

*Conventional wisdom holds that it is cheaper to repair failed motors above ten horsepower than to replace them. While this is true in terms of first cost, when all the relevant factors are considered, replacement with an energy efficient motor makes economic sense in many situations. Field surveys confirm that typical motor repair practice reduces motor efficiency. Quality assurance programs being developed by the motor repair industry and utilities aim to improve field practice so that a motor will emerge from a repair shop with as small an impact on efficiency as possible.*

## 10.1 REPAIRING VERSUS REPLACING

Motor failures are frequently caused by bearing failures and are often accompanied by the breakdown of the coils of insulated wire inside the motor (the stator windings) and other problems. (See Figure 10-1 for the location of components inside a motor.) When a

motor fails, the owner is faced with deciding whether to rebuild it or replace it. Rebuilding, commonly called rewinding, usually entails a lower initial cost compared to a replacement motor, especially for larger motors. Rewinding can preserve and, in rare cases, slightly improve motor efficiency if skillfully done. However, the rewinding

*There are approximately 4,100 motor shops in the U.S., repairing between 1.8 and 2.9 million motors per year.<sup>1</sup>*

### HIGHLIGHTS

- It is technically possible to rebuild motors to match or exceed their original efficiency, but typical rewinds reduce motor efficiency by about one percentage point.
- Motor users are frequently faced with a decision to repair a failed standard efficiency motor or replace it with a new, energy efficient motor. The economics of a rewind versus replace decision should not be based simply on a comparison of nameplate data for the two motors. The old motor is likely to operate below nameplate efficiency because of aging and damage from past or proposed rewinds. Moreover, if the old motor was oversized, as is often the case, the new replacement can be smaller, thus cutting capital cost. Energy efficient motors also tend to last longer. When these factors are considered, it often makes economic sense to replace failed standard efficiency motors with high-efficiency units instead of rewinding them.
- Rewinding is often more cost-effective if one or more of the following conditions hold: the motor is larger than 125 hp, it operates less than 2,000 hours per year, it is already very efficient so little improvement is to be gained by replacing it, it is a specialty design for which high-efficiency replacements are unavailable, and the price of electricity is low.
- The motor repair industry and some utilities are collaborating to develop quality standards, testing, and training in proper motor rewind practice so that motor efficiency is maintained or improved whenever possible.
- Improved motor repair practice is crucial if utilities and end users are to protect their investment in energy efficient motors that will someday fail and need repair.

process provides many avenues by which the motor efficiency can be degraded, greatly increasing operating cost and energy consumption. To ensure the highest quality in repaired motors, the consistent use of test equipment and documentation procedures must be integral parts of the repair process, so that the efficiency of the motor and the quality of its components can be verified before the motor is put back into service.

A critical task in most motor rebuilds is to remove the old windings without altering the adjacent laminated steel cores, and then to wrap new insulated wire around the old cores (see Figure 10-2). The old windings are com-

monly embedded in thick coats of varnish (used to glue the windings inside the core slots) which prevent their easy removal. Heat, chemicals, or mechanical force are commonly used to loosen and pull out old windings; excessive use of any of these can cause damage to the cores. Improper machining, replacement bearings, wire diameter, and winding technique can all compound, resulting in a rebuilt motor with poor performance and lower efficiency.

Although it is technically possible to rebuild a motor to its original specifications, survey results of actual rewind practices show that this is seldom the case. On the average,

