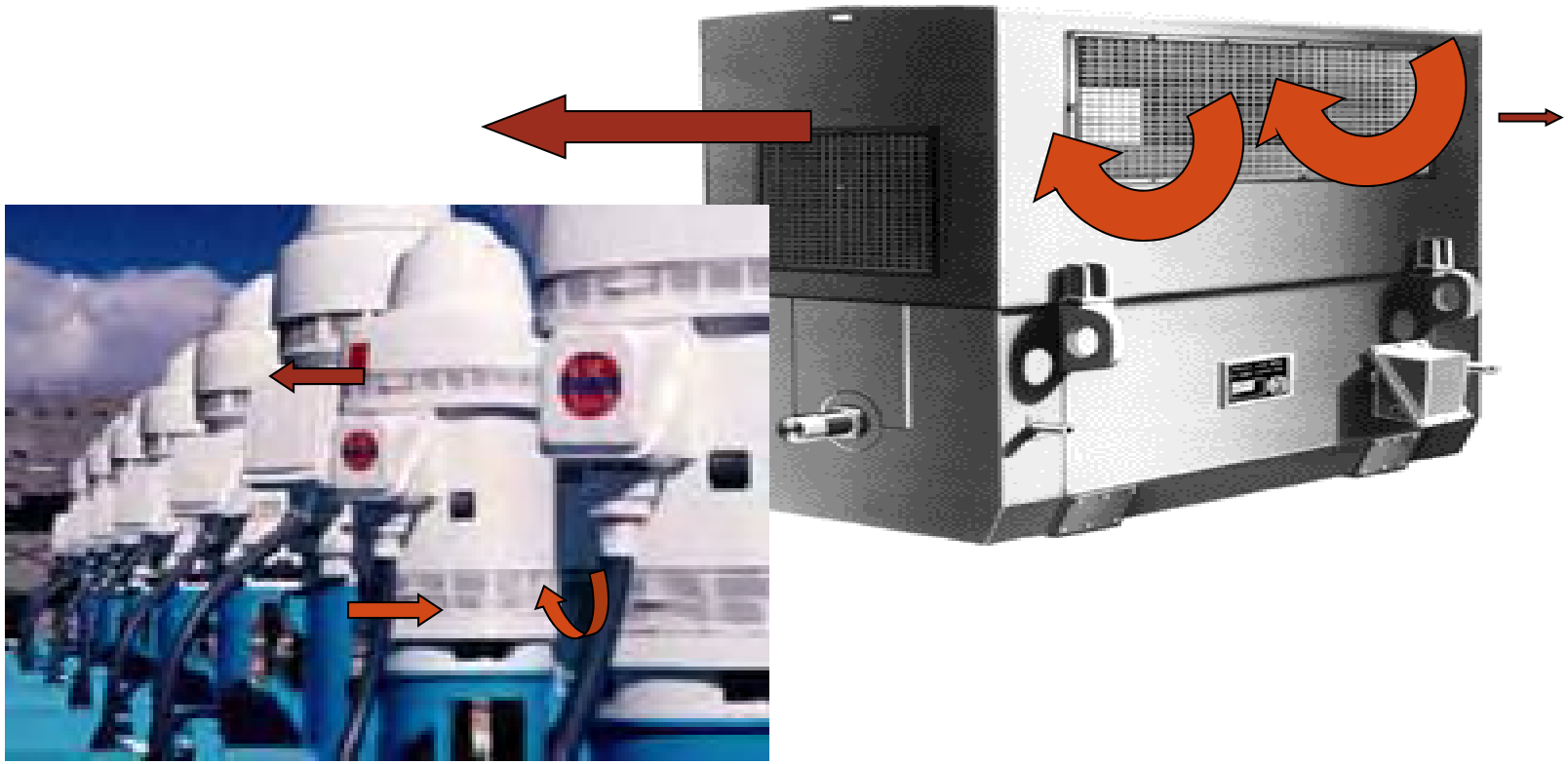


TEXP

- Explosion-Proof **(TEXP)**
  - The Explosion proof type motor is totally enclosed and designed to withstand an explosion of a specified gas or vapor inside the motor casing and prevent the ignition outside the motor by sparks, flashing, or explosion.

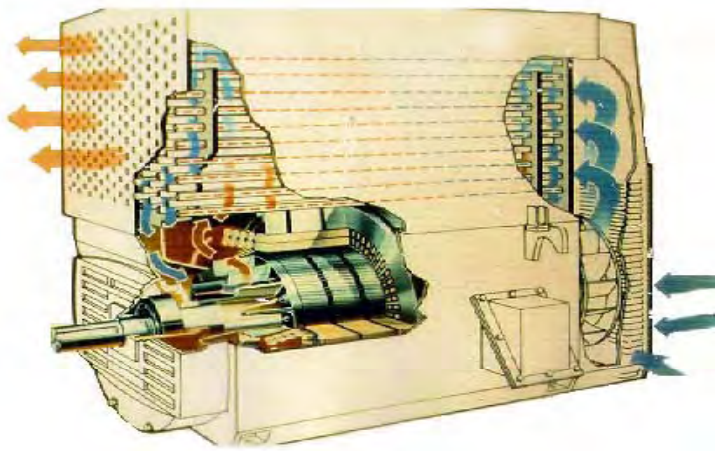
WPI and WPII

- **WPI** & **WPII**
  - These are modified ODPs, with filters, screens, guarded pipe-vent, etc.



Other protections

- TEWAC
- TEWC
- TETC
- IP55 and IP 56 for IEEE841
- (See IEC table)



IEC Protection digits

1st Number Against the solid particles		2nd Number Against the liquids		3rd Number Against the chock	
IP	**Definition**	**IP**	**Definitions**	**IK**	**Definition**
0	Non protected	0	Non protected	00	Non protected
1	dia. 50 mm	1	vertical drop	01	0,15J
2	dia. 12 mm	2	Drop fall at 15° from Vertical	02	0,2J
3	dia. 2,5 mm	3	Drop fall at 60° from Vertical	03	0,37J
4	dia. 1 mm	4	Drop fall at 360°	04	0,5J
5	Dust without danger	5	Water jet at 360°	05	0,7J
		6	High pressure water at 360°	06	1J
		7	immersion from 0,15 to 1 m	07	2J
		8	immersion under pressure	08	5J
				09	10J
				10	20J

