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According to this analysis, a change in your motor mindset may be in order.

It's been a hot topic in industry for decades. One of the most frequently quoted studies related to electric motor reliability is a 1983 Electric Power Research Institute (EPRI) project performed by General Electric (GE) [1] that's been used to support a variety of programs, equipment and other motor strategies. While searching for a copy of the original study, this author has often cited other papers that reference its findings. Such a paper was recently made available by the Institute of Electrical and Electronics Engineers, Inc. (IEEE). A review of it indicates some statements that have discussed or tried to interpret EPRI's findings over the years have been incomplete and/or incorrect. The good news is that the EPRI project wasn't the only major study to target electrical and electric-machine reliability. Studies conducted by others from 1962 through 1995, including those of an IEEE Power Engineering Society group, were supported by various industry groups as late as 2010.

What's particularly interesting about the non-EPRI research efforts is that despite their focus on different industries (such as utilities, petrochemical, general-industry and commercial-building sectors), they report similar results. Here, we review what these studies really mean in regard to their primary emphasis—*larger machines*. This includes identified reliability issues and recommended improvement strategies. While the full breadth of the related studies is more than we can cover in this article, the information presented in these pages will significantly impact how you look at your motor systems.

Regarding the EPRI study

The percentages shown in Fig. 1 are often cited as the conclusion of the EPRI study—*which is correct.*
However, the details behind those percentages are intriguing. This includes the number of motors that failed more than once (and the apparent causes of those failures), as well as the general reliability of electric motors in utilities.

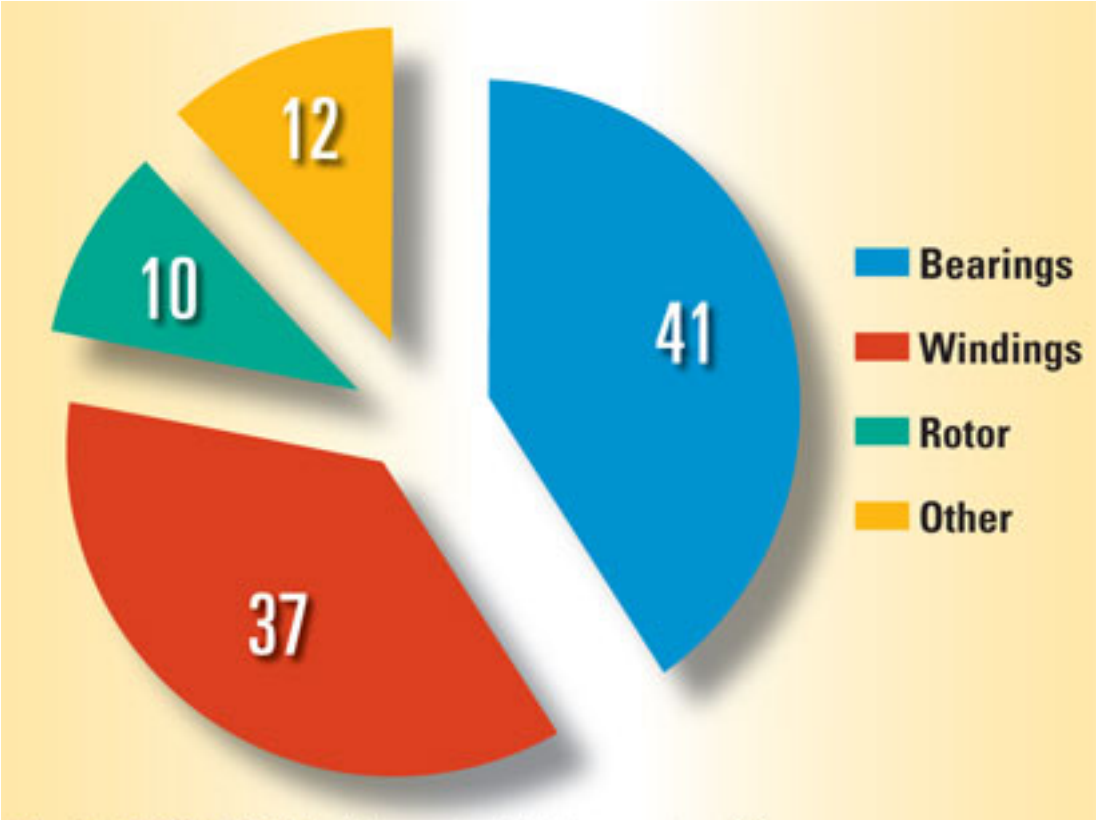

Fig. 1. 1983 EPRI Study motor-failure rates [1]

First it was noted that more than 90% of the failures occurred in 54% of the facilities evaluated, and half of the failures occurred in 17% of the facilities. This means that a majority of the failures occurred in less than half of the evaluated sites. The average failure rate of motors across all the facilities was 3.4% per unit annually, with some operations having a higher rate, and 46% of them having very low failure rates. In all, the study found that those plants at the extremes had a failure rate of 9.3% per year (17% of facilities) and 13% of the sites had about a 0.8% failure rate.

