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**REPORT ON THE FEASIBILITY STUDY
FOR IMPROVING ELECTRIC MOTOR
SERVICE CENTERS IN GHANA**

**J. S. Hsu
P. A. Jallouk
R. H. Staunton**

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**Prepared by
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831
managed by
LOCKHEED MARTIN ENERGY RESEARCH CORP.
for the
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1. INTRODUCTION

On March 3 and 4, 1998, a visit was made to Oak Ridge National Laboratory (ORNL) by two officials from Ghana: Mr. I. K. Mintah, Acting Executive Director, Technical Wing, Ministry of Mines and Energy (MOME) and Dr. A. K. Ofosu-Ahenkorah, Coordinator, Energy Efficiency and Conservation Program, MOME. As a result of this visit, Dr. John S. Hsu of ORNL was invited by MOME to visit the Republic of Ghana in order to study the feasibility of improving electric motor service centers in Ghana.

The MOME in the Republic of Ghana wishes to develop one-stop shopping, repair, and advisory centers that will provide service to industrial and commercial users of electric motors. Currently, a lack of technical expertise at motor repair shops results in large efficiency losses up to 30 percent when a motor is rewound. In addition, there are no energy efficiency standards on labeling requirements for new motors. Hence, users do not have the information needed for economically comparing motor selection options on a life-cycle basis. Improving motor repair performance and providing users information to allow them to make better decisions regarding motor purchase will significantly improve the efficiency of motors used by industry. This will result in decreased electrical consumption and, in effect, provide a very cost-effective increase in available electrical capacity.

In Ghana today, motor purchases are expensive and take longer than is acceptable. Thus, motor rewinding is the preferred option for industrial customers since it is cheaper and requires less down time in the plant. Therefore, the feasibility study needs to assess the centers in each industrial zone in Ghana prior to making recommendations for improving their motor repair capabilities. The addition of a motor sales component to the shops is the next step in the process of making them a one-stop shop and plans need to be developed for adding this capacity. Since these shops will be the primary information source for industrial customers, it would also be advantageous if they could provide value-added services such as efficiency testing and performing optimization studies for the users of motor-driven systems. The shops need to adopt new practices including labeling motors with data that includes efficiency specification(s) and other standards for improving quality. A planning task needs to be included to address this longer-term addition to the centers' list of services.

2. ACCOMPLISHMENTS ON PROGRAM TASKS

Prior to Dr. Hsu's visit to Ghana, a plan for the feasibility study consisting of five tasks was prepared. The activities comprising each task and the progress made to date are described below:

Task 1: Selection of Motor Centers

A preliminary list of eight centers was compiled for consideration. In addition to a sample listing of the sites, MOME provided information on each site. This included total annual volume of repair, number of employees, total annual sales, facility capabilities, location, existing and forecasted industrial base that would be served by the center, and any other information that could be used in the preliminary selection process. ORNL reviewed the

information before the initial visit to Ghana and assessed the sites for each industrial zone based on the information supplied to MOME.

The initial meetings during the Ghana on-site trip was with representatives of MOME to gather information concerning current motor usage in Ghana as well as future projected industrial development.

Visits were made to select sites on the MOME preliminary selection list to ascertain the current status of equipment and personnel capabilities. Information was gathered regarding the financial status of the facility as well as current rewind specifications, practices and standards, current facility condition, workman skill level, motor repair turn around time, testing and quality assurance procedures, material stocking and purchasing procedures, market share, costs and profitability, and foreign business connections. Based on the preliminary assessment, information gained from the site visits, and motor usage information from MOME, it was decided that a final selection of the center sites, which was scheduled to be made at this time, should be deferred pending further discussions with MOME personnel. ORNL recommends an alternate free enterprise approach facilitated by the government in Section 4.

Task 2: Upgrading Repair Capability of the Selected Centers

Information gained during the site visits was used to determine equipment, training, and financing requirements needed to improve motor repair performance. Repair standards developed by the Electrical Apparatus Service Association and best practices from smaller repair shops in the United States were used as the basis for defining how to accomplish a quality motor repair. These standards were tailored to the Ghanaian situation to facilitate the development of a set of procedures. The procedures focus on the repair of smaller motors (1–15 hp), which constitute the bulk of motors used in Ghana. In addition, the repair procedures are to address relatively large motors (over 200 hp) since they are common in Ghanaian industry and consume significant energy.

Once the repair procedures have been established, equipment needs for each of the centers will be identified. The type of equipment, its cost, possible sources, necessary material inventories, minimum floor space, and configuration of the space will be specified. Training needs for personnel at the centers to upgrade their skills and knowledge will be established and specific training programs will be recommended.

After equipment and training needs have been established for each center, ORNL will examine financing options and develop a plan for financing the required upgrade program. The financing plan will take cognizance of the fact that the intent is to develop these centers as private enterprises or joint ventures with overseas partners.

Task 3: New Motor Sales at Motor Centers

In addition to upgraded repair capabilities, it is desired to have the centers sell new motors. Information gained from MOME in Task 1 will define the anticipated market for new motors. Because of continued rural electrification activities, it is anticipated that single-phase motors in the 5–15 hp size ranges will be an important market. A review of international motor manufacturers has been initiated to identify potential partners for a joint motor supply venture. Responses to inquiries were assessed and recommendations prepared regarding the prospects for establishing a partnership.

Task 4: Value-Added Services Provided by the Motor Centers

The goal is to establish the motor centers as a one-stop shop for electric motor purchase and repair. However, the centers could provide a broader range of services by also providing information services that assist users in selecting the proper equipment for their application. This value-added service would include energy efficiency information, development of efficiency standards for new motors, establishing a motor testing standard for repaired motors that allows a new nameplate to be added when a motor is repaired, and training in performance optimization techniques for motor-driven systems.

