Opportunities for Improving the Energy Efficiency of Repaired and Rewound Motors

Vincent O. Schueler, Washington State Energy Office
Johnny Douglass, Washington State Energy Office

INTRODUCTION

More motor horsepower is repaired than sold new each year. In 1993, 2.5 million new motors over 5 hp (totaling between 75 and 100 million hp) were sold in the United States (EPRI 1993). In the same year, between 1.8 and 2.9 million motors over 5 hp (totaling over 200 million hp) were repaired (Schueler, Douglass and Leistner 1994). Improper repair or rewinding can decrease the energy efficiency of an individual motor between .5 and 2.5 percentage points. Estimates of the average reduction in efficiency after repair converge on 1 percent. However, efficiency decreases are not unavoidable consequences of repair or rewinding. Case studies of rewound motors have shown decreased efficiency to be linked to specific short cuts, errors, or parts substitutions. If all motors repaired in the United States in 1993 had been repaired with no efficiency losses motor energy use would have decreased by between 200 and 300 aMW.

Quality motor repair and energy efficiency are closely linked. Maintaining energy efficiency during motor repair usually improves motor performance and reliability. Although interest in demand side resources is declining in this era of increased utility competition, by working with motor repair industry to improve the quality of motor repair, utilities can provide information and services critical to helping industrial and commercial customers manage their energy and improve productivity.

This paper summarizes results of a two-year project to assess motor repair practice in the United States and to identify opportunities for and barriers to improving energy efficiency and quality of repairs. This study was initiated and funded by the Bonneville Power Administration and the Electric Power Research Institute. Key sources of information used to develop findings included:

- A detailed survey of a representative sample 65 United States motor repair shops
- Site visits to more than fifteen repair shops
- More than thirty interviews with key informants among motor manufacturers, the motor repair industry and utilities
- An extensive literature search

In this paper we outline some of the study highlights. We cover the:

- structure of the motor repair industry
- technical energy savings potential and other benefits of moving the industry towards quality motor repair
- elements of quality motor repair
- education, financial, technical and infrastructure barriers to quality repair
- potential utility and government strategies for working with the motor repair industry to transform motor repair practice.

THE MOTOR REPAIR INDUSTRY

There are approximately 4,100 motor repair shops in the United States. In 1993 these shops had about $2.75 billion in gross annual repair revenues, of which 70 percent was for motor repair services only. Most repair shops are independently owned family businesses. They are very stable and most have been in business at least 25 years. Some manufacturers including General Electric, Westinghouse, and Reliance still own repair shops. These manufacturer-owned shops repair motors made by all manufacturers.

Seventy-five percent of repair shops have under ten employees. However, larger shops (ten or more employees) have a bigger share of the market as they are likely to repair more and larger motors. Larger shops repaired 55 percent of the total motors and 75 percent of the total horsepower.

About two-thirds of the shops provided planned motor maintenance and inspection services, which generally include cleaning, inspection and balancing. This appears to be a small (10 percent), but growing part of the motor repair market. Almost all repair shops provide services other than motor repair and rewind. Ninety-five percent of shops we surveyed sold new motors. Eighty percent sold or serviced other electrical equipment.

The major industry association with which shops affiliate is the Electrical Apparatus Service Association (EASA). Slightly under half of repair shops in the United States, accounting for 75 percent of the total repaired horsepower are members. Smaller shops are less likely to be members of EASA.