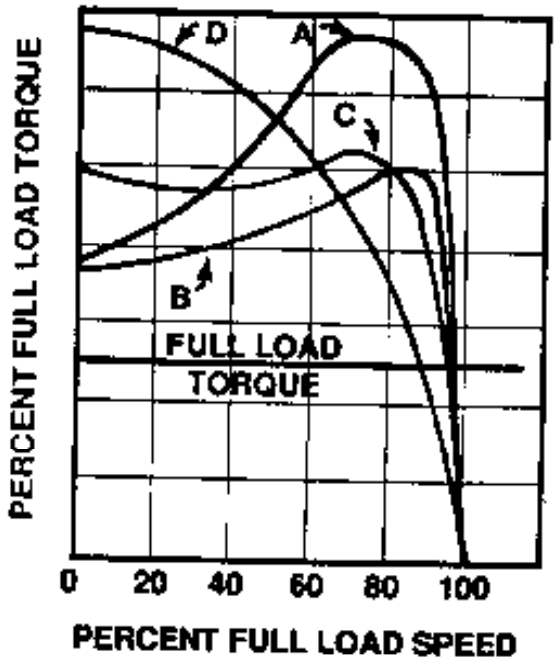
Example: IP55

Standardized Frame (TEFC)

RPM	3600			1800			1200		
NEMA		1952	1964		1952	1964		1952	1964
Program	ORIG.	Revision	Revision	ORIG.	Revision	Revision	ORIG.	Revision	Revision
HP									
1				203	182	143T	204	184	145T
1.5	203	182	143T	204	184	145T	224	184	182T
2	204	184	145T	224	184	145T	225	213	184T
3	224	184	182T	225	213	182T	254	215	213T
5	225	213	184T	254	215	184T	284	254U	215T
7.5	254	215	213T	284	254U	213T	324	256U	254T
10	284	254U	215T	324	256U	215T	326	284U	256T
15	324	256U	254T	326	284U	254T	364	324U	284T
20	326	286U	256T	364	286U	256T	365	326U	286T
25	365S	324U	284TS	365	324U	284T	404	364U	324T
30	4045	326S	286TS	404	326U	286T	405	365U	326T
40	405S	364US	324TS	405	364U	324T	444	404U	364T
50	444S	365US	326TS	444S	365US	326T	445	405U	365T
60	445S	405US	364TS	445S	405US	364T	504	444U	404T
75	504S	444US	365TS	504S	444US	365T	505	445U	405T

NEMA Design Letter

In order to promote standardization, minimum acceptable values for different motor designs have been established by NEMA. The standardized designs are identified by the letters A, B, C, and D.



Torque Characteristics

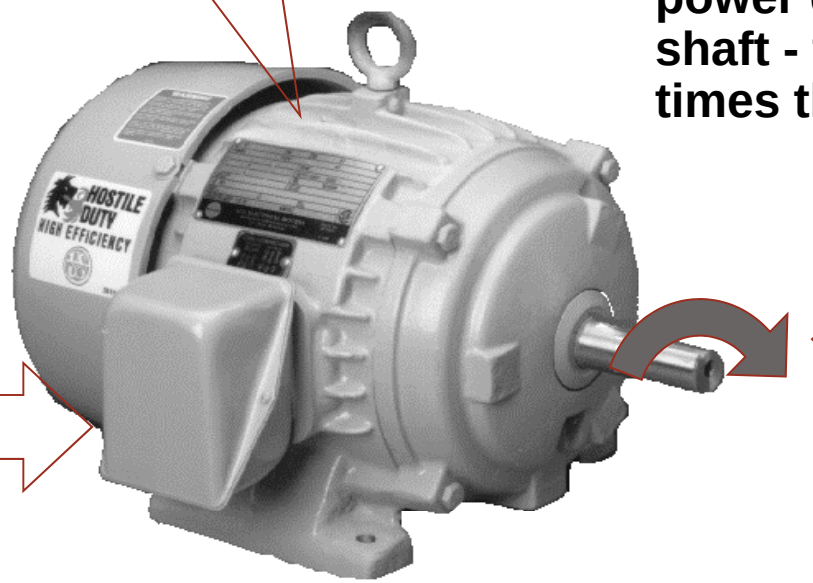
LRT = Lock rotor Torque, LRA= Lock rotor Current

- **Design A (and Design E)**
  - Normal Starting Torque
  - High Starting Current
- **Design B**
  - Normal Starting Torque
  - Low Starting Current
- **Design C**
  - Normal Starting Torque
  - Low Starting Current
- **Design D**
  - High Starting Torque
  - Low Starting Current/ High Slip

- Brief heavy overloads, such as an injection molding machine
- General purpose applications, most common, standard
- Starting heavy loads. Applications like a crusher
- High slip, such as a low speed punch press with a heavy flywheel, or hoisting applications

What is a motor Efficiency ?

Heat rejection , motor losses



Input :Power, KW drawn from power supply to operate

Output: To provide work, the motor needs KW

- **Definition: Useful power output divided by the total power input. Motor output is the mechanical power delivered by the shaft - the shaft torque times the speed (rpm)**

Efficiency is defined as the ratio of the power output by the power input

Efficiency Calculation

It can be calculated as follows:

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} = \frac{\text{Input Power - Losses}}{\text{Input Power}}$$