Subtask 4.1: Motor Efficiency Labeling – Since efficiency labeling is not standard practice in Ghana, motor users cannot adequately compare new motors when making a purchase. Choosing a motor based on purchase price often is a poor economic choice since the operating cost (electricity cost) for the motor over its lifetime can be an order of magnitude higher. Thus, a life cycle cost analysis is required and this in turn requires knowledge of the operating efficiency of the motor. Adding to the confusion is the fact that efficiency-testing standards in the United States, Europe, and Japan have differences that result in the measured efficiencies not being directly comparable. A plan would be developed for the motor centers that would allow them to present energy efficiency information to customers so that the true economics of the new motor decision can be calculated.

Subtask 4.2: Efficiency Standards for New Motors – A plan would be developed for defining and implementing energy efficiency standards for new motors. The plan would take cognizance of recent international efforts (in the United States, for example, the Energy Policy Act mandates minimum efficiencies for a wide range of motors) so that the Ghanaian standards, if adopted at a national level, would be consistent with other international standards. The standards would also have to be consistent with country-specific parameters (climate, motors in use, applications, etc.).

Subtask 4.3: Testing Standards for Repaired Motors – After a motor has been repaired and returned to service there is often no information available that tells the user what the operating efficiency is. Several techniques exist or are under development that would permit a shop to perform a few simple tests and develop enough information such that a new nameplate could be prepared and attached to the motor. One piece of information contained on the nameplate would be the new full-load efficiency. The end-user thus has better

information for making future repair/replace decisions and has a good indication of the quality of the repair. A plan will be developed for defining what steps must be taken to implement this value-added function at the motor centers.

Subtask 4.4: System Performance Optimization – This value-added service is designed to capture the greatest amount of energy savings and provide the motor user with the greatest economic benefit. Previous studies in the United States and Canada have indicated that the energy savings potential associated with system optimization is approximately an order of magnitude higher than that attainable through component improvements alone. By correctly matching the system to the application need, downsizing is frequently possible and loading on the system can be changed (e.g., variable speed drives) to match the system need. A plan will be developed to define the steps needed to train motor center personnel in performance optimization techniques and demonstrate the energy and cost savings possible.

Task 5: Seminar and Final Report

A one-day workshop will be conducted in Ghana now that the feasibility study is complete. The purpose of the workshop is to present the findings contained in the draft final report. Workshop participants will include representatives from the government and the motor centers. The agenda will include the following topics:

- 1) Description of assessment technique;
- 2) Summary of resources needed to establish centers with improved repair capabilities;
- 3) Summary of the potential for creating partnerships for sales of new motors;
- 4) Overview of value-added services, which may be provided by the motor centers, and summary of impact on energy usage;
- 5) Suggested approaches for establishing efficiency standards for new motors, testing standards for repaired motors, and motor efficiency labeling; and
- 6) Summary of expected impacts of single-phase motors in rural areas and role of standards and labeling.

3. TRIP TO GHANA

From March 26, 1998 to April 9, 1998, a trip to Ghana was made by Dr. John Hsu of ORNL. A detailed itinerary is given in Appendix A. During this visit, feasibility and study meetings were held with various representatives of industry and government. Meetings were held in the cities and towns of Accra, Kumasi, and Tarkwa.

4. KEY FINDINGS

As a result of this visit, the following findings related to the first four tasks outlined above are made:

Task 1: Selection of Motor Centers

The facilities visited seemed to generally have the same level of technology and employee skills. Revenue income to repair facilities is small and highly variable. A rough estimate of the facilities visited places monthly gross total revenue at (US) \$3000 $\pm$ 80%. The reason for this is the small motor population base that these facilities service. The rewind practices presently in use are inconsistent and can certainly be improved. In general, considerable potential exists for improving the present motor repair techniques that were observed during the tours. The suggested approaches will be discussed below. Certain facilities, such as the mining motor repair shops, have more space available. The quality and quantity of the repaired motors, however, does not significantly exceed that of the smaller shops. Instead of selecting four regional motor centers at this point in time, it is advisable that the government instead creates an environment conducive to free competition. With assistance from the government, this free enterprise system will result in the best run facilities having the best chance for survival.

Task 2: Upgrading Repair Capability of the Selected Centers

Ghanaian representatives expressed their intention to ORNL for improving their country's motor repair capabilities. A multi-faceted approach was envisioned, including the formation of partnerships with motor repair shops outside Ghana as well as encouraging foreign companies to build small-motor manufacturing facilities in Ghana. Dr. Hsu's recommendation is that instead of upgrading the repair capabilities of the selected centers, the upgrading should be conducted on a broader basis. After the trip, Dr. Hsu contacted several repair shops in the U.S. to inquire about their interest in investing in Ghana. None were interested because of the low level of revenues that repair shops in Ghana generate. Coupled with the large swings in anticipated monthly revenue, the expected payback would not warrant the required time, effort, and financial investment. Thus, it appears unlikely that investment from other countries will be forthcoming in this area. It should be noted that in the U.S., shops that repair and rewind small motors tend to be small, privately owned operations that focus their attention on a specific local geographic area. The motor rewind business is an intensely competitive field and the profit margins are not large. Motors are rarely shipped over large distances and rewinds are generally limited to the larger-sized motors – over 50 hp unless special fitting/mounting dimensions for installation requires the rewinding of small motors. One motor repair shop in Knoxville, Tennessee was visited and photographs as well as a brief description of the operations of this facility are included in Appendix B. This shop is fairly typical of motor repair shops in the United States.

