Quality Motor Rewinding an Energy Efficiency Measure

Regional Technical Forum Submittal
Post-Approval Revision 1.1—May 2008

Originally Submitted and Approved
July 17, 2007

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Executive Summary

- The Green Motors Practices Group (GMPG) is requesting Regional Technical Forum (RTF) approval of deemed savings for motors rewound by participating members and adding this resource to the list of eligible energy efficiency measures;
- NEMA Premium® motor purchases have been incentivized with similar savings and so should efficient motor repair/rewinding offering similar kWh savings;
- Many new energy efficient motors installed under regional efficiency programs are now reaching the end of their life and need repair;
- Green Motor Practices Group members and EASA's process protocol can maintain or slightly improve original motor efficiency during repair/rewinding and save energy.

Introduction

Energy efficiency organizations have long encouraged NEMA Premium® motor purchases with incentives. It's now time to recognize quality rewind practices that will maintain those efficiencies as an equally valuable energy efficiency measure. The Green Motors Practices Group (GMPG)/RTF approval is intended to provide utilities and BPA in the Pacific Northwest with the ability to acquire and enhance this cost effective resource across the Northwest region.

The RTF's approval of the energy efficient rewind practices of GMPG members will hopefully lead to the use of uniform program specifications throughout the region–bolstering the bottom line of industrial firms and local motor service centers that support them**.**

Background

There is a widely prevalent but incorrectly held belief that rewound motors always lose efficiency. In February of 2000 a DOE publication stated, "You should generally subtract two points from motor efficiency on smaller motors (≤40 HP) and subtract one point for larger motors." Not everyone read what the same document goes on to say, "Shops with the best quality-control practices can often rewind with no significant efficiency degradation."[1] Motor Master+ was updated in 2005 with about one-half of these deductions for rewound motors:

- **Deduct 1% efficiency for motors 40 HP or less;**
- **Deduct 0.5% efficiency for 50 HP and larger motors** [2].

Reinforcing the above defaults in 2003 EASA/AEMT released "The Effect of Repair/Rewinding on Motor Efficiency" decisively proving:

- **No losses in motor efficiency provided processes are controlled;**
- **If processes are not controlled larger motors (75-150 HP) lost on average 0.6% efficiency[3].**

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[1] Energy Management for Motor Driven Systems, published by Office of Technologies Energy Efficiency and Reliable Energy, US Department of Energy, see Motor Load and Efficiency Estimation Techniques page 5-7

[2] Motor Master 4.0 Users Guide, produced by Washington State University Cooperative Energy Program see Page 27 numbered bullet 2

[3] The Effect of Repair Rewinding on Motor Efficiency, published by the Electrical Apparatus Service Association, Inc. and the Association of Electrical and Mechanical Trades, see Part 1 page 1-5, group A, B, C1, and C2

This EASA/AEMT study in conjunction with EASA's "Guidelines for Maintaining Motor Efficiency During Rebuilding" is used by the Green Motors Practices Group (GMPG) and is the basis of our RTF request for approval. The nonprofit GMPG was incorporated in 2006 and is operated by motor service industry leaders aided by the Industrial Efficiency Alliance requiring member motor service centers to:

- Sign a commitment to provide energy efficient system services—**including efficiency retention or improvement in the repair/rewind process;**
- Members agree to recommend replacement or repair/rewind on the basis of total cost of ownership;
- Motor repair/rewind procedures are in accordance with EASA's **"**Guidelines for Maintaining Motor Efficiency During Rebuilding**"** and the EASA/AEMT Study;
- Organization and personnel are made available for training, GMPG inspection, and process review;
- When failure event damages may impact motor efficiencies, customers are made aware of the economic consequences;
- Non-compliant motor service center members have six months to comply or be removed[4].

Green Motors Practices Group members are committed to these standards for motor rewinds to maintain motor efficiency and provide the best value to their customers.

Calculating Motor Energy Use and Savings

$$\text{Annual Energy (kWh)} = \frac{Horsepower\ x\ 0.746\ x\ Operating\ Hours\ x\ Motor\ Loading}{Efficiency}$$

Where:

- Horsepower and 0.746 kW/hp are given
- Assumed Operating Hours to be as follows per Year[5]

Size Category	Hours	Size Category	Hours
1-5 HP	2,745	101-200 HP	5,200
6-20 HP	3,391	201-500 HP	6,132
21-50 HP	4,067	501-1,000 HP	7,186
51-100 HP	5,329	1,000 plus HP	7,436
		All Motor Sizes	5,083

- Assumed Motor Loading to be 68.2%[6]
- Efficiency =
  1. If Standard[7], Epact[8], NEMA Premium®[9] or Green Motors Practices rewind then efficiency will be based on appropriate published tables without adjustment[10]