$$\text{Efficiency} = \frac{\text{HP x 746}}{\text{KW Input x 1000}}$$

Example: At 10 HP Load

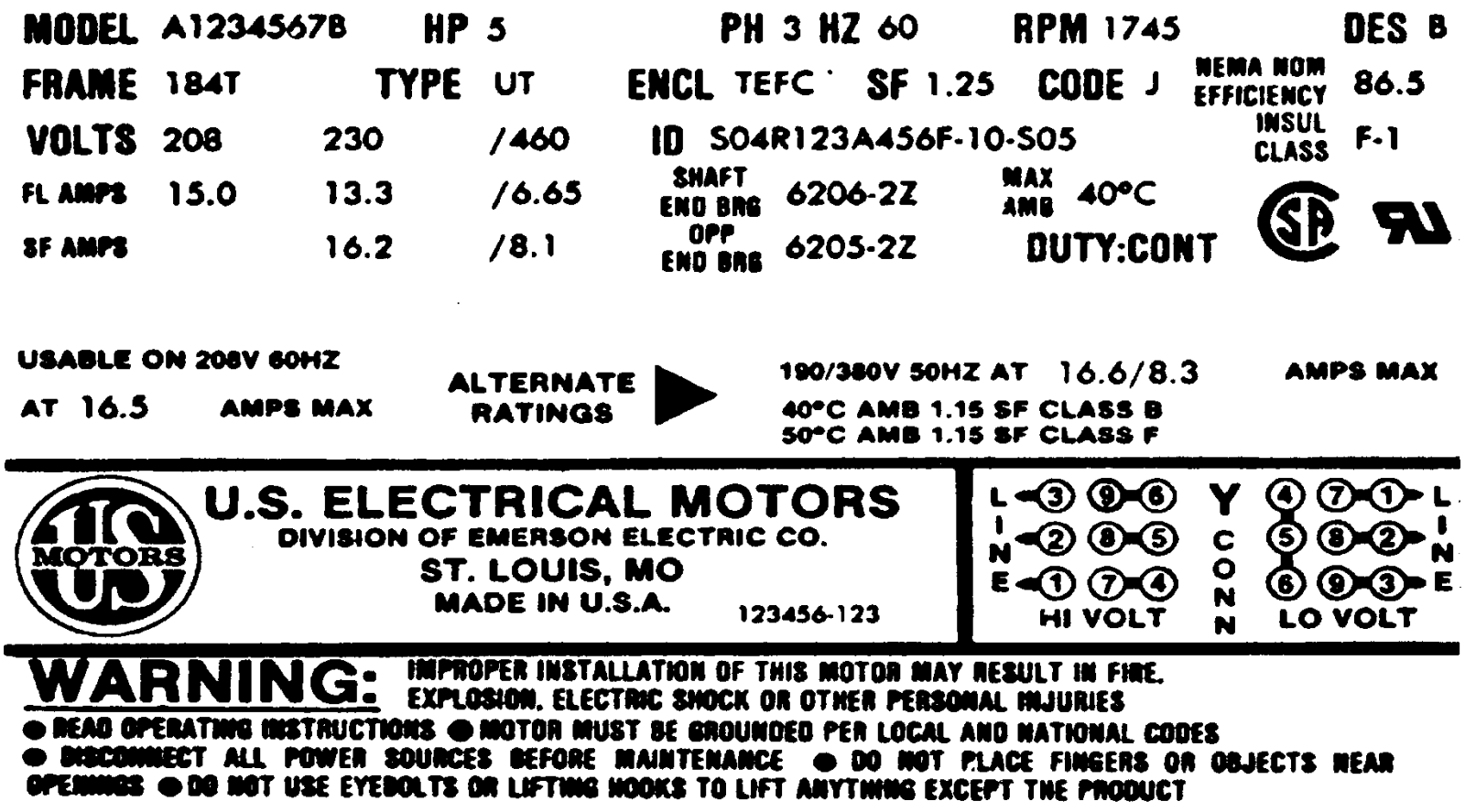
$$\text{Efficiency} = \frac{\text{10 x 746}}{\text{8.8 x 1000}} = .83$$

Estimated annual savings on a 100HP

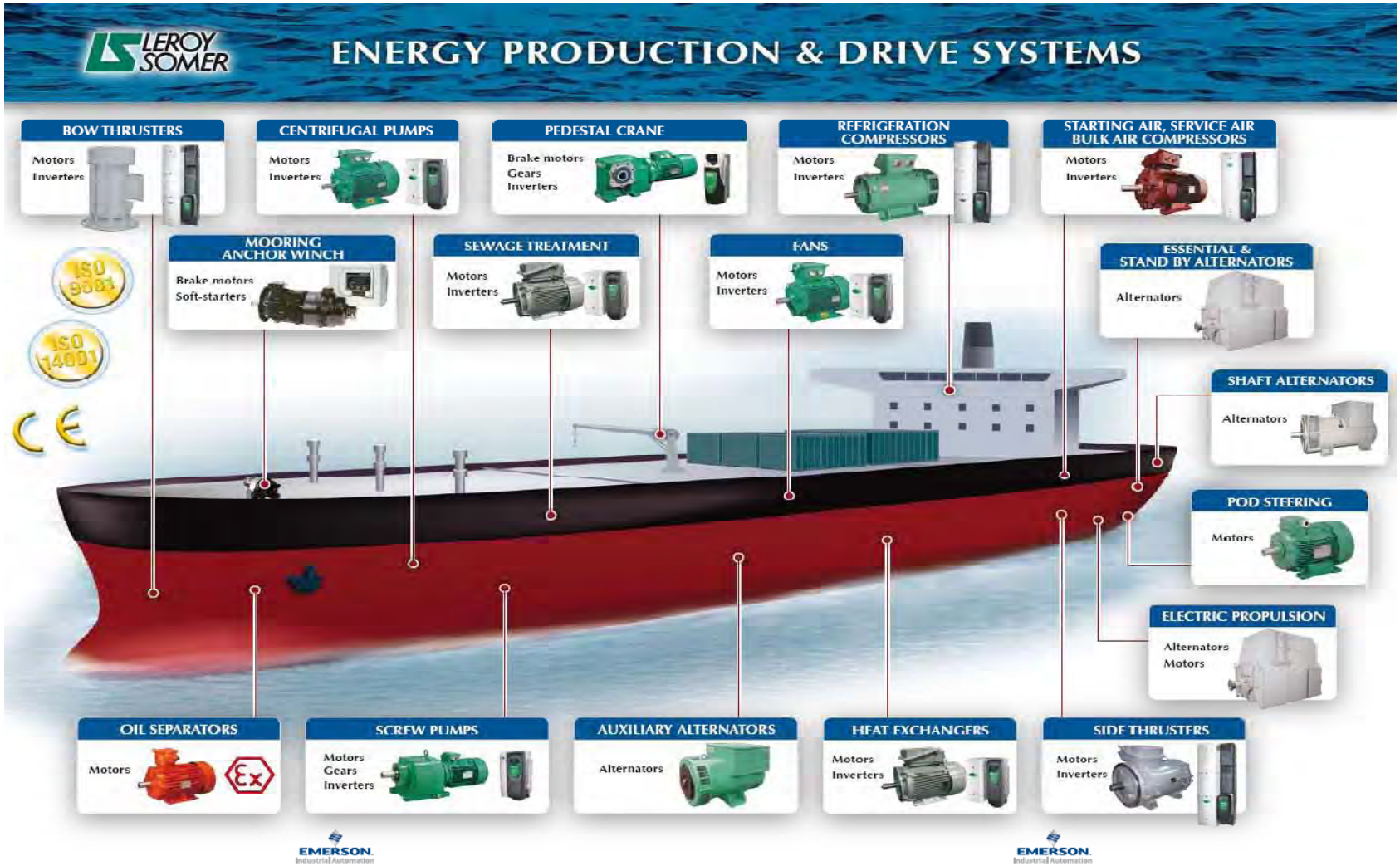
Premium Efficiency Motor Horsepower:	100
Percent Load:	100%(Full)
If you select 'Other', please enter your percent load. (ie. 35)	
Energy cost per kilowatt hour: (ie. 12)	5
Running Time:	120 Hrs/Week
If you select 'Other', please enter your runtime hours per week. (ie. 60)	
Efficiency(%) of Standard or EPACT Efficiency Motor: (ie. 91)	91.5
Efficiency(%) of EPACT or Premium Efficiency Motor: (ie. 94)	95.4