In addition, the name of the following motor repair shop – an Allied Partner in the U.S. Department of Energy's Motor Challenge Program is included here:

Brithinee Electric
620 S. Rancho Avenue
Colton, California 92324
Attention: Mr. Wallace P. Brithinee, President

Brithinee Electric has agreed to provide information and answer general questions on the rewinding of electric motors. You will need to contact them with specific inquiries. Mr. Brithinee, the company president, is very active in Electrical Apparatus Service Association, Inc. (EASA) and has contacts with several countries in the Caribbean area who, like Ghana, are in the process of improving their motor rewind capabilities. One suggestion Mr. Brithinee made when Dr. Jallouk spoke to him was in regard to an EASA convention that will be held at the Metro Toronto Convention Center in Toronto, Canada, from June 27–30, 1999. A part of this convention is an exhibit hall with numerous representatives of motor repair shops and suppliers of material. It is strongly recommended that representatives from MOME or a motor repair leadership group in Ghana attend. This represents a significant opportunity to make direct first-hand contact with the major key suppliers and repair shops in North America. Additional information about this meeting, as it becomes available, may be obtained through EASA's web page on the Internet: www.easa.com.

The repair techniques used in the shops visited were generally inconsistent. Enclosed in Appendix C is the latest copy of the EASA Standards used in the United States. Except for the differences in the voltage and frequency, the standards should be directly applicable to Ghana. A list of equipment needed for a rewind/repair shop is given in Appendix D. Also in Appendix E, information on the advantages and disadvantages of the four methods for motor winding removal are discussed.

There is a low inventory of materials in Ghana needed to repair electric motors. In addition, the established or traditional sources used today result in the importing of materials of inconsistent quality. This can have a significant impact on the consistency of a motor rewind and the resulting energy efficiency. To facilitate the timely availability of quality materials, it is suggested that contact be established with several reputable firms in the major manufacturing countries. A list of suppliers in the United States, who responded favorably to our requests for information, is included in Appendix F. Detailed quality specifications need to be written prior to going out on bids for these materials. In addition, a small effort needs to be set up to randomly test a fraction of the purchased materials to ensure that they meet quality standards. Supplies should be ordered in bulk to obtain most favorable pricing and, upon arrival, be located in a central supply area in Ghana. The delivery of high-quality materials to local repair shops can then be done, as needed, with a minimal turn-around time for a small incremental increase in price over the wholesale level. It is not necessary that this be a government undertaking, perhaps the repair shops in Ghana can form a cooperative association that can undertake this and similar tasks that can potentially benefit them all. Additional personal contacts can be made via trade shows such as the one mentioned above in Toronto this year.

There is a significant dearth of testing equipment for electric motors in Ghana. Without such equipment, it is difficult to determine the present efficiency of the motors in use and how well motors are being rewound. In order to perform adequate motor testing, a minimal set of facilities, equipment and trained personnel are required. The different types of equipment that will be needed as well as the facilities are discussed under Task 4. In addition, a supply of technically qualified personnel and the corresponding training that will be needed are also discussed below under Task 4.

Task 3: New Motor Sales at Motor Centers

It became clear in this study that too many motors are rebuilt (often several times) and too few new motor purchases are made. Although the U.S. may not represent a good source of 50 Hz motors, there are quality manufacturers in Europe whose motors could be purchased and tested, as necessary, to ensure performance is known. The U.S. has established, by law, minimum efficiency requirements for new motors sold domestically. The testing is for 60 Hz motors using IEEE Standard 112, Test Method B and would *not* be suitable for use in Ghana. However, Ghana should eventually establish its own test procedure and minimum efficiency standard for new motor sales.

Stocking new motors should be an important activity at central facilities and motor repair shops need to encourage new motor sales and draw upon the stock at the nearest central facility. In addition, new motor manufacturing in Ghana will certainly lead to greater increased new motor sales.

As with investments in motor repair shops, we received back a similar lack of interest from our contacts with U.S. corporations for setting up branches or subsidiaries in Ghana to manufacture motors for electric fans. Of the numerous letters sent out, only one possible interested party responded. This is presented in Appendix G. Climatic conditions and the low labor costs could result in a significant potential market for fans in Ghana. It is suggested that the Government of Ghana, through loan guarantees, aid in the startup of a total manufacturing enterprise for the production of fans. To minimize initial investment, it is suggested that surplus machine tools be located and imported from the United States or other countries with a significant manufacturing base. Raw materials can be supplied in a way similar to that suggested for motor repair – mainly by utilizing a central supply location. Once this manufacturing enterprise for the production of fans gets underway and is a financial success, it should stimulate the growth of other electric motor industries as well as the demand for electrical parts. This would place the central supply function on a surer footing and 'prime the pump' for additional economic growth in the electrical motor industry in Ghana. In this fashion, some of the motors sold in Ghana can be manufactured there. It is recommended that initially, only small horsepower units be manufactured. It should be noted that testing methods to determine the efficiency of these locally developed motors must be developed and that the local motor efficiencies must be comparable to imported units for such motors to be competitive. This will require that quality assurance procedures be instituted during manufacture. Assistance from international parties in setting up and operating such a facility will help ensure the success of such an undertaking. For example,

assistance available through the United Nations (such as UNESCO) should be investigated. In addition, some organizations in the United States, such as the International Institute for Energy Conservation (IIEC), may be able to provide additional help or guidance in this area. Again, the best way to develop contacts with major suppliers in North America is through conventions such as the one in Toronto in 1999. Here, representatives from Ghana will be able to see firsthand the products that are available and initiate face-to-face contacts with sales representatives.

