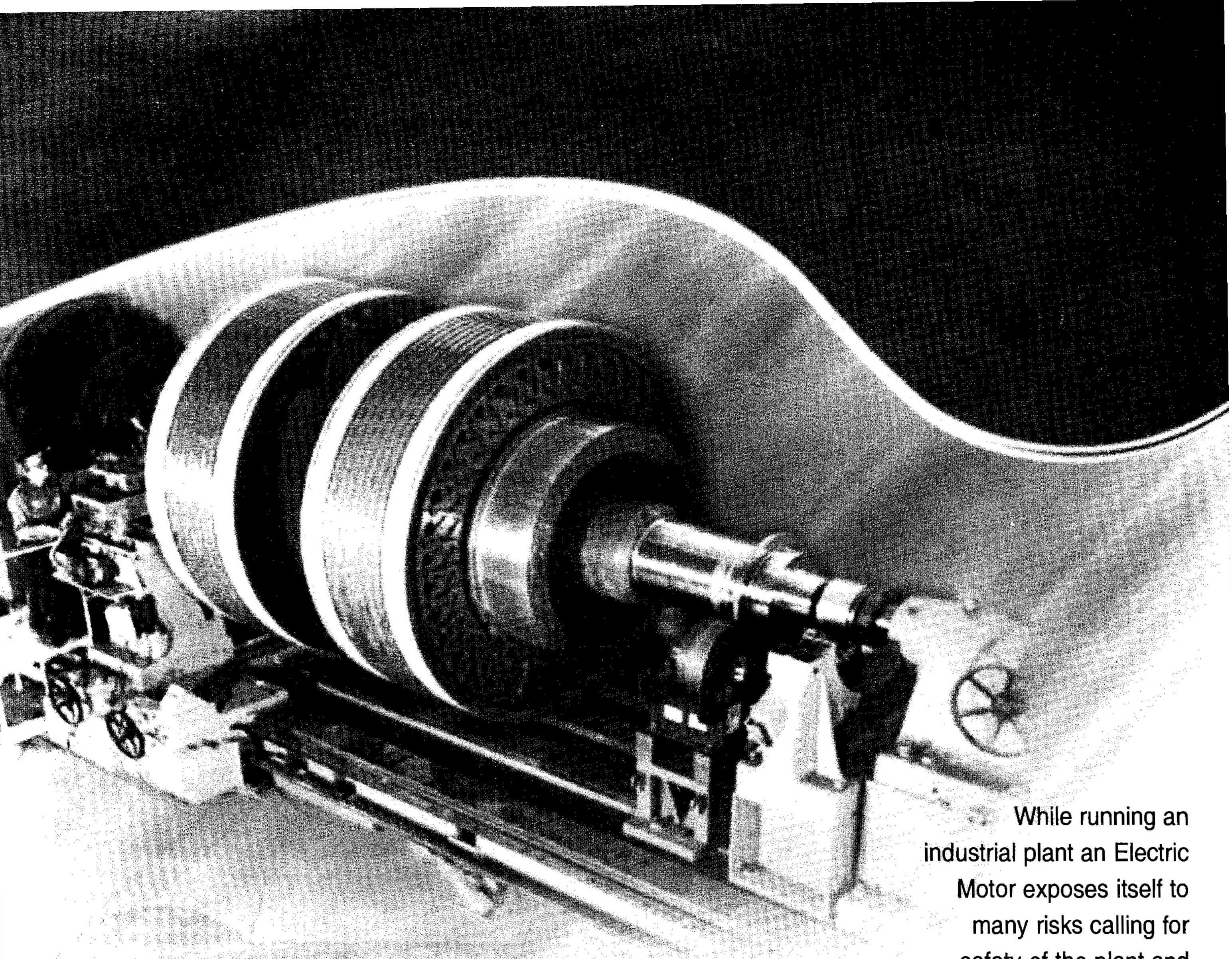

Electric Motor : Major Causes of Failure & Detection

While running an industrial plant an Electric Motor exposes itself to many risks calling for safety of the plant and people operating around it. In cases of failures of general purpose motors, we normally wonder whether a partial repair or a through replacement of the failed part would be sufficient. The most important point to determine at this stage is whether the root cause of the failure was the frequency of starts and stops.

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Electric motors play a very important role in the safe and efficient running of industrial plants and processes. Early detection of abnormalities in the motors will help to avoid expensive failures. The induction machine is the single most common electromechanical energy conversion device available. It is used to drive numerous important propulsion and medium transfer unit. The induction machine is considered inherently reliable due to its robust and relatively simple design. That said, the induction machine does fail most usually as a result of aging or poor construction and, if failure is of a catastrophic nature, hazards to production, safety, and the environment can often fault. Once the motor fails the two options are there whether to repair or replace?

In the past, the decision whether to repair or replace an electric motor has been one of economics. Replacement of an older electric motor with a more efficient model often makes sense for a motor operating continuously. However, in most cases, the decision is more complex than the oft-cited "Replace the motor if repair cost exceeds x% of new." When comparing the cost to replace or repair an electric motor, the equation should include not only operating cost and payback period, but also downtime and associated factors such as capital depreciation, lost opportunities, and customer goodwill.