Annual Savings: $ 1,040

The Nameplate



Electric motor applications



Pumps on a barge

100 tons crane

Myrtle in Gulf

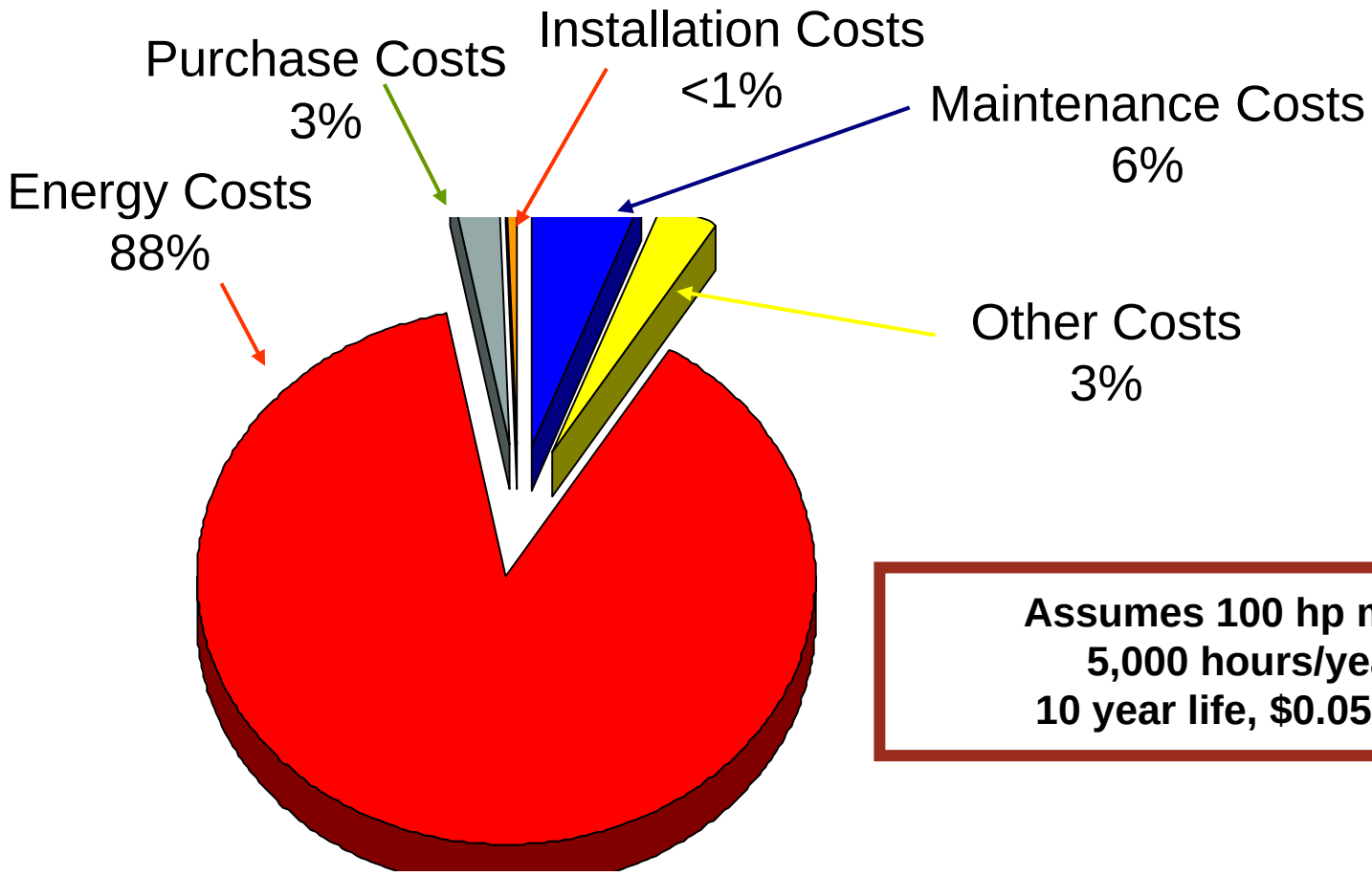
Variable frequency drive

Barge Crane

25 Tons crane

Electric Motor Life Cycle Costing

DOE 2004 Industrial Energy Savings Roadmap



**Assumes 100 hp motor,
5,000 hours/year,
10 year life, $0.05/kWh**

Electric Motor Life Cycle Costing

- Energy cost
- Maintenance cost
- Purchase cost
- Installation cost

Electric Motor Life Cycle Costing

- Down time cost
- Removal and re installation cost
- Repair cost
- Lost of efficiency cost
- Spare storage cost