[4] Green Motors Practices Group application and commitment documents, see Attachments of this submittal
[5] United States Industrial Electric Motor Systems Market Opportunities Assessment, published by US Department of Energy December 1999, Motor Challenge, see Section 1, page 42
[6] Achieving More With Less: Efficiency and Economics of Motor Decision Tools (2006), Prepared By Advanced Energy, see Motor Load Conditions page 29
[7] Standard Table, USDOE, Attachment C, Average Efficiencies for Standard Efficiency Motors at Various Load Points
[8] Motor Efficiency Tables, Washington State University Cooperative Energy Program
[9] NEMA Premium® Efficiency Table, Product Scope and Nominal Efficiency Levels
[10] The Effect of Repair Rewinding on Motor Efficiency, published by the Electrical Apparatus Service Association, Inc. and the Association of Electrical and Mechanical Trades, see Part 1 page 1-5, group A, B, C1, and C2

2. If non-controlled rewind of a motor then reduce efficiency by 1% to 0.5% as per the following (revised) table: [11]

≤25 HP	-1%	50 HP	-0.7%
30 HP	-0.9%	60 HP	-0.6%
40 HP	-0.8%	≥75 HP	-0.5%

kWh Savings Table

The following Table and the Attached Tables are calculated using the above formula, assumptions, and efficiency qualifications:

- Table 1 is a simple average of kWh savings over all RPMs and Enclosures from Tables 2, 3, and 4;
- Attached Tables 2, 3, and 4 assign kWh savings based on *efficiency retention* using controlled repair/rewind processes;
- 36% of industrial and commercial motors are custom[12] and must be repaired/rewound as replacements are difficult to find; Green Motors Practices reaches those motors;
- Replacing standard and Epact with NEMA Premium® motors is best, but controlled repair processes net similar savings.

Table 1: Deemed GMPG Protocol Electrical Savings (Revision 1.1, May 2008)

HP	Original Deemed kWH savings	Revised Deemed kWH savings	Variance	HP	Original Deemed kWH savings	Revised Deemed kWH savings	Variance
1	16		Unchanged				
1.5	25			60	1046	971	-75
2	33			75	1097	1009	-88
3	48			100	1456	1558	102
5	80			125	1771	1891	120
7.5	146	141	-5	150	2116	2254	138
10	196	186	-10	200	2809	2987	178
15	291	274	-17	250	4136	4397	261
20	389	363	-26	300	4952	5269	317
25	573	535	-38	350	5732	6147	415
30	621	575	-46	400	6542	7005	463
40	732	672	-60	450	7349	7859	510
50	796	729	-67	500	8165	8732	567

Table revision per Regional Technical Forum re-calculation advisement

[11] Motor Master 4.0 Users Guide, produced by Washington State University Cooperative Energy Program see Page 27 numbered bullet 2
[12] The Blue Book, page 77, Table 3-9: OEM Restrictions on Equipment with Installed Motors Restrictions, Percent Reporting Replacement motors available only through OEM 22%, Replacement only through one manufacturer 14%

Application and Commitment

The current Green Motors Practices Group commitment document is attached for review; for additional information visit www.greenmotors.org.

Worthwhile and Necessary

- The Green Motors Practices Group is active in the market and ready to expand; however the market needs encouragement as quality repair/rewind processes cost more;
- Motor consumers, Pacific Northwest utilities, and BPA need to ensure efficiency retention and capture the significant energy savings through Green Motors Practices repair/rewinding protocol;
- As NEMA Premium® motors become more prevalent, continuing to replace with another NEMA Premium® or an Epact motor makes less sense from a cost, from an energy and also from an environmental standpoint;
- Motor rewinding has long been and will remain a large part of the motor industry;
- Currently eleven northwest motor service centers are members – about 20% of the rewind market;
- Green Motor Practices for motor repair are cost effective compared to new energy efficient motors (Not all motors can be replaced with NEMA Premium®–making efficient repair the best option);
- Green Motors Practices Group members are offering these services and serve a significant portion of the regional market (The group is growing);
- RTF approval hopefully would lead to uniform utility program specification for efficient motor rewinds throughout the Northwest;
- Uniform specifications would bolster the bottom-line for northwest commercial, agricultural and industrial facilities and encourage local motor service centers that support them.

Protocol Incremental Cost Addition by Horsepower (Revision addition)

	Estimated Standard Rewind Prices			Estimated Green Motors Practices Rewind Price			
HP	6 Pole	4 Pole	2 Pole	6 Pole	4 Pole	2 Pole	Increase
≤ 7½	$429	$429	$429	$536	$536	$536	25%
10	$459	$429	$444	$569	$532	$551	24%
15	$670	$506	$554	$831	$627	$687	24%
20	$754	$560	$617	$935	$694	$765	24%
25	$859	$669	$771	$1057	$823	$948	23%
30	$945	$754	$831	$1162	$927	$1022	23%
40	$1143	$932	$1015	$1406	$1146	$1248	23%
50	$1330	$1069	$1173	$1623	$1304	$1431	22%
60	$1576	$1257	$1379	$1923	$1534	$1682	22%
75	$1789	$1437	$1544	$2165	$1739	$1868	21%
100	$2207	$1790	$1924	$2670	$2166	$2328	21%
125	$2500	$2192	$2291	$3000	$2630	$2749	20%
150	$2785	$2398	$2599	$3342	$2876	$3119	20%
200	$3539	$2994	$3321	$4211	$3563	$3952	19%
250	$4461	$4012	$4192	$5309	$4774	$4988	19%
300	$4889	$4134	$4489	$5769	$4878	$5297	18%
350	$5400	$4594	$4999	$6318	$5375	$5849	17%
400	$5868	$5090	$5788	$6866	$5955	$6772	17%
450	$6294	$5611	$6400	$7364	$6565	$7488	17%
500	$7006	$6122	$6649	$8197	$7163	$7779	17%