Task 4: Value-Added Services Provided by the Motor Centers

As the rural electrification program in Ghana expands, it is also natural that the demand for electrical equipment, including motors, will also expand. To help consumers select the proper equipment for their application, it is important that reliable information be available on the efficiency of the equipment being sold. Additional service tools should be available to help the customer apply performance optimization techniques to match his motor to the system's drive requirements. For developing performance optimization techniques it is recommended that a course be taken similar to the one prepared by Wisconsin Demand-Side Demonstrations, Inc., which uses the book entitled *Performance Optimization Service Training Manual*. This course was offered starting in 1994 in the United States. With regard to additional technical handbooks reference manuals and reports, a wide variety are available through EASA. A package, including a membership application for EASA is enclosed in Appendix H. Note that this package includes an "EASA Materials and Services Price List," which lists many publications available about electric motors. Also included in this package is the May 1998 issue of EASA's monthly newsletter "Currents." The centerfold of this publication contains information on EASA's "Used Equipment Trading Post" that serves as a conduit for the promotion of used, surplus, and reconditioned equipment for sale. While the Orlando convention took place earlier in the year, similar promotions can be expected to occur at the Toronto meeting. This is a relatively straightforward way to obtain equipment at a discount from retail price. It is recommended that EASA and EASA members be contacted for information on the availability of such equipment.

At present there is no adequate methodology established for motor efficiency evaluation in Ghana. Test methods from different countries and between major suppliers vary. In addition, published data are often difficult to compare and required information is not easily available. Thus, it is recommended that testing procedures, similar to those established in the United States and other countries, be promulgated. Once in place, a trained staff will be needed to carry out or observe the testing procedures. In addition, one or more facilities are needed in Ghana where the efficiency of electric motors can be tested. Staffed by trained technicians, proper testing equipment, and clearly defined testing procedures, similar to Institute of Electrical and Electronics Engineers, Inc. [IEEE] 112 Test Method B, these facilities can represent national centers for motor testing efficiency. In addition, the methodology can serve as a first step for the formulation of policies and guidelines for the application of minimum standard efficiencies by the government as it relates to the import and local manufacture of electric motors. It is likely that, at least initially, such facilities be operated in conjunction with or at the site of major centers of higher learning. Such facilities

are most likely to have the interest, training, and knowledge to properly undertake the needed testing. These facilities need to initially be certified by an agency of the government with respect to the availability of the necessary equipment to perform such tests. Additionally, the skilled technicians that perform the efficiency tests need to be certified to insure that they know the proper methods of efficiency testing. Finally, with both certification procedures in place, it will ultimately be necessary that both facilities and operators undergo recertification to insure that the proper procedures remain in use and skills are constantly updated. In the United States, the Department of Commerce, through the National Institute of Standards and Technology (NIST) administers the National Voluntary Laboratory Accreditation Program (NVLAP). NVLAP programs are established for public and private calibration and testing laboratories, including commercial laboratories, manufacturers' in-house laboratories and federal, state and local government laboratories. NVLAP accreditation is based on the evaluation of a laboratory's technical qualifications and competence for conducting specific test methods, measurements, and services in specified fields of calibration or testing. It is granted only after a thorough evaluation of the applicant has demonstrated that all NVLAP criteria have been met. A NIST memorandum on NVLAP is included in Fig. I-1 in Appendix I. Additional information on NVLAP can be found in NIST Handbook 150 and NIST Handbook 150-10. The front covers of both publications are shown in Figs. I-2 and I-3 respectively. The front cover of the IEEE Standard 112 is shown in Fig. I-4. ORNL has an NVLAP-approved motor testing facility on site. Photographs of this facility as well as another facility used to balance motors are presented in Appendix J.

A central facility needs to be established for the leasing of equipment, tools, books, and instrumentation relating to motors and their efficiency. Due to the cost of many of these items along with the fact that no one facility can justify the purchase of much of this equipment due to its infrequent use, a central facility would well serve the needs of the motor repair and testing community. Needed portable equipment can be loaned out for short periods of time to the various users for a nominal fee. Such a facility would also be responsible for maintaining the equipment that is loaned out, insuring its timely return and calibrating the instrumentation to provide users with a degree of confidence. Photographs of the types of equipment needed for such an operating facility were also given in Appendix J.

In short, there is no doubt that the electric motor repair shops need to update their position with improved technology, as well as access to reasonably-priced materials. They also need standards to follow, equipment to test their products, facilities to improve their repair jobs, efficiency test beds, the ability to conduct value-added services, and the capability to replace old motors with high-efficiency motors. The government, helping to guide this effort, can be instrumental to its success. The private business sectors are, however, the fundamental players. The chart, shown in Fig. 1, outlines the elements needed to form the regional centers on the basis of a general improvement of all the repair shops. The government's role as a facilitator is suggested in the chart.

Figure 1
Suggested interactions among various Government Departments and Repair Shops

Task 5: Seminar

As a final activity completing the ORNL study, a seminar or "Motor Repair Centers Workshop" was held in Accra, Ghana on September 15, 1999. A rapporteur assigned by the Energy Foundation provided the following summary (edited by ORNL):

Electric Motor Improvement Project Comments of Participants at Workshop for the Presentation of Consultant's Findings to Stakeholders

Motor-Testing Facility

Dr. Ofosu-Ahenkorah, Executive Director of the Energy Foundation and organizers of the workshop held discussions beginning with a question regarding the typical/average cost of a motor stand (i.e., baseplate, refurbished dynamometer, etc.) from the USA. In response, the ORNL's representative (Mr. R. H. Staunton) indicated that the cost of basic equipment would depend very much on quality of materials, instrumentation, machine capacity, etc. However, he

put the average cost around \$6,000 - \$7,000 for testing up to 100hp motors. In reaction to the ORNL representative's estimate of the average cost of a motortesting machine, a participant indicated that similar equipment used in Ghana is far more expensive than quoted.

The Principal of Ho Polytechnic, who participated in the workshop, indicated that the equipment for the Ho workshop which was donated by the French government cost about €100 million, which was over US \$50,000 at the time of purchase in 1996.