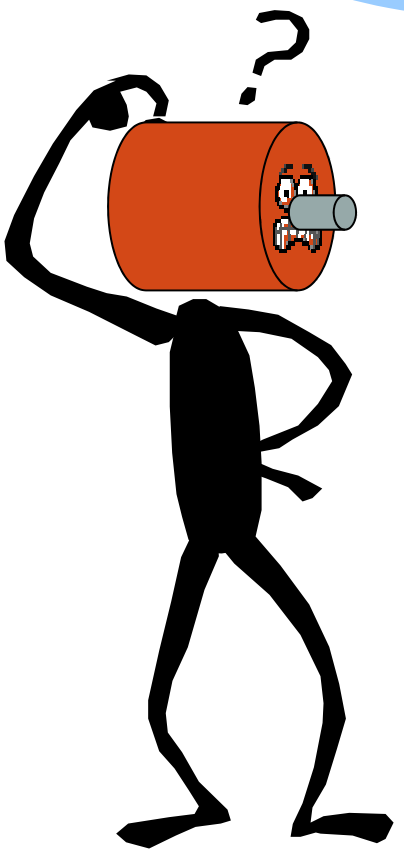
Electric Motor Life Cycle Costing

And a pain in the neck

Motor facts

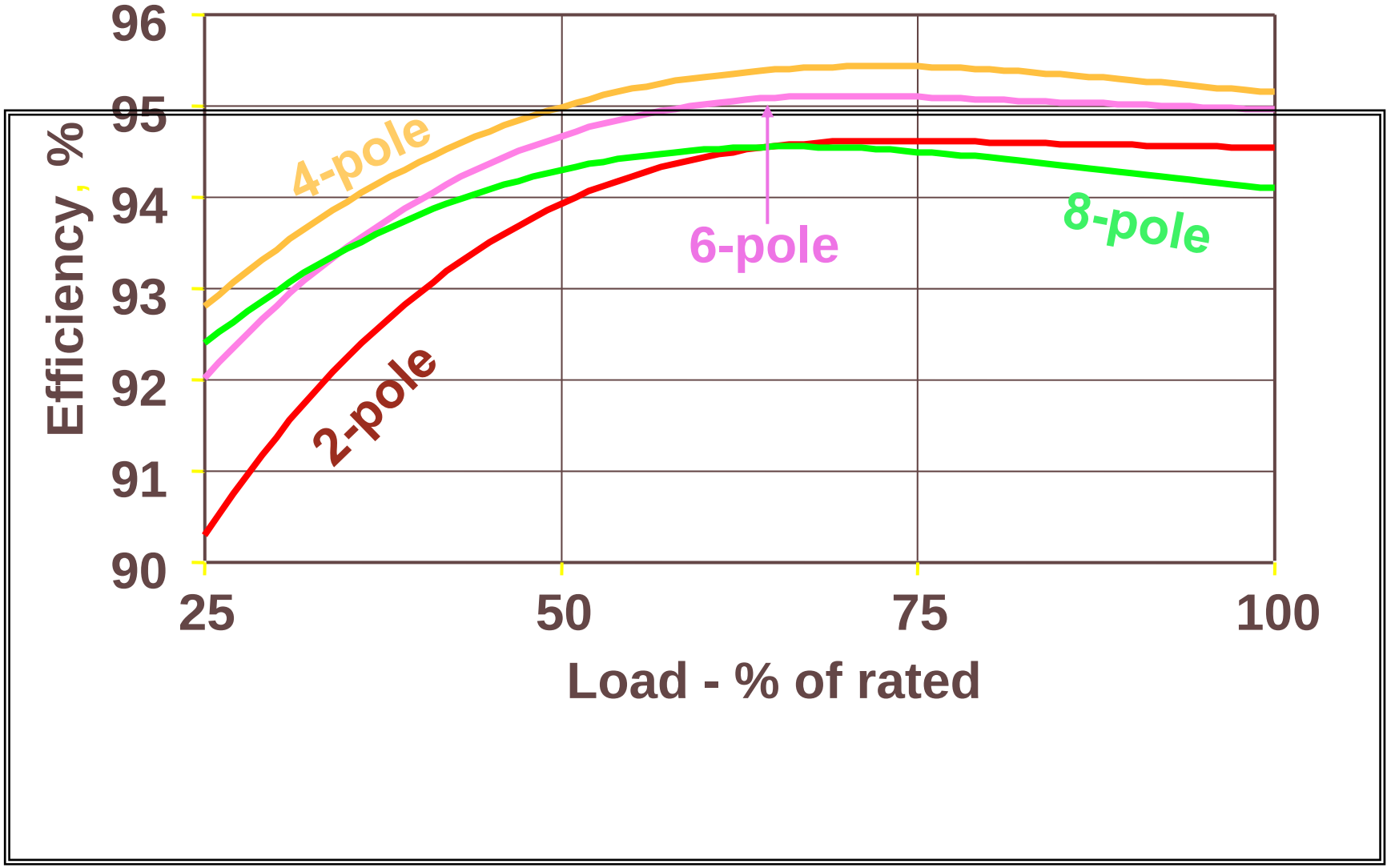
- Industrial motors can have a 20 to 30 year service life
- The average IHP motor is repaired 3 or more times in it's life [source EASA]
- The average IHP motor uses 4 to 6 times it's original cost in electricity per year
- Epact & NR Canada regulations cover less than 65% of motors sold today
- Environmental groups estimate over 5 million units are repaired or replaced by used each year

Efficiency of Repaired Motors Does it Change? Why?



- Limited data available
- Seven case studies (77 motors) reported efficiency decreased between 0 to 2.5% after repair.
- Average is .5 to 1% (8 to 10% increase in losses).
- Efficiency degradation lower for large hp motors.
- Efficiency is rarely increased.
- Efficiency can be maintained over multiple rewindings with quality repair.

Motor efficiencies for 100 hp (75 kW) motors - typical performance curves over normal load range



Some factors reducing motor life

- Working environment

Some factors reducing motor life

- Poor alignment, vibration
- Voltage too low and/or too high
- Excessive overload
- Ambient Temperature
- Air flow obstruction, dirty filters
- Foreign material inside the motor
- Inadequate motor selection for a specific application

IEEE 841 Plus motor cost Savings

IEEE 841+ Type CE
Severe Service Motor

- Exceeds IEEE 841 1994/2001 Specs.
- Meet NEMA MG1 Part 31 for inverter fed motor insulation system.
  - 10:1 Variable Torque, 5:1 Constant Torque
- L-10 Bearing Life greatly increased
  - 50,000 Hours on belted loads
  - 100,000 Hours on Direct connected loads
- Five year warranty on sine wave power

Severe Service Motor
IEEE 841 Plus Type CE Features

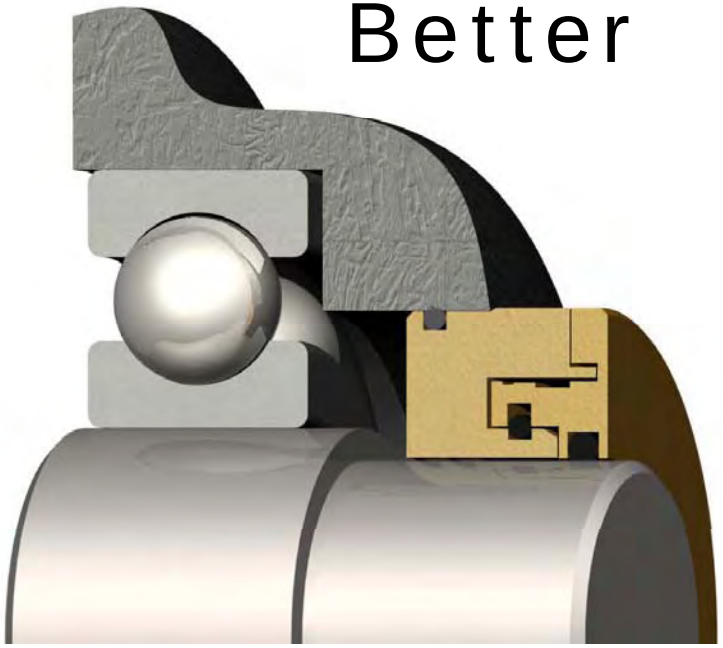
Some additional features :