The motor repair industry is in transition

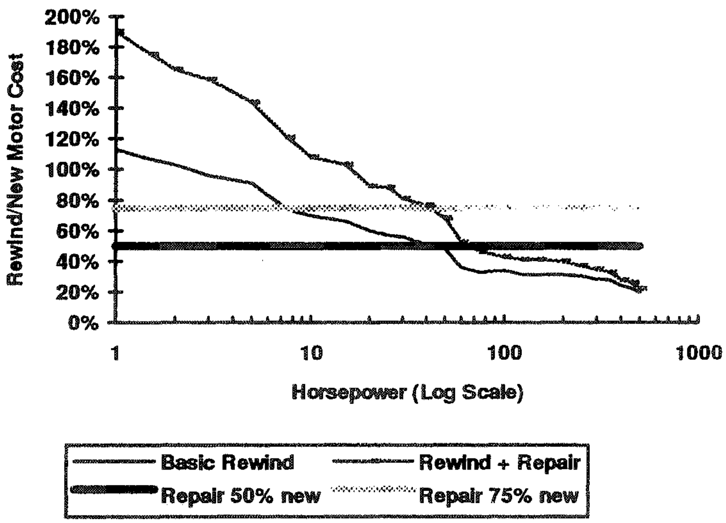
Repair shops are under tremendous pressure to reduce costs, improve quality assurance and technical services and reduce lead times. The equipment and methods for repairing motors have changed little over the years. It has been a process of manual labor relying on craftsmanship and practical experience on the shop floor. The micro computer has not made it into many smaller and some mid-sized shops.

At the same significant advances have been made in testing methods and equipment. Commercial core loss testers are one example. Surge comparison testers have become a valuable tools for performing a variety of diagnostic and verification tests. In some shops sophisticated computerized vibration monitoring equipment is being used for rotor balancing, bearing diagnosis, and even electrical diagnosis. And increasing number of shops are also developing more sophisticated applications of information technology to support operations.

This modernization of plant and practice requires capital in an era of declining profitability for the industry. In a 1993 shop survey sponsored by EASA, almost 75 percent of the shops surveyed reported that profitability had decreased over the past two years. Shops attributed this decline to increasing labor costs, a decreasing market for motor repair, high-tech specifications, increasing costs for meeting governmental regulations, and customers with more sophisticated demands for services (Brutag and Associates 1993).

One reason for the decline in the motor repair market is that the decision point for replacing rather than repairing motors is shifting to larger motors. The decision to repair rather than replace is typically made when repair and rewind costs are 50 to 75 percent of the cost of a new motor (Figure 1). For non-specialty motors the decision point is generally between 10 and 20 horsepower depending on the nature of repairs and local costs. For some specialty motors (for example, high slip or vertical motors) the replacement point may be lower because new specialty motors are more costly and less likely to be in stock. Increasing motor repair labor costs in the United States and declining new motor costs which are driven by offshore production in Mexico and elsewhere and decreases in tariffs are moving the replacement point to higher horsepower motors. Also, failure of a standard motor presents a convenient time to upgrade to one of the much more efficient new models available today. In some high labor cost markets, it is now common to automatically replace and rewind motors up to 50 hp (Mehta 1994).

Figure 1
Rewind and Rewind/Repair Cost as a Percent of New Motor Cost -- 1800 RPM, TEFC Standard Efficiency Motors



Source: Vaughen's 1994

ENERGY SAVINGS IMPACTS

Comprehensive studies on the magnitude and causes of decreased efficiency after repair are not available. In our review of the literature were found five case studies of efficiency loss in motor repair covering 52 motors. Most were under 100 hp. These case studies, summarized in Table 1, illustrate what can happen as a result of repair. Full load efficiency decreased between .5 percent and 2.5 percent. Estimates converged on an average decrease in efficiency of 1 percent for motors in this size range. A rough rule of thumb suggested by Zeller (1994) is that current repair practices increase motor *losses* by about 8 percent after rewind. This is equivalent to a one percent efficiency decrease for motor under 100 hp and one-half-of-one percent for larger motors.