Table notes:
The above ***estimated*** standard rewind prices are a combination of ODP and TEFC motors, which were established using a base copper price of $4.89 per pound and a motor service center shop rate of $75.00 per hour. *Rewinding a NEMA Premium® motor will add 25% to the above Standard and GMPG Rewind Price Table.* "Vaughn's 2007 AC Motor USA Average Prices of 3-phase Random Wound T-frame Motors through 600 volts" has been used as a reference. Estimated Green Motors Practices Rewind Price percent of increase is a median average of GMPG members surveyed by telephone.

The incremental costs for Green Motors practices would include: debt service and depreciation for additional equipment and instrumentation, ongoing technician and supervisor training, regular calibration and testing of equipment, additional time for motor testing before and after rewind, core repair if needed, upgraded materials such as wire and insulation, and conversion of concentric to lap winding when appropriate.

Acknowledgments:
We would like to thank the Strategic Energy Group's Steven Scott for his review and suggestions.

Comments or Questions Contact:
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Phone: 208-322-6999, E-mail: greenmotors@cs.com

ATTACHMENTS

GREEN MOTORS PRACTICES GROUP (GMPG)

ANNUAL MEMBER COMMITMENT (Revision 1.1, May 2008)

As a member of the Green Motors Practices Group (GMPG), if _____ service center agrees to complete the following high-level service goals/tasks:

1. Adopts and publishes a company-wide shop practices policy, and communicates it effectively with stakeholders (customers, employees, investors, service center suppliers);
2. Commits to include in their shop practices and policies to actively support customer/client motor driven system efficiency and reliability improvements;
3. Agrees to promote "continuous energy improvement" by customers/clients;
4. Identifies primary person to work with the GMPG to prepare and implement a marketing plan that includes life-cycle cost analysis;
5. Identify shop (internal) personnel to work with GMPG and staff to support shop practices, continuous energy improvement, and key performance indicators as outlined in EASA's Tech Note 16 as modified from time to time by EASA.
6. Agrees to random inspection by a Group representative (see attachment A);
7. Agrees to inform customers and exclude in writing motors that may not sustain reliability and/or efficiency and should not be considered for repair as a compliant product of the GMPG (see Attachment B);
8. Agrees that Sales and Shop-floor Champions will participate in and document eight-hours annually of Professional Development (e.g. EASA chapter meetings, EASA International Conference breakout sessions, Industrial Efficiency Alliance Training);
9. Submits Information Request Forms, submits shop equipment digital images, supplies copies of current calibration certification, and documents Professional Development to the Group;

…In turn, the Green Motors Practices Group (GMPG) will provide to members:

1. Website listing recognizing compliant GMPG Membership;
2. GMPG public relations marketing and co-operative marketing materials;
3. Members license to display GMPG name and logo on advertisement copy and associated materials (e.g. stationary, business cards) see Attachment C;
4. The GMPG will maintain the integrity of the Group by notifying members that do not adhere to the standards set forth that their status as a GMPG member may be revoked. If corrective action has not been taken within six months of notification recognition and license to use GMPG branding privilege will terminate.

_____
Service Center Executive

_____
Service Center Shop Manager
(Must be an employee)

_____
Dennis Bowns
Green Motors Practices Group,
Executive Director

Execution date / /2008
Renewal date Jan 2, 2010

Annual Member Commitment Attachments (Revision 1.1, May 2008)

Attachment A:
Random inspections by a Group representative shall be done by a Group approved individual with sufficient GMPG training and may not be currently employed in the motor service industry or considered biased by GMPG or by the service center being inspected. Inspections shall be by appointment at a mutually agreed place, date, and time. Focus shall be limited to equipment and methods as described or may impact efficiency as described by EASA's Tech Note 16 "Guidelines for Maintaining Efficiency During Rebuilding".

_____ _____
Executive Initial Shop Manager Initial

Attachment B:
If a motor has sufficient damage or other circumstances that may cause loss of efficiency or reliability when rebuilt the customer shall be notified prior to repair and provided with an estimate of additional energy costs as a result. If the repair or rebuilding process continuous to completion it shall be noted on service records and the customer's invoice that the motor may not comply with GMPG standards. The intension of Point 7 is to allow necessary exceptions, at the discretion of the motor service center, based on the condition of the equipment, by identifying product or products that may not comply to GMPG standards and that have been excluded.

_____ _____
Executive Initial Shop Manager Initial

Attachment C:
Only members in good standing may have license to use and display the Green Motors Practices Group name and logo and in addition the limited license requires specific application use approval.