There was a general consensus that assistance (i.e., cash and otherwise) from the Energy Foundation and the Ministry of Mines & Energy should be made available to facilitate acquisition of motor-testing machines for the motor repair centers. These machines should be able to calibrate motor testing instruments, measure rewound motor efficiency, etc. Specialized testing apparatus such as hand-held testers would be very useful. Supporting manuals for efficient use of test machines/instruments were recommended. These can be provided by ORNL. Participants were informed about the existing collaboration between the Ghana Standards Board (GSB) and the CSIR - Instrumentation Unit for the calibration of test instruments. The participants were advised to contact the GSB or the CSIR for assistance, as needed.

Motor Manufacturing Plant

It became evident from the discussions that it was time for a local motor manufacturing plant to be established in Ghana to produce energy-efficient small to medium size motors for appliances such as fans, pumps, etc. Such a venture, if successful, would likely address the problem of reduced efficiencies due to frequent motor rewinds. Because of the hot climate, the importation of fans is likely to continue well into the future.

The laudable move for a motor manufacturing plant notwithstanding, it was generally agreed that much emphasis must be placed on the *quality* of motors produced by the proposed manufacturing plant.

On the issue of duties on imported motors, the Honorable Member of Parliament, Mr. Thomas Yeboah, explained that motor repairers could enjoy tax (duty) exemption if the Ghana Standards Board develops efficiency standards for motors. These standards will facilitate the categorization of motors into those which are subject to duties and those which are not. It was revealed that the Energy Foundation was seeking a financial assistance package to facilitate the work of the GSB in developing the minimum efficiency standards.

Motor Repairers' Association/Financial Assistance

The fact that motor repairers need financial assistance for smooth running of their operations was emphasized and collectively agreed upon. There were suggestions advocating the Ministry of Mines & Energy and the Energy Foundation to assist the motor repair centers by sourcing for funds for the centers. These funds could be managed by a financial institution (bank) selected by the Ministry or the Foundation. A revolving fund could also be set up for the same purpose.

It was also unanimously agreed that for the motor repair centers to have a much stronger bargaining power with the financial institutions, there is the need for them to pool resources through the formation of an association. The association is the surest solution to their capital investment problem.

A representative of the Banks (Agricultural Development Bank), who was present, informed the motor repairers about the readiness of the banks to finance energy-efficient projects since they are good investments. Similar statements have been made by other banks that attended workshops organized by the Energy Foundation in the past.

Welcoming as this message was, the general sentiment was that the Bank interest rates need to be reduced. There was also an appeal for streamlining procedures for loan approvals by the banks.

Training

Participants recommended periodic training programs for motor repair centers to refresh their knowledge and expose them to up-to-date technologies and practices in the trade. These programs are to be organized by the Foundation in such a way that they will benefit motor end-users too.

The GSB indicated that it conducts management programs for motor rewinders and performs laboratory accreditation too. After certification, the Board runs a surveillance program to ensure adherence to standards and regulations.

On the issue of apprentice training, there was a suggestion the Polytechnics should be equipped so that they can train both apprentices for the motor repair centers and polytechnic graduates aspiring to work in such centers.

Breakdown of Motors

A number of factors, apart from age, that contribute to the breakdown of motors were cited. These are bearing failure, lack of under-voltage protection, inadequate maintenance, lack of overload protection (relays), humidity changes, etc. In the case of humidity changes, this can be addressed by phase heating. It was emphasized that motor end-users need to be educated on the importance and cost-effectiveness of preventive maintenance. The issue of soft starters for motors and applications that could benefit from their use should be addressed. It was noted that some motor end-users run their motors without starters.

It was generally agreed that the draft report prepared by ORNL is a good one.

The participants attending the workshop are provided in Table 1.

Table 1 Motor Repair Centers Workshop Attendees

Name	Company	Title
Herbert Lutterodt	Germany	Student
Patrick L. Abban	Takoradi Polytechnic	Student
Albert Asante	Bert Rewinding Service	
Winfried Odjidja	Electricity Company of Ghana	
Michael Attua Obeng	Accra Polytechnic	
Geoffrey D.	Rockland Elec. Eng.	
Albert Oware	G.T.P. Tema	Elec. Eng.
Theophilus Mohem	Resdem, Accra	Mech. Eng.
George Asiedu Mantey	Ho Polytechnic, Box 217, HO	Elec. Eng.
T. W. K. Agbadi	HO Polytechnic	Mech. Eng.
Von Gaertner	C/O Agogo Hospital	Consultant
Odame-Adame E. F.	Sonic Control & Eng. Serv.	Director
D. F. Bonnah	K. T. I. (Kumasi)	Motor Rewinding Instructor
Danquah-Darko	Ghana Water Co. Ltd.	Head of Ops.
I. K. Mintah	Mome	Tech. Director
Ofosu-Ahenkorah	Energy Foundation	Exe. Director
E. K. Annan	UST	Lecturer
Emmanuel Amarquaye	Gilgal Agency	Director
Kwame Ampofo	Energy Commission	Commissioner
K. A. Kyeremeh	ECG	RD/SUBT
Eng. A. T. Barfour	ECG	RD/ACCRA East
W. K. Agyemang-Bonsu	EPA	PO/MID
Hon. Thomas Yeboah	Parliament	Chairman-Mines/Energy Com.
T. A. Okyere	ECG	SM/Protection
J. C. T. Armah	GSB	HD
F. S. Annorbah	Francis/Elec.	Manager
Edward Baiden-Ghartey		
P. K. D. Hedihon	Agric. Dev. Bank	Manager
F. O. Kusi	Empretec GH. Foundation	Financial Ana.
Peter Bismark Tetteh	Sam & Frank Ltd.	O. M.
Gershon Frank		
E. Kwa-Kofi	Ghana Stds. Board	Scientific Office
W. Kyeremateng	ECG	DM/OPS
G. M. Afeti (Dr)	HO Polytechnic	Principal
P. K. Akomaning	Nat. Board for AG.E.D. Small Scale Industries	
M. Addo-Ashong	SSNIT	Architect
Dr. N. K. Smart Yeboah	Elec. Company of Ghana	Reg. Director
Opuni Adomeko	Opuni Elec.	Manager
Mr. S. K. Dayi	S. D. Electricals	Manager
S. Ankrah	Ghana Consolidated Diamond	Manager
Edward Awotwe	Centa Coasta	Manager
A. Z. Mahama	Ghana Investment Prom. Ctr.	Officer
Francis Baffoe-Ashun	SCIR-IIR	Head of Div.
Frank Baidoo	Sam & Frank Corp.	M. D.
Issah Nikabs	Min. of Trade & Industries	SIPO
A. A. Dsane	Ghana Standards Board	S. O.
E. A. Jackson	School of Engineering	Head of Dept. (Elec. Eng.)
A. Sanful	G. C. D. Ltd.	Snr. Elec. Eng.
Emmanuel M. Agbavior	CSIR-IIR	CTO
Nick Kopesky	Nifes Consulting Group, UK	
Kwasi Boateng	Stanconsult	Elect. Eng.