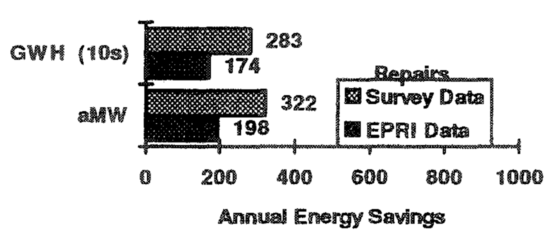
Table 1

Empirical Studies of Efficiency Loss During Motor Repair

Study	Sample Size	Decrease Full Load Efficiency	Comments
McGovern (1984)	27	1.5 - 2.5%	Motors ranged from 3 to 150 hp - Wide range of motor age and rewind histories General Electric
Colby and Flora (1990)	4	.5 - 1.0%	Standard and Premium 5 and 10 hp motors. North Carolina
Zeller (1992)	10	.5% Rated Load .7% 3/4 Load	Controlled test. Identical 20 hp Premium Efficiency Motors Shops in British Columbia
Ontario Hydro (1991)	9	1.1 % Rated Load .9 % 3/4 Load	Controlled test. Identical 20 hp Standard Efficiency Motors Shops in Ontario
Ontario Hydro (1992)	2	40 hp 2.2% Rated Load 100 hp .4% Rated Load	Motors rewound four times each

These losses are preventable. Ontario Hydro found in its work in 1991 and 1992 that with proper care, diagnostics and attention to detail, most repaired and rewound motors and be returned to pre-repair levels of efficiency. If all the motors under 500 hp repaired in 1993 were repaired with no increase in losses, electric energy end-use would decrease between 200 and 300 aMW a year (Figure 2). The difference in the two estimates depends on how the number of repaired motors is estimated. If all repaired motors currently in operation had no decrease in efficiency after repair, savings would be on the order of 2000 aMW. This is equivalent to two large power plants. Achievable savings are likely to be half or two-thirds of technical potential.

Figure 2
Technical Savings Potential
For Motors Repaired in 1993 in GWH and aMW



Technical savings potential was calculated by multiplying estimated percentage decrease in efficiency resulting from improper rewind by estimates of the number of motors repaired, between 5 and 50 hp and, 50 and 500 hp. The median hp within these bins were 25 and 150 hp, respectively. This was used to calculate a median kWh impact in each bin using the formula:

$$kWh_{impact} = \textit{Hours of operation} * hp * Load * .746 * (100/(E - IL) - 100/E) * NMR$$

Where:

Load = Average motor load. Assumed at 75% of full rated load.

E = Nominal Efficiency Rating for 25 and 150 hp Standard and Premium Efficiency Motors.
IL = Change in efficiency (%).
NMR = Number of motors repaired.

Key assumptions for estimating national kWh impacts from efficiency decreases after repair are documented in Table 2

Table 2
Key Assumptions for Used In Calculating kWh Impacts by Motor hp

	Motor Size Bin		
Parameter	5 to 50 hp	51 to 500 hp	Source
Median motor (hp)	25	150	EPRI (1992)
Average standard motor efficiency (%)	89.3	93.0	McCoy (1990)
Average premium motor efficiency (%)	92.5	95.0	McCoy (1990)
Premium motors share (%)	5	5	Schueler et. al. (1994)
Annual Operation (hrs)	2628	4380	EPRI (1992)
Load	.75	.75	
Decrease in Efficiency (%)	1.0	.5	
Number of Motors Repaired in 1993			
EPRI Data	1,367,000	520,482	EPRI (1992)
Survey	1,890,000	910,000	Schueler et. al (1994)

The Energy Savings From Individual Motors Are Small
Significant gains in energy efficiency are possible if quality motor repair practices are more widely adopted. However, these gains are made in very small increments, one motor at a time. For a 25 hp motor that operates one shift a day (3,000 hours/year), eliminating a 1 percent decrease in efficiency from rewinding saves about $50. Assuming a 10 percent premium for quality repair, this yields a simple payback of three years. Although this is a reasonable investment, it is unlikely that the magnitude of the energy savings alone would generate much demand from motor users for quality repair.