There were 4797 motors evaluated in the study, with a total of 1227 failures on 872 units. This means 335 of the 1227 failures were repeat failures. The best sites saw some of their motors

fail two to three times versus results from the median group, which saw failures of four or more times, and the worst group, which saw an even higher repeat-failure rate.

The apparent causes of failure were also surprising: Only 34.1% were blamed on misapplication and misoperation. (As noted, though, causes weren't specified for more than half [50.2%] of the failures.) The failure modes were correctly identified, with repeated incidents being the same as the original failures. Table 1 identifies the failures and the percent of each failure mode.

Of these failures, design was determined to be 39.1% and workmanship was 26.8%. In effect, the survey determined that 65.9% of the motor failures were related to the manufacturer and rebuilder.

The failure rate by manufacturer was found to range from 0.84% to 5.27% for the top seven OEMs: 16.44% for one manufacturer, and a combined total of 6.50% for all the others. The manufacturers were not identified.

One issue brought to light by statistics in the 1983 EPRI study is that insulation-to-ground faults are the majority of winding faults. Quotes related to this study and other industry statements identify turn faults as the initiation of failure—*but such a statement is not found in the EPRI research or follow-up studies* .

Table I. 1983 EPRI Study Motor-Failure Modes [1]

Failure Mode	Number of Motors	Percent of Total (%)
Other – Unspecified	313	35.9
Insulation to Ground	161	18.5
Sleeve Bearing	85	9.7
Ball Bearing	43	4.9
Thrust Bearing Vertical	41	4.7
Oil Leakage	36	4.1
Turn Insulation (Short)	32	3.7
Rotor Bar Failure	31	3.5
Roller Bearing	20	2.3
Bearing Seal	20	2.3
Loose Blocking	16	1.8
Rotor Shaft	13	1.5
Oil System	12	1.4
Stator Slot Wedges	11	1.3
Loose Iron	9	1.0
Stator Frame	7	0.8
Line Cable	6	0.8
Coil Connection	5	0.6
Balance Weights	5	0.6
Accessories	4	0.5
Thrust Bearing Horizontal	2	0.2

[redacted]