APPENDIX A

TRIP ITINERARY

- March 24, 1998 Traveled from Oak Ridge to Frankfurt, Germany.
- March 25, 1998 Traveled from Frankfurt, Germany, to Accra, Ghana.
- March 26, 1998 Meetings with Mr. Isaac K. Mintah, Technical Director, Ministry of Energy & Mines; Dr. A. K. Ofori-Ahenkorah, Acting Chief Programme Officer; Mr. Orison Mawumenyo Amu, Senior Programme Officer; Mr. Charles Anderson, Senior Program Officer; Prof. Fred Akuffo, Dept. Dean, School of Engineering, K.N.U.S.T, Kumasi; Mr. Michael Opam, Director, Bureau of Tariff & Economics, P.U.R.C.; and Mr. N. L. Hesse, Asst. Director (Laboratories), Ghana Standard Board.
- March 27, 1998 Visited Golden Spoon Flour Mill, Ltd. and had meetings with Managing Director, Mr. E. K. Asare Amankwa and Production & Engineering Director, Mr. Joseph Kwadjo Teye.
Traveled to Tema and visited Francis Electric Rewinding Works and met with the Managing Director, Mr. Francis Sekoh Annorbah.
Traveled back to Accra.
- March 28, 1998 Saturday
- March 29, 1998 Sunday
- March 30, 1998 Traveled from Accra to Kumasi.
Visited Ghana Consolidated Diamonds Ltd. and met with Chief Engineer, Mr. S. K. Ankrah.
- March 31, 1998 Visited University of Science and Technology, Kumasi. Talked to Prof. E. K. Annan.
Visited the Motor Repair Shop of the University.
Visited Lumber Mill.
- April 1, 1998 Visited Centa Costa Motor Repair Shop.
Visited Opuni Electrical Works and met with the Managing Director, Mr. G. O. Adomako.
Traveled from Kumasi to Tarkwa.
- April 2, 1998 Visited Sam & Frank Rewinding Shop.
Visited Bert's Rewinding Service.

Visited S. D. Electrical Repair Services and met with the Manager, Mr. S. K. Dayi.

April 3, 1998 Traveled from Tarkwa to Accra.

April 4, 1998 Saturday

April 5, 1998 Sunday

April 6, 1998 Traveled to Tema and visited Rockland Electrical Engineering Works.

April 7, 1998 Briefed Dr. A. K. Ofosu-Ahenkorah, Ag. Chief Programme Officer, on the status of this travel.
Met with Mr. Geoffrey Dedoo, Managing Director of Rockland Electrical Engineering Works.
Met with Dr. F. Addo Yobo, Cambridge Engineering & Economic Research Consultants.
Met with Mr. Frank E. Y. Achampong, Managing Director of Facol Ltd.

April 8, 1998 Visited the Institute of Industrial Research CSIR and met with the Director, Dr. Kofi A. Owusu-Ansah and the Head of Applied and Industrial Physics Division, Dr. Samuel E. Quagraime.
Visited Mr. N. L. Hesse, Asstant Director (Laboratories), Ghana Standard Board.
Visited Ghana Investment Promotion Centre and met with Deputy Director, Dr. Peter Ankrah.

April 9, 1998 Briefed Dr. A. K. Ofosu-Ahenkorah, Acting Chief Programme Officer, about preliminary finding.
Met with Deputy Minister, Hon. Simon Abingya, MP.
Traveled from Accra, Ghana, to Amsterdam, Netherlands.

April 10, 1998 Traveled from Amsterdam, Netherlands, to Oak Ridge, Tennessee.

APPENDIX B

A REWIND MOTOR FACILITY

A set of pictures is included here from a motor rewind shop located in Knoxville, Tennessee. This facility is Southern Armature Works, Inc. located on 1721 Potter Street. They rewind electric motors in the horsepower range of less than one hp to several hundred hp. The company employs a staff of seven people of which six are directly involved in motor rewind. On average, the shop works 8 hours a day, 40 hours a week. Their estimates of the number of motors they are capable of rewinding is as follows:

• Fractional hp to 20 hp:	8 motors/day;
• 20 hp to 100 hp:	2 motors/day;
• 100 hp to 500 hp:	1 motor/day; and
• Greater than 500 hp:	2 motors/week.