Energy savings are not the only benefit.
Although this has not been investigated empirically, efficiency maintaining quality motor repair would be expected to improve the reliability of repaired motors, reduce the risk a premature failure, and reduce forced downtime - cost that are significant to motor users. Excess losses are manifest as increased operating temperature. There is a will documented negative correlation between temperature and insulation and lubricant life. For utilities, working with key industrial and commercial customers to help them use electricity-consuming equipment more effectively and productively can generate valuable good will. This good will and a greater appreciation of the utility's added value is a key asset as large customers consider alternative sources of electric supply

QUALITY MOTOR REPAIR
There is no single dominant cause of efficiency loss during motor rewinding and repair. Maintaining efficiency during repair is a cumulative process that requires getting many small details right. These details include, but are not limited to:

- Using the correct replacement bearings.
- Proper greasing.
- Avoiding mechanical modifications to bearings, bearing fits and seals during disassembly or reassembly.
- Avoiding overheating the core during winding removal.

- Protecting core laminations during repair to prevent shorts that result from sand blasting, mishandling, or assembly pressure.
- Maintaining the circular mils and number of turns in the windings.
- Maintaining properly designed winding patterns.
- Replacing loose or cracked conductor bars with equivalent parts.
- Detecting and repairing damage to end shields and bent motor shafts.
- Maintaining the air-gap symmetry between stator and rotor.

Many of the things that can go wrong during repair to decrease reliability and motor energy efficiency are subtle, and they require testing to diagnose properly. A detailed discussion of motor testing during repair can be found in *Electric Motor Repair Industry Assessment: Current Practice and Opportunities for Improving Customer Productivity and Energy Efficiency* (Schueler, Leistner and Douglass 1994). The case studies reported above, especially the work of Zeller, found that it was very difficult to isolate one particular cause of decreased efficiency because the repair circumstances for each motor may be different and increases in one type of loss can interact or be offset with other types of losses. No single strategy will reduce efficiency decreases during repair.

Canadian utilities, which lead efforts in North America to reduce efficiency decreases have found a strong link between shop quality assurance efforts and the likelihood that motors will be repaired without decreasing efficiency. By encouraging quality assurance and quality repair, efficiency losses can be reduced and the reliability of rewound and repaired motors improved. This approach delivers energy savings and supports a strong motor repair industry. For many motor repair customers, the improved reliability and related productivity gains associated with quality repair are more compelling than the energy benefits.

BARRIERS

Why are quality repair practices not as broadly implemented as they could be? Critical educational, financial, infrastructure, and technical barriers need to be eliminated. The most critical are highlighted below.

Motor repair customers do not recognize quality motor repair and seldom ask for it.
Customers seldom provide shops with repair specifications, much less specifications for quality repair or for maintaining energy efficiency. Customers need tools to identify:

- The elements of a quality repair.
- The challenges faced by repair shops and what shops need from the customer to provide the best repair.
- The value of paying for higher levels of service and efficiency.
- How to get shops to provide higher levels of service and rewind motors rewound without efficiency reduction.

There is a strong framework of general quality assurance in the repair industry, as well as strong standards covering specific aspects of motor repair (bearings, motor efficiency testing). Until recently, there were no model standards and specification which comprehensively considered energy-related aspects of motor repair. This has been changing. EASA has developed the EASA - Q Quality Management System. EASA-Q incorporates all the elements of the International Standard Organization's (ISO) 9002-1994 Quality Management Standard. EASA-Q covers all phases of motor repair shop operation from record keeping to performance measurement. EASA-Q certification is strong evidence, though not a guarantee, that a shop is likely to provide quality motor repair services. Some non-EASA shops also have developed independent quality assurance standards. The Electric Power Research Institute and Bonneville Power have also developed detailed Model Repair Specifications drawing on the best repair specifications currently available. These specifications also include sample forms for submitting repairs and reporting key test results. At the time of submittal these specifications were awaiting final review and publication. Other useful motor repair specifications developed and continuously modified from specifications prepared a large industrial firm are also being circulated somewhat like freeware. They can be obtained through services like the Motor Challenge and Energy Ideas Clearinghouse.