- Meet NEMA Premium™ Efficiency Values
- Inpro VBXX bearing isolators at each end from frame 143 to 449 included as standard.
- SKF "CARB" Toroidal Bearing (1996) option available.
- Precision balance to 0.05 IPS or better
- Same size bearing up to frame 400.

NEMA Premium™

One motor can spare ANY application

Better



Inpro/Seal VBX®

Best

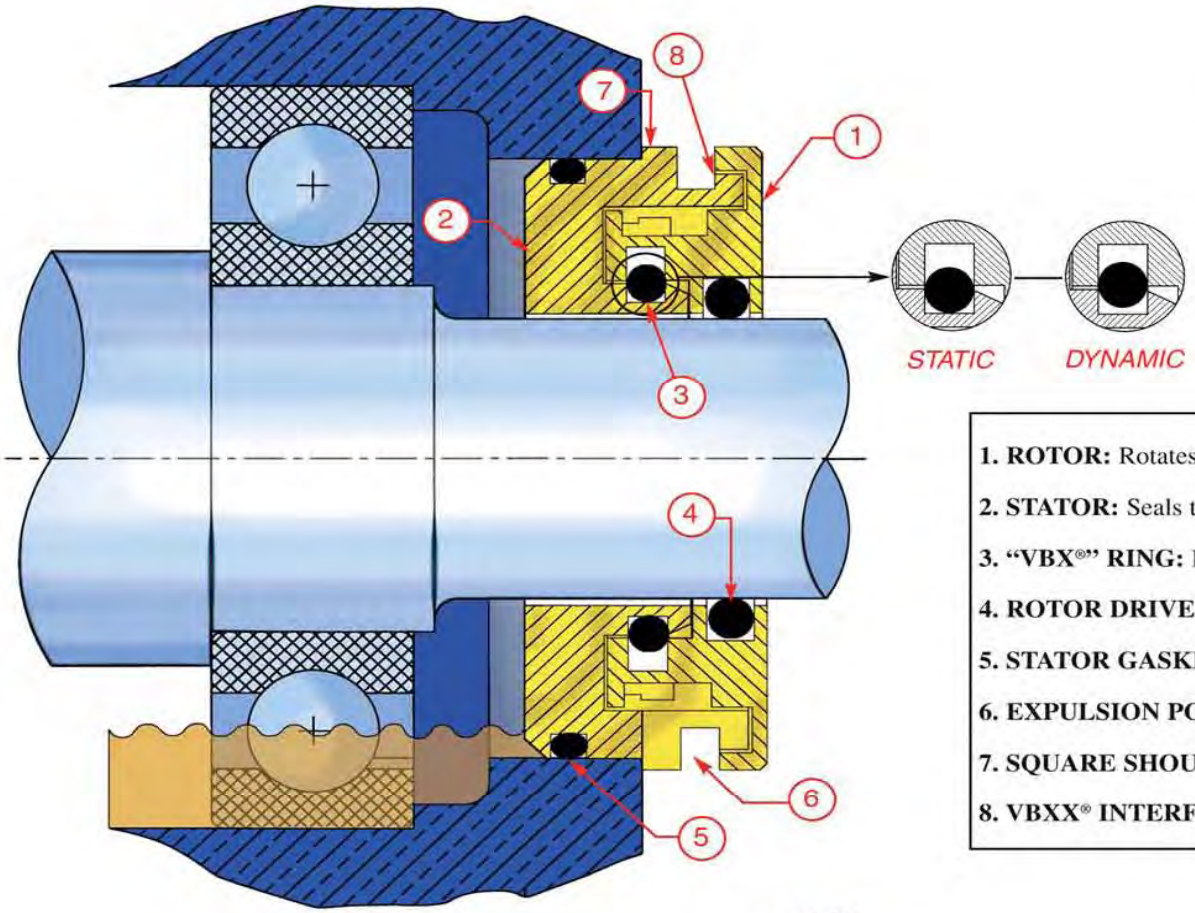
Inpro/Seal VBXX ®

The Inpro/Seal® VBX ® Bearing Isolator consists of two parts, a rotor and a stator, assembled into a single unit and axially locked together by an O-ring insert. The rotor, driven by a tightly fitting drive ring is fixed to and revolves with the shaft. The stator, a stationary component is press fitted to the bearing housing with an O-ring gasket.

The new and improved Inpro/Seal ® VBXX ® Bearing Isolator is the latest and best technology in non-contacting labyrinth seals. The VBXX® combines the best interface for contaminant exclusion with the tried and proven VBX® Vapor Blocking O-ring.

The end result is a bearing isolator with upgraded design features, advantages and benefits that provide levels of protection previously unavailable in any kind of bearing protection device.

INPRO/SEAL® VBXX®



RECOMMENDED OPERATING CONDITIONS

This Isolator is designed to operate in a horizontal attitude with a rotating shaft.

- **Continuous Temperature Limit:** -40 to +400 F
- **Maximum shaft runout:** 0.005" TIR
- **Maximum shaft-to-bore misalignment:** 0.007"
- **Maximum shaft surface speed:** 12,000 ft./min.