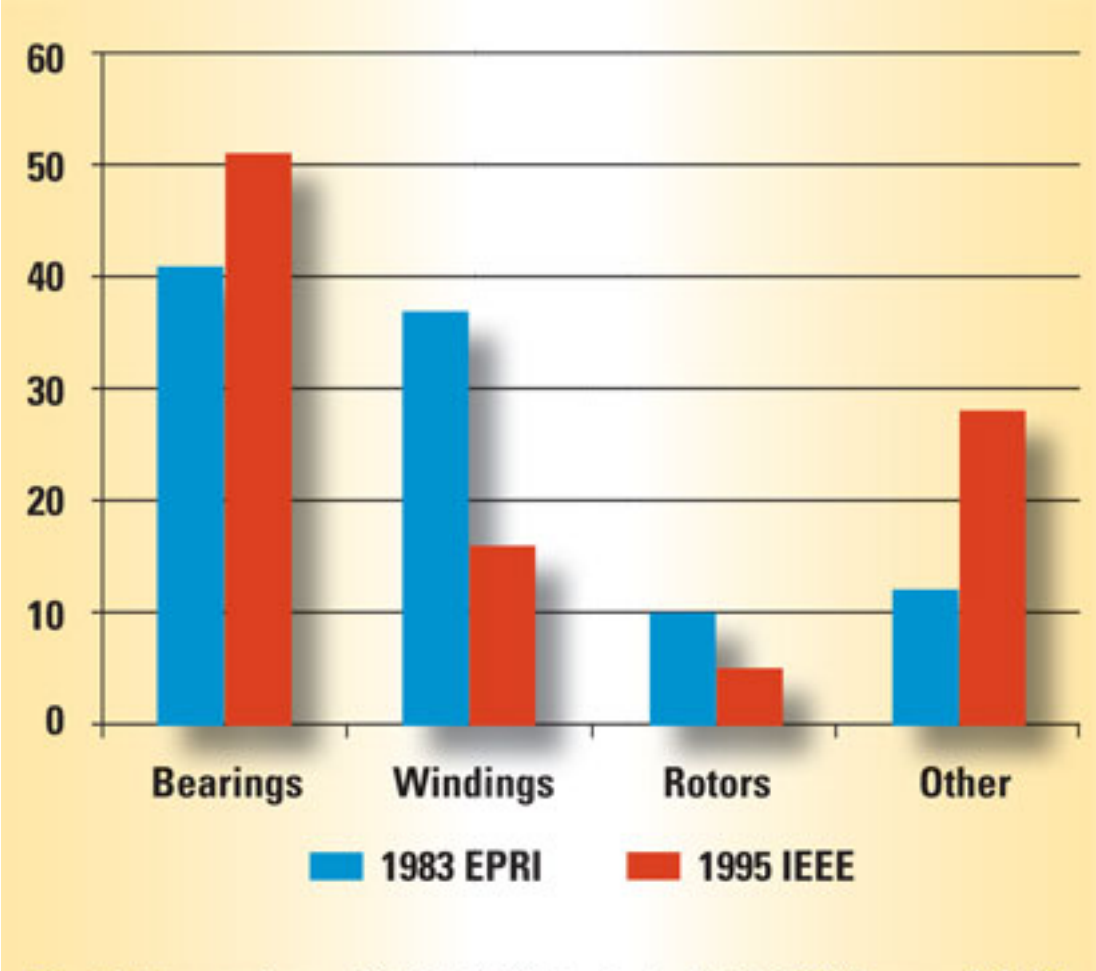

Fig. 2. Comparison of 1983 EPRI Study to 1995 IEEE Survey [1], [3]