For general purpose motors, there are many cases where replacing a failed motor with a new one will be the best choice. However, the motor may fail again unless the root cause of failure is addressed through some modification to the motor or the system. There are also many cases where repairing the existing motor is the best choice. This is especially true if modifications can be made to minimize the possibility of future failure, or in cases where cost, availability, or unique performance are an issue. In general basic faults and their percentage found in electric motors as shown in Fig. 1 While checking for the failure following is the application checklist

Voltage

- What is the nominal voltage?
- How much voltage variation is present?
- Is there voltage drop when starting under load?
- Is there nuisance tripping?
- Are there transient peaks?

Environmental factors

- What is the frequency of moisture ingression?
- What is the frequency of condensation?
- What is the ambient temperature range?
- What other contaminants are present?

Load conditions

- Are there load swings? If so, how wide?
- What is the hp required versus rated hp?
- What is the load pump, fan, compressor, conveyor?

How is the motor mounted/coupled?

- Direct coupled
- What are the thrust conditions?
- Overhung load
- Describe the motor's mounting.

Starting method

- Across-the-line
- Part-winding start
- Star start, Delta run
- Soft-start.

Frequency of starting

- What is the running time

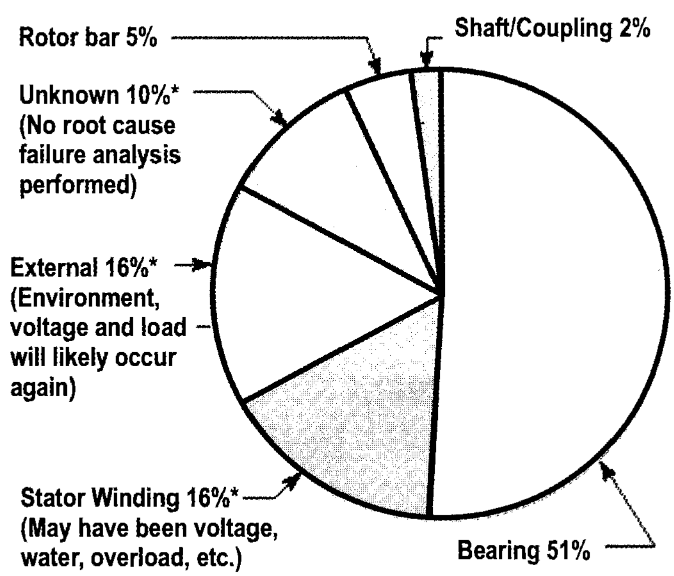


Fig.1

between starts?

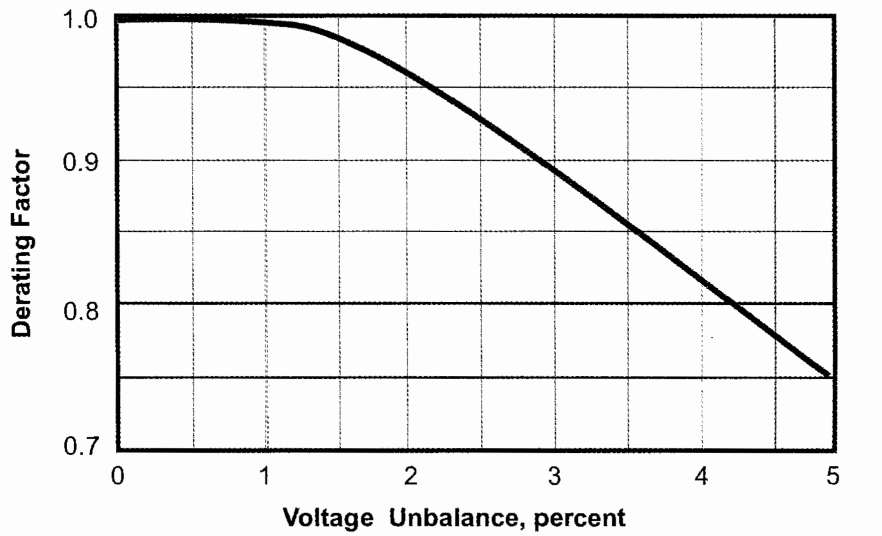
- How many starts per hour / 8- hours / 24- hours?
- Is it a demand system?
- Is it a constant or variable load?
- Describe the cycling.
- Are there load-shedding opportunities?

Describe the application

- How critical is the operation?
- Is it a dedicated or redundant system?
- What is the availability of spares or backups?
- What are the consequences of shutdown?

History of failures or repairs

- Has the motor been rewound? If so, how many times?
- What is the mean time between failures?