Figure B-1
Staff of Southern Armature Works, Inc

Figure B-2
Taking Parts Out of a Garbage Disposer Motor

Figure B-3
Burning Off Old Resin Insulation

Figure B-4
Cutting Off End Windings With An Air Hammer

Figure B-5
Steam Cleaning of Motor Parts

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Cleaning Motor Parts In a Solvent

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Winding Coils

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Metal Spray for Shaft Repair

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Turn-To-Turn, Phase-To-Phase and Phase-To-Ground Test of Winding
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Figure B-18
Cracked Rotor Bar Test

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Portable Vibration Test Meter To Check Rotor Balance

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Repairing Fan Blades

Figure B-21
Repairing A Fan

Figure B-22
Transportation of A Newly Rewound Motor

APPENDIX C

EASA STANDARDS

Enclosed as an attachment to this document is the latest copy of the EASA Standard entitled: *Recommended Practice for the Repair of Rotating Electrical Apparatus*, EASA AR100-1998. This document contains the association's standards for the repair, rewinding and testing of rotating equipment. A section on Electrical Testing Safety Considerations is also included.

As indicated in Appendix H (i.e., Figure H-3), EASA was not able to permit ORNL to include the document in this report. However, the title page and table of contents are included in this appendix to provide an indication of the scope of information included. Once membership with EASA is obtained, additional copies of the complete document may be ordered as needed.

ELECTRICAL APPARATUS SERVICE ASSOCIATION INC.

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**INTERNATIONAL HEADQUARTERS
1331 Burr Blvd., St. Louis, MO 63132**

Phone 314-993-2229

EASA AR100-1998

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APPENDIX D

LIST OF EQUIPMENT NEEDED FOR A REWIND/REPAIR SHOP

A list of the equipment needed to properly rebuild electric motors was supplied by David L. Gebhart, PE, staff engineer with EASA. His letter is included herewith.

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We feel it is necessary to have the following equipment to properly rebuild motors:

1. An assortment of wrenches, hammers, screw drives, etc., hand or power operated, for dismantling and reassembling motors.
2. Hoists for unloading motors and lifting parts. The number and size will depend on the size of the plant and the largest motor you expect handle.
3. Equipment for moving parts between operations.
4. Pullers for removing bearings/couplings corroded to the shaft.
5. Equipment for cleaning the dirt and grease from the parts. This can be a chemical spray or sand blast equipment or both.
6. Equipment for stripping the old windings. This could be a burnout oven or chemical stripper. *Do not* use a torch or open flame. After the varnish is softened or burned off, you need coil cutters to cut off the coil on one end and coil pullers to remove the winding.
7. Winding machines for making coils, preferably that can layer wind.
8. Winding heads—you may want both three phase and single phase.
9. Coil racks for storing wire behind the winding machine.
10. Dereelers to keep the wire from becoming tangled.
11. Tension devices to apply tension to the wire while the coil is made.

US: 14: 98 US: 33 PM *EASA ST LOUIS P03

12. Dipping the wound stator in a tank of varnish and baking it in an oven is the most popular way to treating the windings. This procedure is used by manufacturers, as well as by repair companies. All stators should be given at least two dips and bakes. The Tickle Process and V.P.I Process are other methods.

13. Balancing equipment.

14. Test equipment such as volt meters, amp meters, ohm meters, dielectric test sets, core-loss testers, surge testers, etc.

15. Repairing shafts, frames, etc., requires metallizing equipment.

There is a magazine devoted exclusively to the repair and maintenance industry. There are many articles in each issue that would be of interest to you. The name of the magazine is *Electrical Apparatus*. It is published by Barks Publications, Inc., 400 North Michigan Avenue, Suite 900, Chicago, Illinois, 60611-4198. They also publish a yearly directory of manufacturers of material, shop equipment and test instruments. Their phone number is (312) 321-9440.

If we may be of additional service, please advise.

Sincerely yours,

David L. Gebhart, PE
Staff Engineer

DLG:jw

APPENDIX E

MOTOR WINDING REMOVAL METHODS

This appendix provides information on the advantages and disadvantages of the four methods for motor winding removal. This write-up, while still in rough draft form, should be of assistance to motor rewind facilities.

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FAX COVER SHEET

ATTENTION: Julie Van Hemel

FROM: David L. Gebhart, PE
Staff Engineer.

COMPANY: Hagler Bailly Consulting

ENGR FAX: 314.993.2998

LOCATION: San Francisco, CA

DATE: February 20, 1997

FAX NO.: 415.882.1610

PAGES: 2

MESSAGE

SUBJECT: Fact Sheets on Motor Winding Removal Methods

The following are my comments on the four methods contained in your February 19 fax to Bruce Benes.

1. Cold Stripping Chemical Method

Description:

There is more than one type of chemical that can be used. Therefore, in your first sentence I suggest you drop "dichloromethane (CH_2Cl_2)" and insert "a chemical". You can drop the word "chemically" before "soften". Drop your entire second sentence and replace it with "The time required would depend upon the size of the motor."

Disadvantages:

Add between your first and second sentence: "A given chemical may not attack all varnishes."

2. Burnout Oven

Description:

The material doesn't have to go completely to ashes. In the second sentence change "are turned to ash" to "have softened to the point where the winding and insulation can be removed." The last word in description should be "puller".

FAX: Julie Van Hemel
February 20, 1997
Page 2

Disadvantages—Technical:

Some motors will not be damaged at 345°C. I suggest you replace "exceeds the recommended 345°C" with "becomes excessive".

3. Coil Puller with Gas or Propane Warming

Title:

Drop "Coil Puller with" from the title. All methods use a coil puller

Description:

First sentence—I feel 10°C is too low. Reading some literature from Thumm (maker of this type of equipment) I believe a range of 25-50°C would be more accurate.