_____ _____
Executive Initial Shop Manager Initial

Attachment D ***(revision 1.1, May, 2008):***
Member Motor Service Center agrees to adhere to the Green Motors Practices Group Repairing Specification, April 2008. In the event a repair or rewind is non-compliant to this specification it shall be noted on the customer invoice and may not be identified in any way as a Green Motors Practices compliant product.

_____ _____
Executive Initial Shop Manager Initial

Table 2: Rewinding NEMA Premium® motors with GMPG protocol applied (Revision 1.0)

	1200 RPM kWh Savings		1800 RPM kWh Savings		3600 RPM kWh Savings	
HP	ODP	TEFC	ODP	TEFC	ODP	TEFC
1	17	17	16	16	18	18
1.5	24	24	24	24	25	25
2	32	32	33	33	33	33
3	47	47	47	47	49	49
5	79	79	79	79	82	80
7.5	145	144	144	143	148	146
10	190	192	190	190	195	193
15	285	285	281	283	290	287
20	377	380	375	375	383	383
25	562	562	558	558	570	570
30	602	606	599	602	615	615
40	709	709	709	709	722	722
50	775	775	772	772	784	784
60	1039	1039	1034	1034	1049	1049
75	1081	1081	1076	1071	1092	1092
100	1434	1434	1428	1428	1456	1448
125	1749	1749	1742	1742	1766	1749
150	2090	2082	2082	2082	2119	2099
200	2787	2775	2775	2764	2799	2787
250	4108	4091	4091	4074	4126	4091
300	4930	4909	4909	4889	4930	4909
350	5752	5728	5728	5704	5752	5728
400	6546	6546	6546	6519	6546	6546
450	7333	7364	7333	7333	7364	7364
500	8148	8182	8148	8148	8182	8182

Table 3: Rewinding Epact motors with GMPG protocol applied (Revision 1.0)

	1200 RPM kWh Savings		1800RPM kWh Savings		3600 RPM kWh Savings	
HP	ODP	TEFC	ODP	TEFC	ODP	TEFC
1	18	18	17	17	-	19
1.5	25	25	25	25	26	26
2	33	33	34	34	34	34
3	49	48	49	48	50	49
5	81	81	81	81	82	81
7.5	148	146	148	146	149	148
10	193	195	195	195	197	195
15	290	290	287	287	292	290
20	383	386	383	383	386	386
25	570	570	570	565	574	574
30	632	626	628	622	632	632
40	741	739	741	736	742	750
50	804	769	807	796	809	817
60	1049	1049	1049	1049	1056	1056
75	1092	1092	1086	1086	1099	1099
100	1448	1448	1448	1442	1465	1456
125	1766	1766	1759	1759	1775	1759
150	2110	2099	2099	2099	2131	2110
200	2814	2799	2799	2799	2814	2799
250	4108	4126	4108	4126	4147	4108
300	4930	4951	4930	4930	4951	4930
350	-	-	-	-	-	-
400	-	-	-	-	-	-
450	-	-	-	-	-	-
500	-	-	-	-	-	-

Table 4: Rewinding standard motors with GMPG protocol applied (Revision 1.0)

	1200 RPM kWh Savings		1800 RPM kWh Savings		3600 RPM kWh Savings	
HP	ODP	TEFC	ODP	TEFC	ODP	TEFC
10	200	200	202	200	202	202
15	299	296	297	296	297	301
20	394	391	393	389	391	397
25	584	582	584	581	587	590
30	703	696	699	692	703	703
40	928	926	928	922	929	939
50	573	568	575	568	577	584
75	1111	1112	1114	1108	1127	1120
100	1476	1468	1478	1476	1483	1494
125	1795	1787	1791	1795	1814	1812
150	2142	2137	2137	2137	2168	2161
200	2826	2829	2847	2823	2859	2865
250	4192	4143	4174	4178	4228	4228
300	5014	4966	5003	4977	5009	5046
350	-	-	-	-	-	-
400	-	-	-	-	-	-
450	-	-	-	-	-	-
500	-	-	-	-	-	-

Chart: GMPG Savings by Industry/Horsepower (revision 1.0 addition)