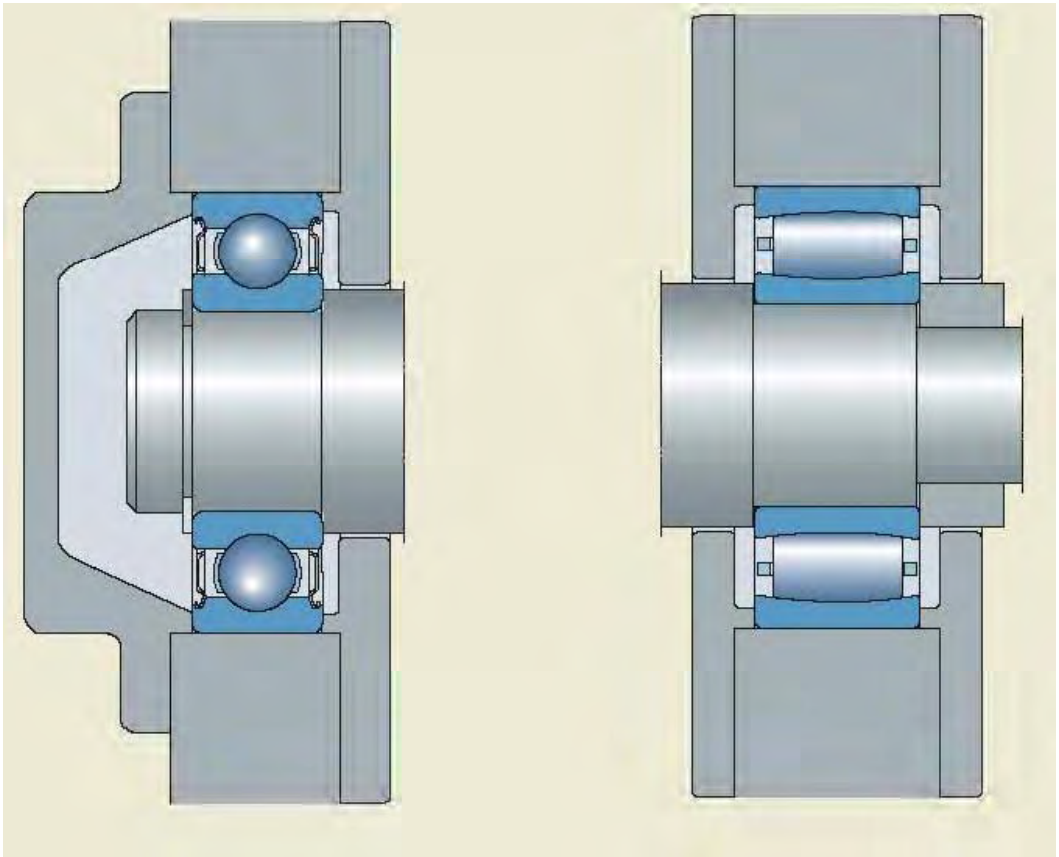
1. **ROTOR:** Rotates with the shaft deflecting contaminants
2. **STATOR:** Seals the housing I.D. with a metal to metal press fit
3. **"VBX®" RING:** Blocks vapor intrusion through the Bearing Isolator
4. **ROTOR DRIVE RING:** Seals the shaft against contaminants
5. **STATOR GASKET:** Additional housing I.D. seal
6. **EXPULSION PORT:** Drain for contaminants
7. **SQUARE SHOULDER:** Aligns the stator to the housing
8. **VBXX® INTERFACE:** Best contaminant protection in the industry

SAME DAY SHIPMENTS

INPRO/SEAL® COMPANY
#1 IN BEARING ISOLATORS
4221-81st Avenue West
Rock Island, IL 61201
Ph: 309.787.4971 • 800.447.0524
Fax: 309.787.6114 • 309.787.6190
e-mail: info@inpro-seal.com
Visit us on the web: www.inpro-seal.com

The Robust motor bearing design – with CARB

Ball Bearing **CARB Bearing**

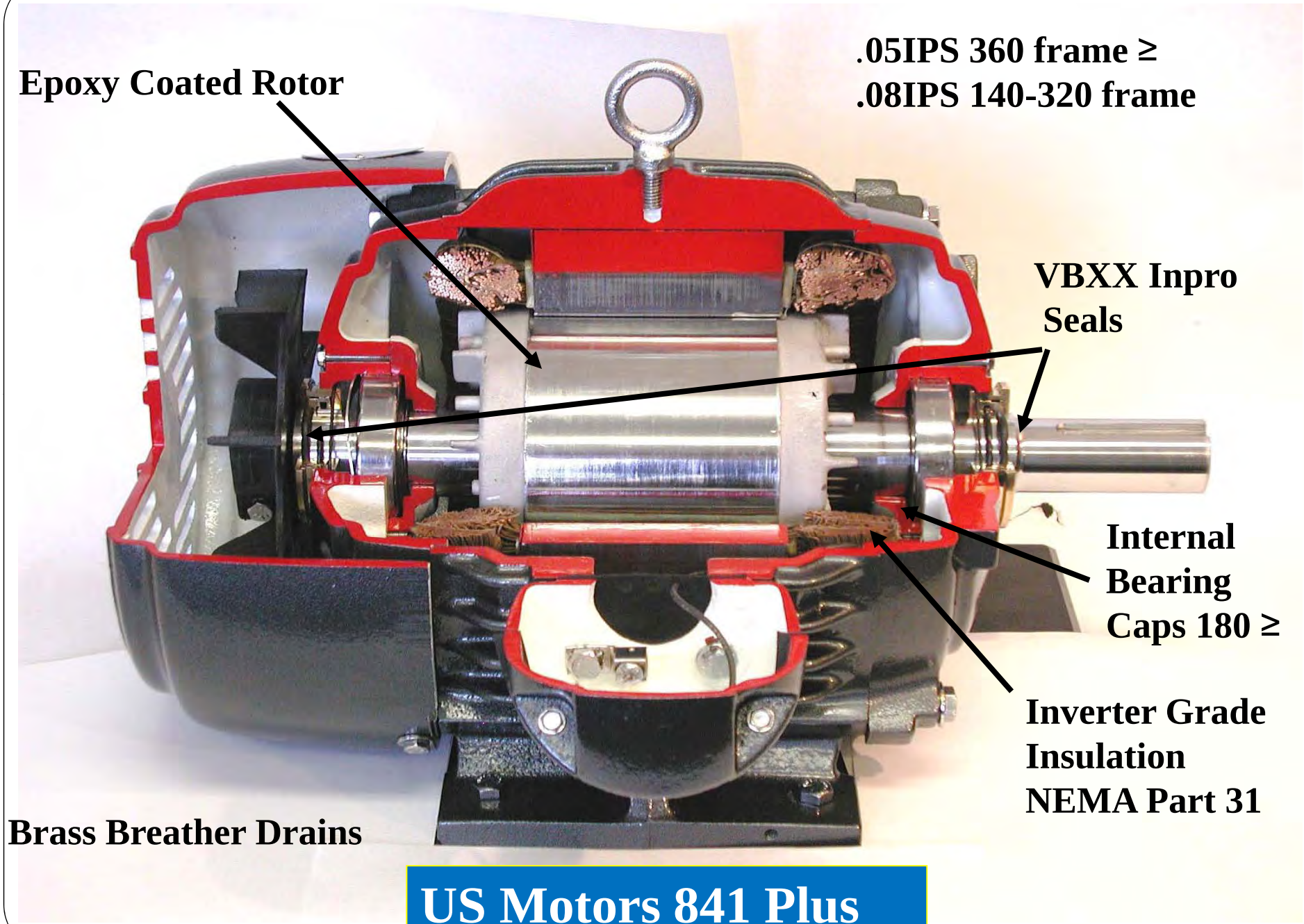


Short End **Pulley End**

- Ideal for:
  - Belt drives
  - Very high loads
  - Misalignment

Allows for:

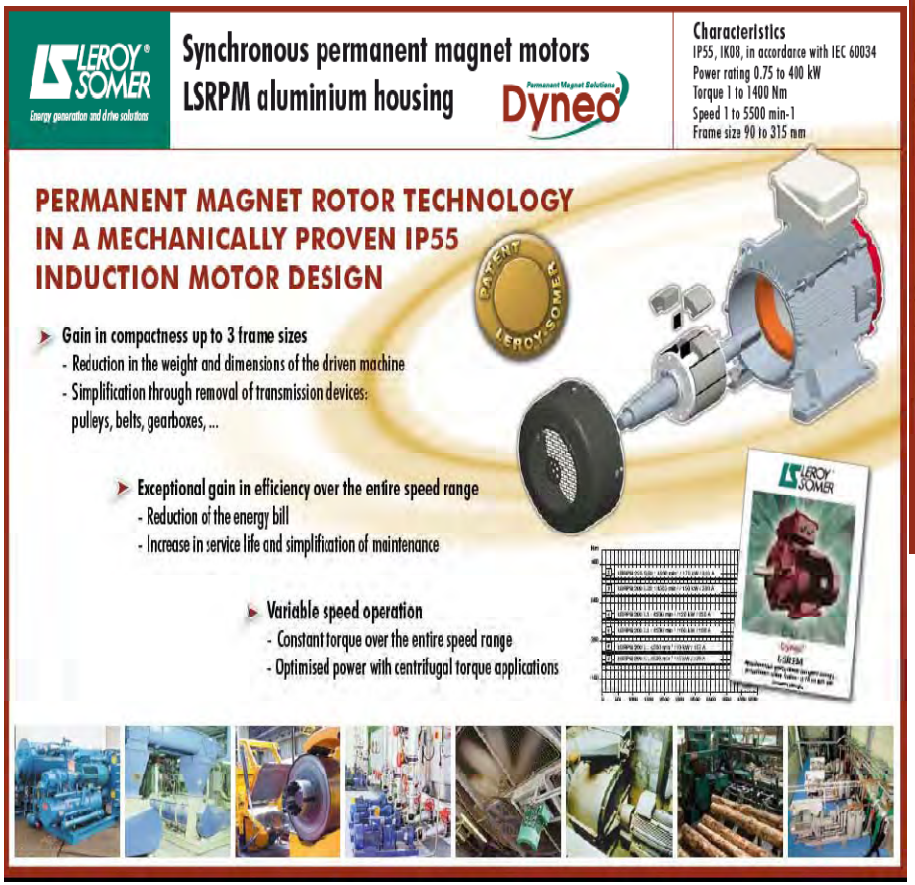
- Direct drives
- Shaft bending

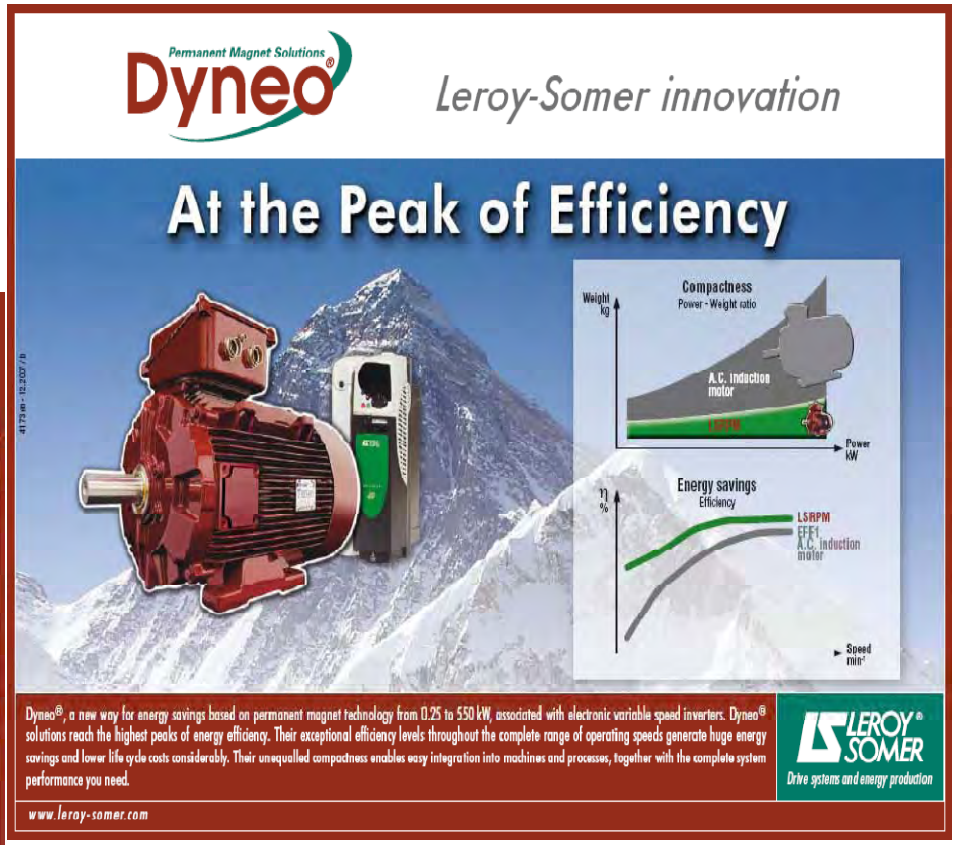


US Motors 841 Plus

New technology : system solution

Permanent Magnet Synchronous Motor





Bow Thrusters Propulsion motors

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