Figure 10-1

Induction motor cutaway

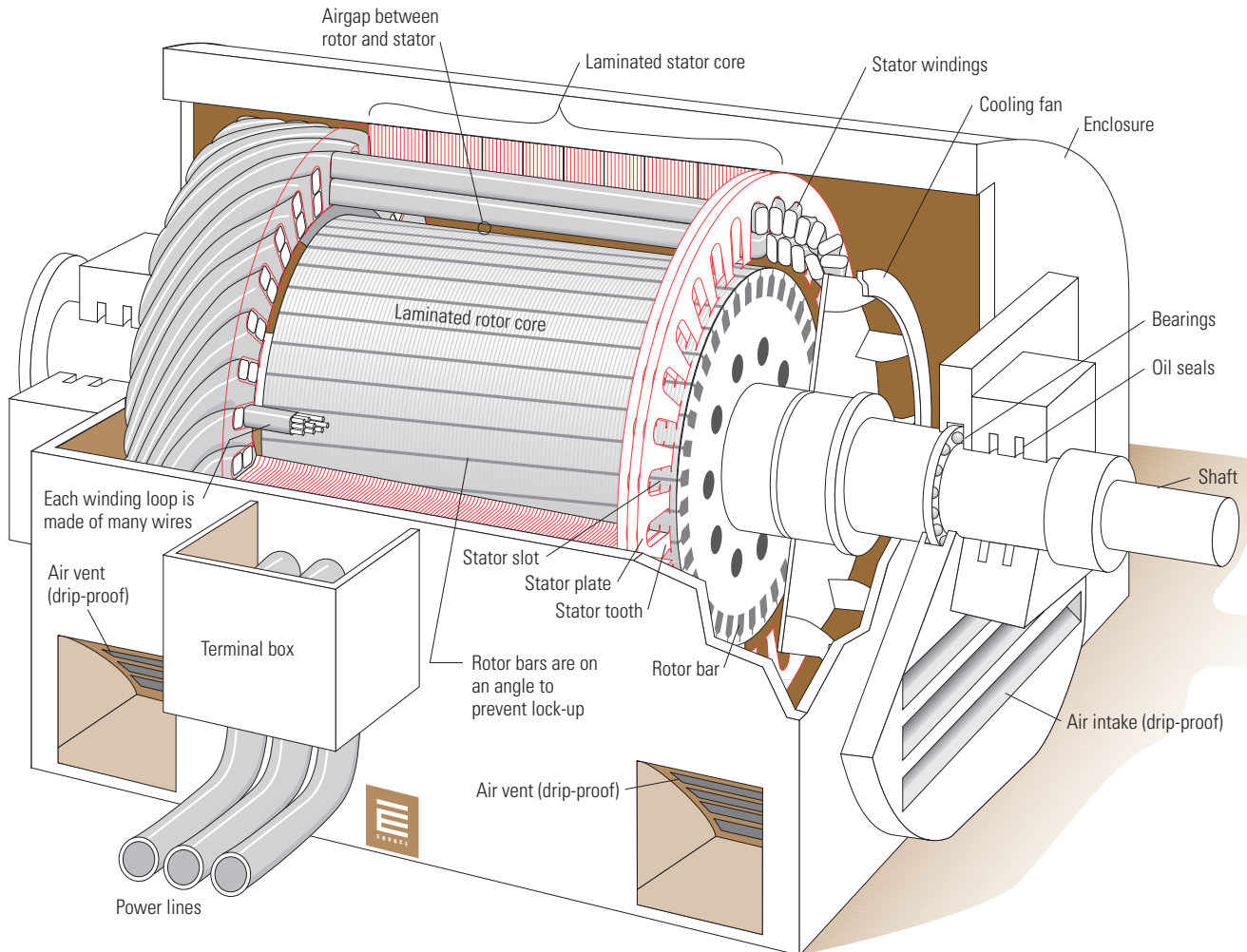
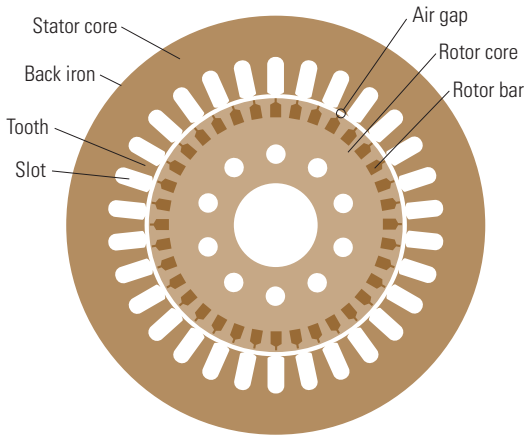


Figure 10-2

**Profile cutaway of an induction motor stator and rotor**



rewound motors are less efficient than they were before rewinding (see **10.7**). The magnitude of this problem can vary widely from one rewind shop to another, and can only be properly identified when efficiency measurements are taken before and after rewinding.

**10.1.1 Deciding to repair or replace**

Conventional wisdom among many facility managers and motor distributors is to rewind all failed motors larger than 10 or 15 hp, rather than replacing them with high-efficiency units. One of the most aggressive and successful corporate energy efficiency programs we are aware of, at the Southwire Corporation, takes a very different approach. Southwire replaces all failed motors below 125 hp with new high-efficiency models, and makes a case-by-case decision on rewinding or replacing failed motors larger than 125 hp. E SOURCE believes that when one considers all of the system benefits of upgrading to energy efficient motors, Southwire's approach represents the most cost-effective policy. The economics vary from case to case, however, so we present some tools for analyzing individual situations.