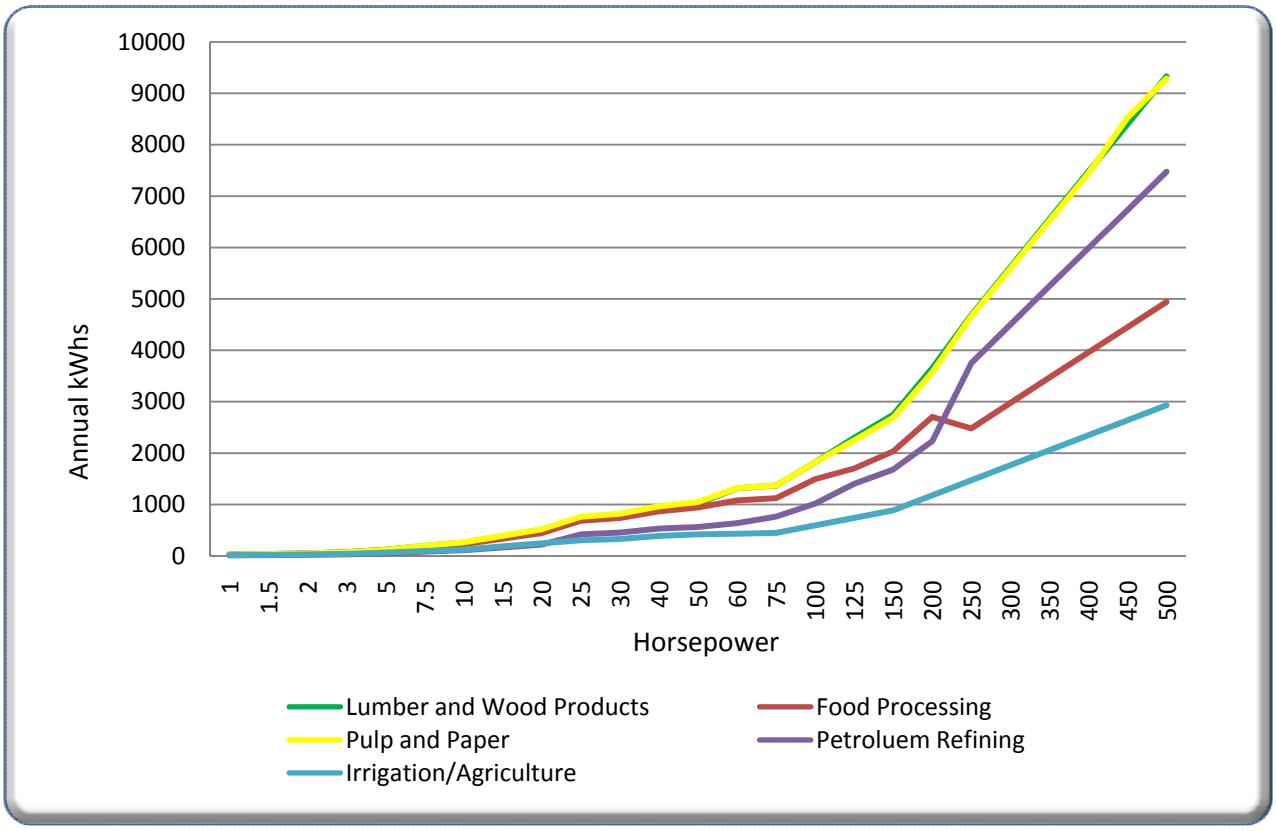

Chart notes: kWh savings are based on the calculation from page 4 however annual hours per industry were substituted from the RTF's "Deemed Savings Calculator for NEMA Premium Motor Installations" spreadsheet.

GREEN MOTORS PRACTICES SPECIFICATION (Revision 1.1, May 2008)

1.0 INTRODUCTION

This Specification covers Green Motors Practices Group (GMPG) repair and rewind efficiency retention protocol of low-voltage random-wound three-phase AC squirrel cage induction motors and lists and describes the minimum requirements for repair and overhaul of such machines.

2.0 INITIAL INSPECTION

If tests and inspection indicate defects of a catastrophic nature, the machine's owner or designated person shall be contacted and given a description of the defects, plus an estimate of their effect on energy consumption, delivery, and associated costs.

2.1 WINDING REMOVAL

2.1.1 Winding Data shall be recorded so as to permit replicating precisely the original configuration. Replacing concentric with a lap winding configuration is preferred when appropriate and based on the following: Changes that do not affect the magnetic densities or current densities by more than 2% are permissible, as well as changes that reduce the current density (increase cross sectional area per turn). Otherwise, the total cross sectional area of a turn, the turns per coil, the end turn extension, the span and connection of the coils shall not be changed.

2.1.2 Core Loss. A core loss test shall be done on all stators both before and after stripping and iron repair, to check for damaged interlaminar insulation. The tests shall be done at a flux density of 85,000 lines per square inch rms. Exciting current and watts loss shall be recorded each time, as well as a physical check carried out for hot spots. If data from previous tests are available, the results shall be compared. Testing at other flux densities may be done if previous data is available. If hot spots exceed 15°C above the average temperature after 15 minutes, or losses are excessive overall either before or after stripping, the situation shall be discussed with the purchaser before proceeding further. For a core without any hot spots, the losses after stripping shall not be more than 10% higher than the pre-strip losses. To avoid misleading results, the second core loss test should not be done until the core has been cleaned and dried.

2.1.3 Burn Out. The winding shall be burned out in a controlled temperature burnout oven where the part is monitored by attaching a sensing probe to the stator core and temperature is limited by means of fuel control and supplementary (water spray) cooling to 360°C (680°F) for organic (C3) or 400°C (750°F) for inorganic (C5) interlaminar insulation. If a higher temperature is deemed necessary, repairer shall reference communication or documentation from the motor manufacturer indicating that the core iron can safely withstand the temperature and confirmed by the core loss test. It is acceptable to cold or chemically strip windings provided the lamination is not exposed to an open flame and the laminations are not flared (splayed).