Recommendations:

- New standards are not warranted. The critical need is for tools to communicate essential elements of standards clearly and effectively and ensure that energy issues are addressed in these standards.
- Establish a voluntary, industry-led repair shop certification and labeling, which shops could earn by going through training, having key testing equipment and implementing existing quality assurance systems (ISO 9000 or EASA-Q). To be most effective these types of labeling must be industry-run.
- Utilities can play an important role in educating motor repair customers on how to identify good repair shops and on the benefits of quality motor repair. Virginia Power/North Carolina Power's Motor Rewind Education Program is a successful model. VP/NP jointly considered an effort to certify motor repair facilities on their own. Instead they chose to work with EASA because EASA already has motor repair standards and is aggressively pursuing ISO 9000/EASA-Q certification for its members. Further, the utilities felt a program run by EASA would be more cost-effective, credible, and less controversial. VP/NP became Associate members of EASA, one of three utilities with this status as of 1994. EASA membership provided access to literature, standards and conferences. VP/NP educates customers on EASA standards during energy audits and customer meetings. In 1994, VP/NP conducted motor seminars for over 300 commercial and industrial customers and distributed EASA standards and information to them. VP/NP strategy is to educate the customer to base their decision whether to repair or replace existing motors on economics and individual motor circumstances. An important part of the recommended motor repair/replacement policy includes selecting a quality repair facility that meets EASA standards. VP/NP does not recommend that motor repair customers choose or avoid specific repair shops.

Many repair shops do not understand how to maintain energy efficiency during repair.
Many shops do not appreciate the value of maintaining energy efficiency or they have significant misunderstandings. Some significant misunderstandings include:

- Energy-efficient repair practice is only important in repairing premium-efficiency motors.
- Premium-efficiency motors are significantly more costly and more technically difficult to repair than standard-efficiency motors.
- Core losses from burn-out practices are the only important source of decreased efficiency, and controlling burn-out is the only important loss prevention strategy.

Most shops take their craft very seriously. However, many shops, especially the smaller ones, do not appear to use quality assurance guidelines. Only two of five repair shops (one in twenty of those with ten or fewer employees) surveyed in 1993 reported using written quality assurance standards of any type. A major reason for this is few customers use repair or quality assurance standards. Only 15 percent of the shops indicated they very often or somewhat often got repair specification from customers beyond the requirement to return the motor to its original condition.

A significant number of repair shops, especially smaller ones, are not aware of repair practices which may reduce repair quality. Problem practices include changing winding configurations without adequate redesign, removing windings with high burn-out temperatures, and inadequate testing practices.

Recommendations:

- Continue efforts to communicate technical data to shops through industry associations and utilities. Complete and distribute practical guidebooks on quality motor repair.
- Provide training seminars on maintaining efficiency during repair in conjunction with key repair industry conferences.
- Improve the visibility of quality repair in shops -- e.g. dos and don'ts posters.

Quality repair can take more time.
Motor repair shops are often under tremendous pressure to get motors repaired and back on line, particularly if the repaired motor is critical to the customer's operations. Conducting thorough motor diagnostics before and after repair, finding matching parts and wire, and replicating winding configurations accurately may take time that the

shop may not have been given by the customer. Motor repair shops must balance the customer's need to have motors repaired as quickly as possible with the time requirements needed to do the job right.

Recommendations:

- Educate motor repair customers on reasonable expectations for motor repair turn-around and the possible trade-off between rapid turn-around and ability to maintain quality. These issues should be addressed in repair specifications and guidebooks for motor repair customers.
- Encourage practices which reduce the need for "crisis" repair, such as stocking spares for common motors and planned maintenance overhauls, and comprehensive motor management programs.

Quality repair costs more.

Quality motor repair practices can be expected to increase repair costs by up to 10 percent. Sources of increased costs include additional equipment and labor for testing and for controlling burn-out and increased inventory costs for maintaining adequate stocks of parts and wire. Quality assurance programs may also have significant start up costs for certification and registration. For example, ISO 9000 registration and follow-up certification may cost several thousand dollars per site. There are also significant investments required for measurement, benchmarking, and internal information sharing that are an essential part of total quality management approaches.