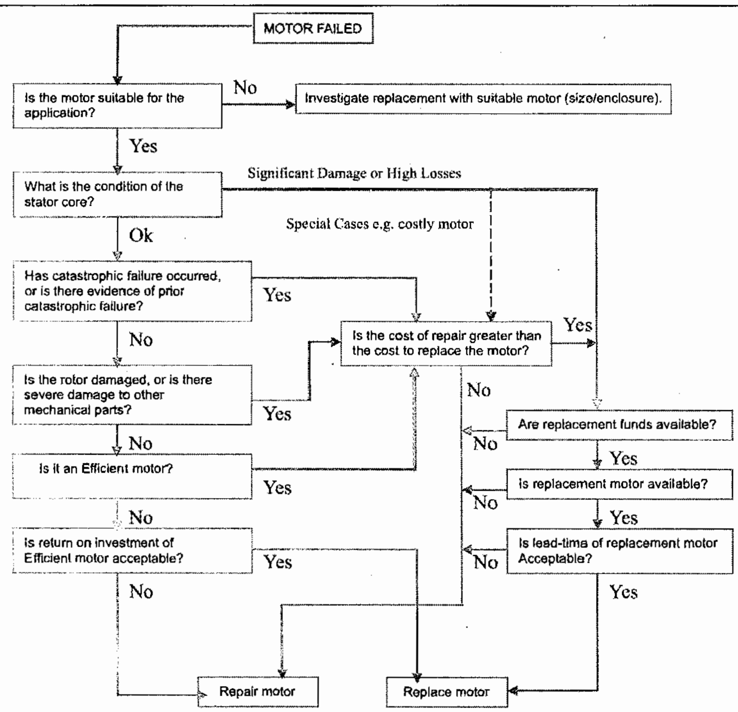


$$\% \text{ Unbalance} = \frac{100 \text{ X maximum voltage deviation from average voltage}}{\text{average voltage}}$$

Fig.2

Root cause failure analysis

- What is the cause of failure?
- What can be done to eliminate the cause?
- What is the best method to detect the condition?
- Are there similar motors and applications?



The intuitive decision - making process for most motor failure

Overheating Electric Motors:

Maintenance experts agree that, excessive heat causes rapid deterioration of motor winding insulation. The common rule states that insulation life is cut in half for every 10 C of additional heat to the windings. As an example, if a motor that would normally last 20 years in regular service is running 40 C above rated temperature, the motor would have a life of about 1 year. Leading standardization organizations have concluded that 30 percent of motor failures are attributed to insulation failure and 60 percent of these are caused by overheating.

Overload conditions :

Stator current is frequently used to measure load level, but load level can easily be masked by an over voltage condition. A common mistake is made in operating at an over voltage to reduce the stator current and to reduce the introduction of heat. It has been shown that for motors ranging from 10-200 hp, operating at a 10 percent over voltage would typically decrease losses by only 1-3 percent. Even though the motor current may vary when applying over voltages, the excessive damaging heat in the motor will not improve. A load error of more than 10 percent can be introduced by relying on stator current readings to access probable load and heat levels. Under full load conditions, this is the difference between life and death to a motor. In industrial applications, perfect voltage conditions are rare. Losses, not current levels alone, are the true source of heat. These losses are a destructive factor to windings and a significant reason for bearing damage. This justifies the need for accurate knowledge of operating load level. Only accurate load level calculations can give reliable measurements of excessive losses and overheating in the motor.

Power condition:

Electric motors in manufacturing plants generally need to be derated because of poor power conditions in order to maximize their useful life. NEMA MG-1 Sections II and IV specify what voltage quality, as a function of balance and distortion, allows what level of percentage load. ***Fig 2*** shows the NEMA derating curve for percentage of unbalance. According to the derating curve, the higher the level of unbalance, the lower the acceptable level of steady state load. For example, if a 100 hp motor has an unbalance factor of 3 percent, the motor should be derated to 0.88 or 88 percent of capacity, 88 hp.

Effective Service Factor :

The key to finding the most frequent causes of overheating is accuracy in estimating load level. This can be identified by looking at only currents and voltages. The formula for calculating effective service factor is

[%load] / [%NEMA Derating]

Effective service factor provides predictive maintenance professionals a solid conclusion of stress on any particular motor load application.

Frequent starts and stops :

Limiting the frequency of startup, the most stressful portion of motor operation, is highly important. Many well-documented cases of recurring motor failure were addressed by increasing the horsepower rating of the motor which shortened the time between failures. However, the root cause of the failure was actually the frequency of starts and stops. The key is to closely monitor the number of starts-hourly for small or medium motors and daily for larger motors.

Environmental conditions

Thermography is frequently used to determine the conditions where electric motors are being used. Poor cooling due to high ambient temperature, clogged ducts, etc., are typical examples of no electrically induced temperature stress on both the motor and insulation system. Chemical abrasive substances in the air, wet operation, and high altitude operation are a few common environmental stresses.

Test to standards

Bearing and winding failures are the most common motor failures. The fundamental reason usually is excessive heat. Preventive maintenance practices frequently limit on-line electrical measurements to interpreting current levels. While important, this method is inconclusive in identifying failures caused by excessive winding heat. The best way to ensure successful preventive maintenance and monitoring is to test according to NEMA and other professional standards. Automated assessment is necessary to effectively ensure motor health. ■

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