2.1.4 Winding Extraction. Lamination damage due to coil cutoff or splaying of teeth shall not be permitted.

2.2 CORE PREPARATION

2.2.1 Iron Damage. All obvious iron damage and significant frame damage, plus any defects indicated by a core loss test, shall be corrected and/or reported to the purchaser (consumer) before proceeding further.

2.2.2 Method of Repair; shall be chosen from the following:

Grinding; Grinding of the lamination is not permitted, however limited de-burring is acceptable.

Removal of lamination; Removal of individual lamination(s) is not permitted. However, restacking part or all of the assembly with the same number of de-burred laminations that have the same material composition, dimensions, and interlaminar insulation characteristics as the original lamination assembly is permitted.

Mica between lamination; Inserting split mica between the laminations is permitted provided lamination assembly dimensions remain unchanged.

2.3 WINDING

2.3.1 Insulation system shall be equal to or better than the original materials supplied by the manufacturer. Individual insulation system components shall be compatible as a group and suitable to the environment intended.

2.3.2 Conductors and conductor cross sectional area shall be equal to or greater than the original materials supplied by the manufacturer.

2.3.3 Stator coil(s) extension shall not be greater than original. Care must be taken to minimize crossed slot conductors.

2.3.4 Coil connections or splices shall be equal to or greater than the conductivity of the winding conductors. Compounds or chemicals used in the connection process shall be neutralized.
2.3.5 Impregnation method shall include preheating, treatment, and curing of stator with materials suitable for operating temperature and environment.

2. 4 ROTOR TEST AND REPAIR
2.4.1 Testing. All rotors shall be given a test for damaged bars and end rings, whether the motor is suspect in these areas or not. This test shall apply a stable single-phase voltage to the stator of the assembled motor while the shaft is slowly turned through at least one revolution. Variation of stator current in excess of three percent is an indication of a rotor defect. When electrical or mechanical defects with the rotor are suspected, or if the stator winding is defective, other tests shall be used, including one or more of the following:

- Growler tests.
- Current analysis or vibration analysis of a loaded motor.
- Physical examination.
- Ultrasonic or magnetic impression examination of the bars and end rings.
- Core loss tests (axial current thorough shaft).

2.4.2 Repair. Since repair of squirrel cages can be expensive and difficult, no further work shall be permitted. In the event a rotor is determined to be defective, if the motor is repaired it shall *NOT* be identified as a GMPG product.

2.5 SHAFT AND BEARING FITS
2.5.1 Shaft extension shall be checked to be straight and to size. If dimensional tolerances are unavailable reference ANSI/EASA AR100-2006, Tables 2-1 and 2-2. If defective it shall be corrected and the consumer notified of the fault.
2.5.2 **Bearing fits** both at shaft and end bracket contact points shall be measured and verified to be within bearing manufacturer tolerance. If dimensional tolerances are unavailable reference ***ANSI/EASA AR100-2006***, Tables 2-13 and 2-14.

2.6 END BRACKETS
2.6.1 Repairs to end bracket bearing housings shall be by building up the metal and machining to size concentric and parallel to rabbet. Welding, plating and sleeving are the accepted methods. Wear resistant high strength epoxy products designed for use on bearing journals shall be acceptable. General epoxies or other compounds, knurl, and/or peen shall not be used to lock or seat bearings.

2.7 FANS
2.7.1 Fans shall be checked for cracks and fit to the shaft or rotor. Fans shall be firmly fixed to the shaft or rotor by the original factory method, unless there has been corrosion between dissimilar metals, in which case a new method shall be proposed to the purchaser. Welding to the shaft is not permitted. Repairs to fans shall only be made after discussion with the consumer. Replacement fans shall have the same number of blades, be dimensionally, and structurally equivalent to the original manufacturer supplied fan. It is preferred to replace fans with an original equipment component supplied by the manufacturer specifically designed for the applicable motor. If a fan is replaced and air velocity or quantity is varied from original characteristics the repaired motor shall *NOT* be identified as a GMPG product.

2.8 BALANCING
The motor rotor shall be checked for balance. In the event rotor unbalance exceeds manufacturer's original specifications it shall be dynamically balanced and meet the following criteria:
Half key. It shall be balanced with a half key in the keyway.
Tolerance G2.5 (ISO 1940-1; generally, the permitted total imbalance is 7.5W/N = oz in/plane where W is weight of rotor in pounds and N is operating speed in RPM. (213 W/N gm. in/plane)
Tolerance G1.0 (ISO 1940-1); two Pole rotors should be balanced to 3W/N = oz. in./plane. (85 W/N gm. in/plane)
Material removal; if material is removed, electrical and structural integrity and fan capacity shall be maintained.
Added material; added material shall be able to withstand the centrifugal forces and be positioned either in the manufacturer's designated positions and locked in place, or positioned in a location where centrifugal force will tend to keep the material in place. Weights may be attached to metallic parts only.