Recommendations:

- Retail approaches to improving quality of repair, such as rebates, are cost-prohibitive because they yield only small annual savings increments for individual motors under 100 hp. The small savings will not be large enough to attract the attention of industry except for the very largest motor user or to support administrative requirements. Market transformation and education-oriented approaches which target the market as a whole make much more sense.
- Reduce the initial cost for capital intensive testing and repair equipment. Many shops do not have the capital reserves to upgrade burn-out ovens with water suppression systems, to purchase more advanced testing equipment, or to make other capital investments that are helpful in maintaining efficiency. A core-loss tester alone can cost between $15,000 and $30,000. Manitoba Hydro ran a very effective program in which they offered to co-fund 50 percent of the cost of a core-loss tester up to a maximum of $10,000 (Canadian $) in exchange for commitment from the shops to participate in development of a Quality Motor Service Program.

Working with small shops in an industry in transition.

Anyone making an effort to work with the motor repair industry must acknowledge that the industry is under pressure from declining profit margins, increasing labor costs, and the declining manufacturing base in the economy. Shops will resist efforts that rely on more government regulation and mandates. Additional mandates could weaken the industry.

Numerically, the industry is dominated by small shops that have low repair volumes, work on smaller horse power motors, and have small staffs. These shops are the least likely to have the right equipment or training for quality repair and are the least able to afford it. Requirements for more equipment and testing, and for maintaining larger stocks of spare parts could have the indirect impact of driving smaller shops out of the repair business.

The small potential for energy savings may not justify significant direct utility involvement with small shops. It is not cost effective to subsidize the purchase of a $15,000 to $30,000 core-loss tester, other test equipment, or sophisticated burn-out equipment in the typical small shop. A small shops repair around 500 motors per year, most under 40 hp. At energy costs of $.05/kWh and $9.00/kW, the maximum energy savings that such an investment would yield assuming a significant impact on practice would be just $50,000 per year.

Recommendations:

- Small shops should not be excluded from quality repair efforts. Instead, low-cost strategies for improving motor repair practice, such as tip sheets, are needed to complement larger efforts.

Manufacturer's motor specifications are often unavailable or inaccessible.
Shops reported that winding data were not readily available for 30 to 40 percent of the motors they repaired. Specifications for bearings, fans, and lubricants are not accessible in a timely fashion from all manufacturers. These specifications are critical for returning the motor to its original condition. In some cases, this information can be reverse-engineered, but this practice is time-consuming and can be inexact.

Data availability varies considerably by manufacturer. Manufacturers do not have a strong incentive to provide these data and make motors more repairable. Some consider the data to be proprietary and are reluctant to release it. Others consider the data to be a salable commodity and charge for it. Although motor end-users expect larger motors to be repairable, new motor customers do not stress ease of reparability when purchasing motors. Further complicating this situation is the absence of a system to provide repair specifications to shops in a timely manner.

Recommendations:
- Recognize motor manufacturers that provide good access to manufacturing specifications. Utilities and government have a role in encouraging more motor manufacturers to cooperate more effectively with the repair industry.
- Work with manufacturers to improve nameplate data. Two important pieces of information for quality repair that are not normally available on nameplates are winding resistance and no-load wattage.
- Improve dissemination of data on manufacturers specifications. Two ideas that have strong support from shops is a 1-800 or same day service for manufacturers data and an accessible computer database for motor winding data.

Parts and wire sizes are not available locally.
Small and mid-size shops reported difficulties keeping complete stocks of wire sizes and bearing types on hand. Costs for keeping large inventories of seldom-used wire sizes and bearings can be prohibitive. Shops will use substitutes if the correct sizes or types are not available.

Recommendations:
- Encourage motor manufacturers to stock replacement for custom bearings and make them available quickly with out excess mark-up.
- Develop a recommended wire and parts stocking list for the "well-equipped" shop. Consider working with shops and industry associations to develop specialty parts and wire clearinghouses and purchasing cooperatives.