**SOUTHWIRE COMPANY REWIND POLICY**

While many companies rewind most failed motors over 10 hp, the Southwire Company, one of the largest wire and cable manufacturers in the U.S., rewinds virtually no motors below 125 hp and has a policy to purchase the highest efficiency motors available. The firm's motor rewind and purchase guidelines are summarized below:<sup>2</sup>

- All new motors should be energy efficient motors. **Table 10-1** shows Southwire's minimum efficiency standards for new motors. In a number of size classes, these purchasing guidelines exceed the NEMA Table 12-10 levels that are the basis of impending national standards in the U.S. and Canada (see **2.4**).
- Replace rather than rewind standard AC motors *up to 125 hp* when new energy efficient motors are available. Above 125 hp an

individual evaluation should be made to determine if the difference between rewinding and purchasing a new energy efficient motor can be recovered in five years.

- When energy efficient motors fail, rewind them for a cost of up to 40 percent of a new motor. Require all rewound motors to be tested with efficiency documented.
- Require rewind shops to have temperature controls on burnout furnaces.
- Improve stock of essential motors by better recordkeeping to determine frequently changed motors. All motors in stock should be energy efficient.
- Target certain motors for replacement based on misapplication, good payback, or low replacement cost.

Table 10-1

**Southwire's minimum motor efficiency standards for new induction motors**

HP	Drip-proof minimum efficiency	TEFC minimum efficiency
5	89.5	90.2
10	91.7	91.7
25	94.1	93.6
50	94.5	94.1
125	95.4	95.4
200	96.2	95.8

Source: Southwire Co.

**10.1.2 Economic comparison of rewinding versus replacement**

Most analyses of the comparative economics of rewinds versus replacement consider only a few parameters, including first cost, the difference in nameplate efficiency between the failed motor and a potential replacement, duty factor, electricity price, and demand charges.

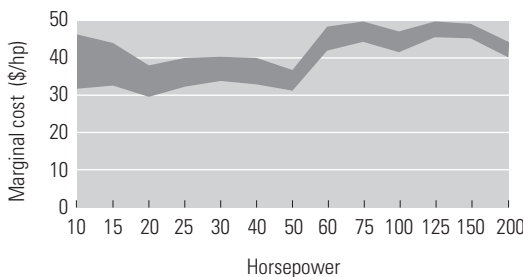
A more comprehensive analysis should consider the following:

- Lifecycle cost, cost of saved energy or, at least, a simple payback analysis.
- The efficiency of the failed motor may be several percentage points lower than its nameplate due to damage from past or proposed rewinding.
- In a significant number of cases, the failed motor may be oversized for its application. This opens the possibility that the energy efficient replacement motor can be smaller than the original unit, thus reducing its marginal cost and allowing it to operate at optimal loading and efficiency.
- With proper installation and maintenance the energy efficient replacement motor is likely to last longer than a rewind unit.

Figure 10-3

**Marginal cost for motor replacement vs motor repair**

New energy efficient motors cost \$30 to \$50 more per horsepower than motor repairs. New motor prices are average list prices less 40 percent.



Source: Vaughan's Price Guide for Motor Repairs and New Motors (1992) and MotorMaster (1992)

New energy efficient motors typically cost about two to three times as much as a repair job in motors under 125 hp, and up to six times as much as a repair in larger motors.<sup>3</sup> Figure 10-3 expresses this relationship in terms of marginal cost per horsepower. The cost-effectiveness of rewinds tend to improve at larger motor sizes because labor requirements for rewinding rise more slowly with motor size than do materials requirements for new motors. There is wide scatter in rewind costs, however. In Canadian field studies presented in section 10.7, rewind prices varied by as much as a factor of two.

Although a new energy efficient motor costs more than a rewind, it typically pays back quickly in reduced energy costs. As discussed in section 8.1, Figure 10-4 shows a conservative assessment of the cost of saved energy (CSE) from high-efficiency replacement versus rewinding, for TEFC motors. It shows a CSE of under 2.5¢ per kWh for motors up to 200 hp at duty factors of 4,000 hours per year or more. As noted in section 3.4, the average duty factor of commercial and industrial motors is over 4,000 hours per year. While the numbers shown in Figure 10-4 reflect the assumption that the rewind motor is two percentage points less efficient than its nameplate (due to damage from past or proposed rewinding), the potential that frequently exists for motor downsizing is ignored, and

Figure 10-4

**Cost of saved energy of energy efficient motors vs rewinds of standard motors**

Assumes 1800 rpm, TEFC motors, 75 percent load, 75 percent duty, a discount rate of five percent, and an investment life of 10 years.