2.9 REASSEMBLY
The assembly of the motor is the reverse of the disassembly process and the following points shall be observed:

- Match marks shall line up.
- On reinsertion of the rotor, take care not to damage the journals or the stator windings and laminations.
- Dowels and fitted bolts shall go back into the same holes that they came from.
- On motors with insulated bearings, the insulation shall be checked and noted.
- Bearing type (open, shielded or sealed), internal fit, and lubricant shall be equivalent to the original.
- On vertical motors, the endplay shall be the same as the original manufacturer's setting, unless the consumer and repairer agree that a modified setting would give better performance.
- Motors for use in hazardous environments shall have all explosion-proof features maintained and be recertified in accordance with UL674.

2.10 FINAL TESTS

2.10.1 Insulation. Prior to running, the motor shall be given an insulation resistance test to ground at 500 volts DC. The minimum value shall be 5 megohm corrected to 40° C. If acceptable, the winding shall be hipot tested in the following manner:

- Rewound motors shall be tested for one minute at 1700VDC plus 3.4 times the machine's voltage rating, e.g. 3264VDC for a 460VAC machine.
- Repaired motors not rewound shall be hipot tested to 65% of the new winding value.

2.10.2 Running Test. After the insulation tests, the motor shall be run at no load at rated terminal voltage. The test shall determine that:

No Load Amps; no load current unbalance should not exceed- six to ten times voltage unbalance.

Vibration; Horizontal, vertical and axial readings shall be taken at each bearing and results recorded. Tolerance shall not exceed ANSI/*EASA AR100-2006, Table 4-5*, or other standard provided by the consumer.

3.0 QUALITY CONTROL

3.1 MEASURING INSTRUMENTS

3.1.1 Calibration. All measuring instruments shall be calibrated regularly, including burn off oven temperature control. The calibration records shall be available for consumers and GMPG inspection. Minimum frequency of calibration shall be annually, except:

Insulation Testers; Insulation resistance testers—checked every six months to a known resistance value.

Dimension Meters. Micrometers, vernier calipers and other dimension measuring devices—every six months against a minimum *grade B* certified gauge block set.

Bore Gauges. Bore gauges shall be calibrated to a certified standard before and after each use.

Core Loss Test Equipment; shall be calibrated per manufacturer's instruction and documentation shall be on file and available for review.

3.3 TESTS AND INSPECTION DURING WORK

3.3.1 Records. Records shall be kept of all tests and inspections carried out during the work. Supervisor signed copies of these records shall be shipped in original form, at the same time as the motor, to the designated client or consumer contact person.

3.4 FINAL INSPECTION. Consumers shall have the right to be present for tests on any motors. In emergency cases, tests will not be held up waiting for consumer representatives, but every effort shall be made to keep a consumer informed so that they can be present if possible.

3.5 TEST RESULTS AND DOCUMENTATION. All final inspection and test results shall be sent, in their original form, to the designated consumer contact person. GMPG completed compliant motors shall be tagged as such and documented. The tag shall include power cost to operate based on estimated kilowatt hours per year consumed. GMPG documentation shall be completed for each motor processed and digitally reported monthly to GMPG headquarters. Motors not meeting GMPG standards but still repaired shall NOT be tagged as compliant and the consumer shall be notified.

SPECIFICATION REFERENCES

EASA ANSI/EASA AR100 Recommended Practice For The Repair of Rotating Electrical Apparatus
EASA Guidelines for Maintaining Motor Efficiency During Rebuilding (Tech Note 16)
IEEE Std. 43, Recommended Practice for Testing Insulation Resistance of Rotating Machinery
Std. 112, IEEE Standard Test Procedure for Polyphase Induction Motors and Generators
NEMA Std. MG-1, Motors and Generators
USDOE Office of Industrial Technology, Model Repair Specifications for Low Voltage Induction Motors

Revision 1.1, April 2008-3.0 Quality Control, 3.1.1 Dimension Meters *changed to Grade B from Grade AA*

Sample Incentive Application Form (Revision 1.1, May 2008)

GREEN MOTORS PRACTICES GROUP ™

Service Center Rewind Incentive Application

Is Rewind Compliant to GMPG Specifications ○ Yes ○ No R-1

CRAFTSMEN SAVING ENERGY ™ GREEN MOTORS PRACTICES GROUP™

Customer Information

SC ID - Motor Tag No.	–		
Cust ID #	Customer		
Street, (No PO Boxes)			
City, ST, Zip			
Customer Contact Name			
Phone			
Email			
Customer Utility and Acct No			
Industry Sector			
Sector			
Is the Motor Installed at Customers above Address? ○ Yes ○ No	If No, Provide Installation Location.	Street	
		Building	
		City,ST,Zip	

Motor & Invoice Information

Invoice Date			
InvoiceNo			
SC Responsible Employee			
Customer Incentive Credit		Incentive Credit	$ 0.00
Is the Motor a Spare?	○ Yes ○ No		
Estimated Reinstall Date			
(NEMA Standard Rated) HP	0		
kWh Savings Per Unit		Deemed Savings	
Motor Runs at Est. % of Full Load			
Effiency %			
RPM			
Frame			
Enclosure			
No. of Shifts		Hrs	

Insert Invoice PDF

Estimated Annual Operation Cost

Cust.Cost Per kWh:	Estimated Annual kWh
	?

Estimated Annual Operating Cost: ?