Tools and equipment for winding and winding redesign are not available.
Even with good winding data and the right wire in stock, shops change winding patterns without proper redesign. Not all shops are aware of the potential reliability and efficiency impacts of changing winding configurations. Small and medium-sized shops often do not have the equipment to test the impacts of alternate winding paths, nor the tools to properly replicate the original configuration. In the 1994 survey, 15 percent of shops, mostly small volume operations, noted they changed winding configurations because of equipment limitations.

Recommendations:
- More information on the impacts and trade-offs of changing winding specifications needs to get to the shop floor.
- Include minimum winding equipment standards in any certification efforts and quality assurance specifications.

Winding removal strategies that do not damage motor cores are needed.
Most windings are removed by burning them out in ovens. Motors that have been rewound previously pose even more challenges because of the numerous dips, bakes, and epoxies used. Almost 40 percent of the shops surveyed burned out cores at temperatures of 750° F or more, which can cause core damage. Forty percent of the shops did not have water suppression systems, most temperature controls were not frequently calibrated, and few shops

placed temperature sensors in the motor cores. However, this problem may be less severe for new motors with cores made with C-5 steel laminations which is less subject to overheating problems.

Recommendations:

- In the long-term, the best strategy may be to develop dips and varnishes that are easier to strip or burn-out during rewind. Chemical companies need to work with motor repair shops and manufacturers to develop more effective processes and products. Federal research support could accelerate progress here.
- In the near term, more research on low cost strategies for improving temperature control and distribution during burn-out would be useful. Field research on the level of impact from over and under heating in uncalibrated ovens may be instructive.
- Continue on going efforts to educate repair shops on the importance of controlling burn out temperatures and the proper use of temperature control strategies (core sensors and water suppression systems).
- Utilities could provide financial assistance to shops to encourage purchase of burn out ovens with better controls.
- Include standards for burn-out equipment and calibration intervals in any voluntary certification programs.
- Investigate system that combine moderate heating with mechanical winding pulling.

Lack Of Standardized Designs.

Shops reported that one of the biggest barriers to returning motors to their original condition was finding parts and wire for motors using non-standard components. The diverse number of wire sizes, bearing types, and other motor components that a motor repair shop must work with is very challenging. There has been some movement towards more standardized motor designs in the European motor market in response to this problem.

Recommendations:

- In the long-term the issues could be best dealt with by working with manufacturers to standardize key motor parts as is now being done in the European motor market. An initial feasibility assessment should be considered.

Comprehensive data on the magnitude and sources of increased losses after motor repair and the costs and effectiveness of remedies is needed.

Little comprehensive research has been done to associate the magnitude of efficiency decreases with specific motor repair practices and to understand how these practices interact. Existing studies have very small sample sizes and are restricted to small horsepower motors. Key questions that need further investigation include:

- Are the efficiency decreases for large motors of the same magnitude as for smaller motors? Are the problem practices as common in the repair of larger motors?
- What are the efficiency and performance implications of specific problem repair practices?
- How effective are alternative strategies for reducing core loss during burn-out (oven calibration, water suppression systems, warm and pull, and alternative burn-out regimes) and for diagnosing core losses?
- How much do specific repair practices that maintain efficiency contribute to motor reliability and performance? For example, does using smaller wire size significantly impact repair life?
- What are the incremental costs for specific repair practices that maintain efficiency?

FINAL REMARKS

There are opportunities for maintaining energy efficiency during motor repair which can result in significant energy savings. As energy-efficient motors claim a larger share of the installed motor base, quality motor repair is an important strategy for maintaining these gains. Ultimately the energy savings benefits of quality repair are secondary to benefits in improved reliability and reduced downtime. For utilities, support for quality motor repair provides an opportunity to provide a valuable service to major industrial and commercial clients. The success of efforts to reduce efficiency decreases during motor repair depends on keeping the focus on quality and service. If quality is maintained or improved, efficiency follows.

ACKNOWLEDGMENTS
This paper draws heavily on research and reports funded by a Electric Power Research Institute and the Bonneville Power Administration tailored collaborative. This work would not have been possible without the support and review of Ben Bannerjee at EPRI and Craig Wohlgemuth at Bonneville Power Administration.

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