To begin with, the IEEE survey focused on motors greater than 50 HP and

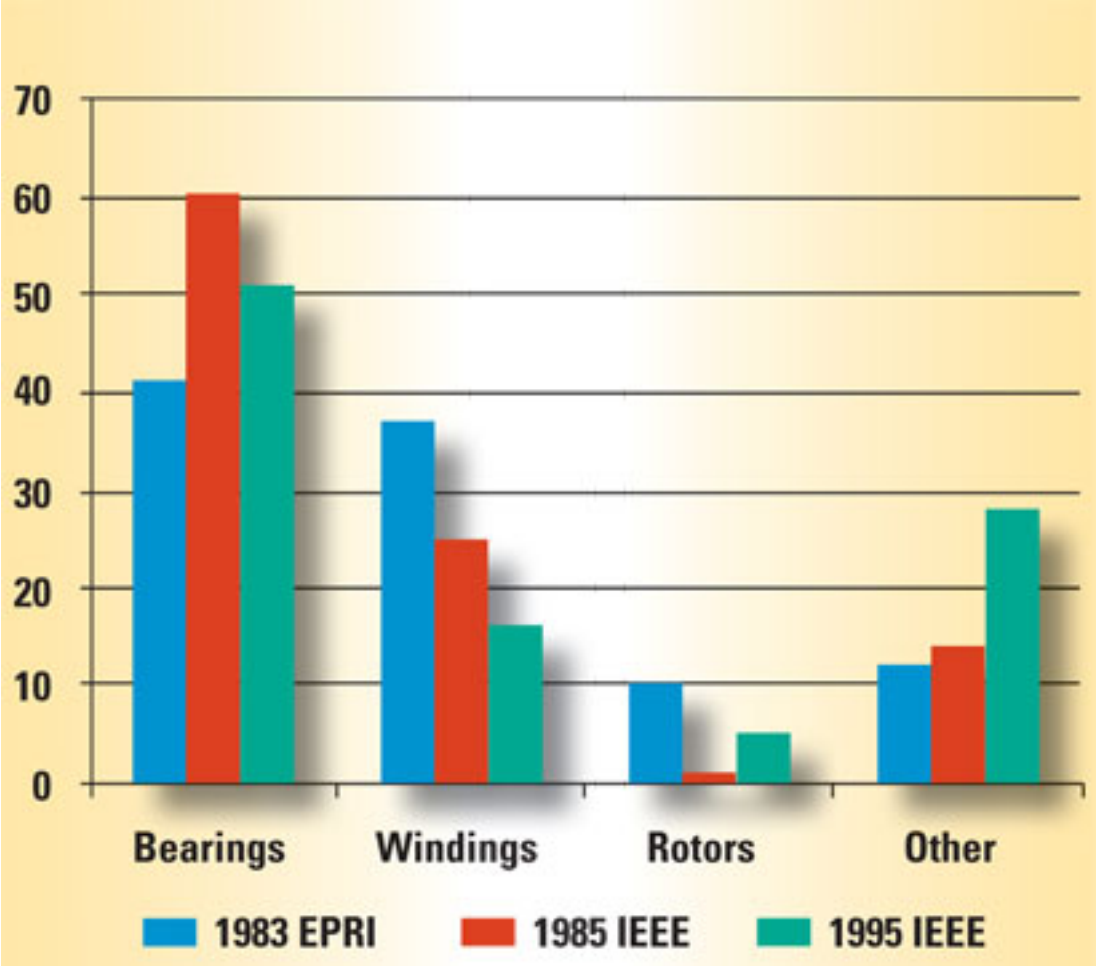

Fig. 3. Comparison of 1983 EPRI to 1985 and 1995 IEEE Surveys [1], [2], [3]

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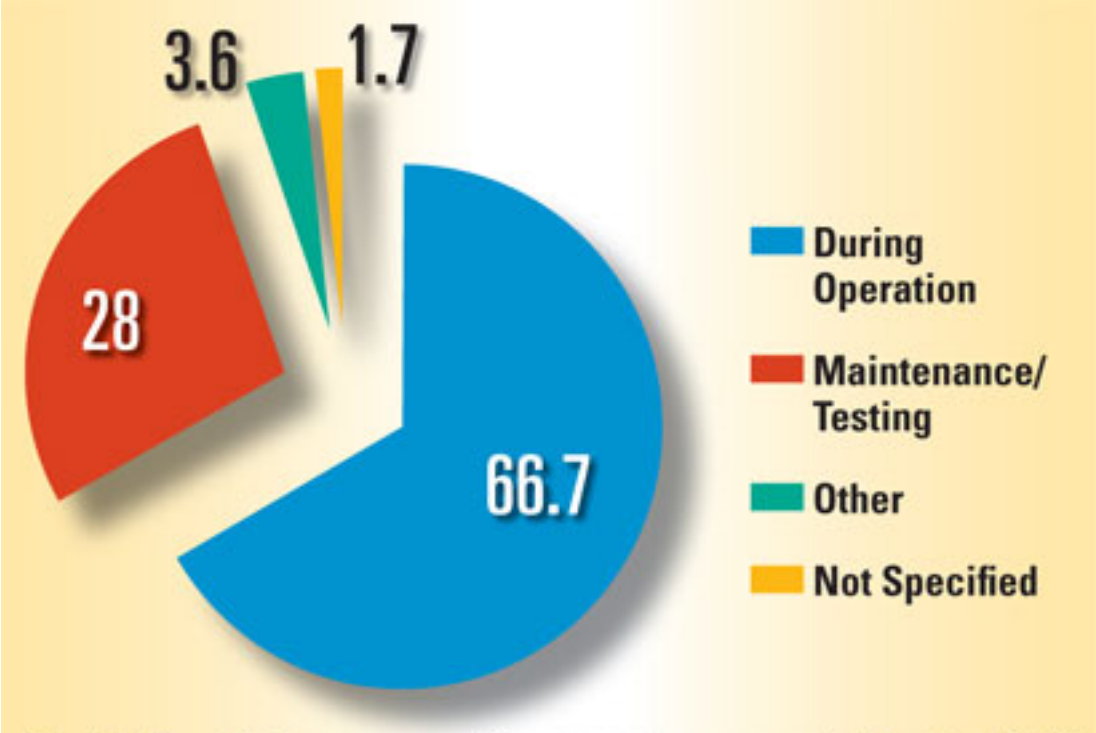

Fig. 4. Time failures were discovered, as reported by the 1985 IEEE survey [2]

[redacted]

Table II. Maintenance vs. Failure Rate, According to 1985 IEEE Survey [2]

Level of Maintenance and Frequency	Failure Rate (FPU)	Median Hours Downtime/Failure (Impact on Production)
Excellent, <12 Months	0.1115	8
Excellent, 12-24 Months	0.0364	24
Excellent, >24 Months	0.0315	36
Excellent, Average	0.0708	16
Fair, <12 Months	0.0872	16
Fair, 12-24 Months	0.0403	54
Fair, >24 Months	0.0719	165
Fair, Average	0.0710	16
Poor, 12-24 Months (All)	0.0563	96

The maintenance practices that encompassed "excellent" maintenance included:

[redacted]

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