Rewind

Beginning Watts per lb			
After Watts per lb			
Watts Lost			
Credit/Reimbursement		Credit/Reimbursement	$0.00

Sample Motor Tag (Revision 1.1, May 2008)

The motor nameplate is made of stainless steel, two color etched and is permanatly attached with rivets to compliant motors before leaving the member service center. The “ID No” identifies the meber service center who preformed the work and the individual motor. The “ID No” is reported on service center incentive applications and is apart of the report to particpating utilities.

Sample of Motor Service Center Auditor's Form (Revision 1.0 addition)

Date: ___/___/200_ Auditor: _____

Company: _____ Address: _____ _____ ___ _____ Phone: _____ E-mail: _____	Service Center Executive: _____ Commitment Employee Endorser: _____ Number of employees at this location: _____ Incentive Form Authorizer: _____

GMPG Incentive database: ____Yes, ____No
Hardcopy file: ____Yes, ____No
Motor records up to date: ____Yes, ____No

Number of motors repaired compliant to Green Motors Practices:
_____ in 2006, _____in 2007, _____in 2008
Total number of motors repaired by this location:
_____ in 2006, _____in 2007, _____in 2008

Is there a written shop policy? ___Yes ___No
Are GMPG rewinding practices reviewed? ___Weekly, ___Monthly, ___Quarterly, ____Yearly
Are electrical costs of standard and/or Epact compared with NEMA Premium® motor and provided to consumers?
___Yes ___No

Is there a sales policy promoting efficiency of motor driven systems? ___Yes, ___No
Service center engages in off-site services: __Pumps, __Refrigeration, __Compressed Air, __Air Handling, __HVAC, __Mechanical, __Vibration Analysis, __Laser Alignment, __VFD, __Motor Control, __Power Quality, __Electrician, __ Energy Management __Engineering
Service center engages in on-site repair of: __Pumps, __Fan and/or Blower, __Air Compressors, __Power Transmission, __VFD, __Motor Control Repair, __Motor Control Integration
Is there a sales policy promoting continuous energy improvement? ___Yes, ___No

List employees engaged in professional development, activities, and number of hours:
_____
_____
_____
_____

Equipment Calibration:
Pyrolysis (burn-off) Oven thermostat, date: ___/____/200_
Insulation testers known value: _____ _____ _____ (every six months)
Dimension meters: date: ___/____/200_ (every six months)
Bore gauge certified standard available: ____Yes, ____ No

Operational core loss equipment: _____Loop Test, _____Manufactured Core Loss
Are records available for individual core loss tests? ____Yes ____No
Is a Pyrolysis (burn-off) oven used to strip stators? ____Yes, ___No
What is the current temperature set at? _____°F, _____°C Is the water mist operational? ___Yes, ___No

How is varnish removed from the stator bore? _____
Is the balance equipment suitable to the HP range serviced? ___Yes, ___No
Are stator and end-brackets match marked? ___Yes, ___No
Are disassembled motor parts stored separately? ___Yes, ___No

Green Motors Practices Group Statement of Purpose

Mission

The mission of the Green Motors Practices Group is to organize, identify, and promote member motor service centers that commit to energy saving shop practices, continuous energy improvement, and motor driven system efficiency and reliability.

Vision

Green Motors Practices Group will be universally identified as energy and reliability leaders focusing on the electric motor services industry.

Strategy

- Green Motors uses its' Website to promote member service centers, continuous energy improvement concepts, and distributes practical energy related material;
- Green Motors submits documentation to the Regional Technical Form enabling electric utilities to offer motor consumers or service centers rebates or incentives based on Green Motors Practices' standards;
- Green Motors encourages excellence through continuing education by training members at several levels on in-shop practices and process controls, continuous energy improvement, and consumer motor driven system efficiency and reliability;
- Green Motors takes a proactive approach to environment issues by examining carbon emission reduction through the repair process;
- Green Motors seeks to become self-sustaining by demonstrating value to service centers, electric utilities, and associate members.

Tactics

- Maintain the Group's Website bi-monthly in a fresh and up to date state avoiding stagnation so visitors return on a regular basis to see what's new and take advantage of the resource;
- Improve the credibility of the organization, members, and standards on an annual basis or more often when needed;
- Utilize the Industrial Efficiency Alliance by soliciting participation of staff that has experience in the Regional Technical Form and has access to developed driven systems training materials;
- Present training workshops to service centers both in person and online beginning with in-shop practices September of 2007 adding driven systems and continuous improvement late fall of 2007. Establish reasonable attendance fees or obtain subsidies from utility or utility group associate members;
- Ongoing discussion of the recycling possibilities and carbon credits/greenhouse gas emission reduction by service centers implementing Green Motors Practices with environmental groups, utilities, and EASA International;
- Complete a comprehensive business plan no later than July 2007.

GMPG Officers/Board of Directors (Revision 1.1, May 2008)

President: Steve Skenzick
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Secretary/Clerk: Kevin "Fuzz" Thurston
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Board Member: D. Craig Peterson, P.E.
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eddie.young@bchydro.com

For Green Motors Practices Group Member Roster visit "www.greenmotors.org" and click on "Practicing Members"