4. Blow Torch

I would prefer to drop the mentioning of this method altogether. I don't want to encourage its use. Just being mentioned may make some people think it is all right and would delay their investment in other methods.

If you do keep it in, then under Description drop "reduced to ash" and replace it with the above wording under burnout oven.

pc: Bruce Benes

FAX COVER SHEET

Hugler Bailly Consulting, Inc.
455 Market Street, Suite 1420
San Francisco, CA 94105

Phone: (415) 882-1602

Fax: (415) 882-1610

Internet E-Mail: jvanhemel@habaco.com

TO: Bruce Benas, BASA

FAX No.: 314/993-1269

CC: Eugenio Tellez

FAX No.: 011-52-22-435-437

FROM: Julie Van Hemel

DATE: February 19, 1997

SUBJECT: Fact Sheets on Motor Winding Removal Methods

NUMBER OF PAGES (INCLUDING THIS COVER PAGE): 5

Missing pages or unreadable copy? Call (415) 882-1602 and ask for: Angela Billings

Original documents will

☐ Not be sent

☐ Follow by:

Attached please find the winding removal fact sheets I spoke to you about on the phone a few minutes ago, for review by someone familiar with the technical specifications for each of these methods. We basically want to make sure we haven't missed any obvious or important advantages or disadvantages of each of these methods.

Please let me know if you have any questions and thank you very much for agreeing to have someone take a look.

Best regards,

Julie A. Van Hemel
Research Associate

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COLD STRIPPING CHEMICAL WINDING REMOVAL METHOD

*Fact Sheet
Draft of 2/18/97*

*Time required
7-10 hours on size*

A CHEMICAL
Description: This method of removing motor windings involves dipping the entire motor in dichloromethane (CH_2Cl_2) in order to chemically soften the insulation and varnish to allow the windings to be pulled. The motor must be left in the chemical overnight (approximately 8 hours) in order to allow enough time for dissolution of the varnish and insulation. Two inches of water must cover the top of the liquid to avoid evaporation and hazardous fumes escaping from the solution. After soaking, the motor must drip dry and then be washed using a pressurized washer to clean the chemical residue from the motor stator. Then the motor must be dried again prior to winding.

Cost: Approximately \$500. One drum of the chemical will be enough for approximately 50-100 motors, depending on size. The cost can be significantly higher depending on the number of motors stripped each year when viewed over a 10 to 20 year period.

Advantages:

- ▶ **Cost.** Because this method is relatively inexpensive, it can be utilized by even the smallest rewind shops. Efficiency losses will be lower using this method than using the current blow-torch method employed by most shops.
- ▶ **Turnaround time.** Multiple motors can be immersed in chemical at once (depending on motor size).

Disadvantages:

- GIVEN CHEMICAL IN 1977, 1987, 1997, 2007, 2017, 2027, 2037, 2047, 2057, 2067, 2077, 2087, 2097, 2107, 2117, 2127, 2137, 2147, 2157, 2167, 2177, 2187, 2197, 2207, 2217, 2227, 2237, 2247, 2257, 2267, 2277, 2287, 2297, 2307, 2317, 2327, 2337, 2347, 2357, 2367, 2377, 2387, 2397, 2407, 2417, 2427, 2437, 2447, 2457, 2467, 2477, 2487, 2497, 2507, 2517, 2527, 2537, 2547, 2557, 2567, 2577, 2587, 2597, 2607, 2617, 2627, 2637, 2647, 2657, 2667, 2677, 2687, 2697, 2707, 2717, 2727, 2737, 2747, 2757, 2767, 2777, 2787, 2797, 2807, 2817, 2827, 2837, 2847, 2857, 2867, 2877, 2887, 2897, 2907, 2917, 2927, 2937, 2947, 2957, 2967, 2977, 2987, 2997, 3007, 3017, 3027, 3037, 3047, 3057, 3067, 3077, 3087, 3097, 3107, 3117, 3127, 3137, 3147, 3157, 3167, 3177, 3187, 3197, 3207, 3217, 3227, 3237, 3247, 3257, 3267, 3277, 3287, 3297, 3307, 3317, 3327, 3337, 3347, 3357, 3367, 3377, 3387, 3397, 3407, 3417, 3427, 3437, 3447, 3457, 3467, 3477, 3487, 3497, 3507, 3517, 3527, 3537, 3547, 3557, 3567, 3577, 3587, 3597, 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6927, 6937, 6947, 6957, 6967, 6977, 6987, 6997, 7007, 7017, 7027, 7037, 7047, 7057, 7067, 7077, 7087, 7097, 7107, 7117, 7127, 7137, 7147, 7157, 7167, 7177, 7187, 7197, 7207, 7217, 7227, 7237, 7247, 7257, 7267, 7277, 7287, 7297, 7307, 7317, 7327, 7337, 7347, 7357, 7367, 7377, 7387, 7397, 7407, 7417, 7427, 7437, 7447, 7457, 7467, 7477, 7487, 7497, 7507, 7517, 7527, 7537, 7547, 7557, 7567, 7577, 7587, 7597, 7607, 7617, 7627, 7637, 7647, 7657, 7667, 7677, 7687, 7697, 7707, 7717, 7727, 7737, 7747, 7757, 7767, 7777, 7787, 7797, 7807, 7817, 7827, 7837, 7847, 7857, 7867, 7877, 7887, 7897, 7907, 7917, 7927, 7937, 7947, 7957, 7967, 7977, 7987, 7997, 8007, 8017, 8027, 8037, 8047, 8057, 8067, 8077, 8087, 8097, 8107, 8117, 8127, 8137, 8147, 8157, 8167, 8177, 8187, 8197, 8207, 8217, 8227, 8237, 8247, 8257, 8267, 8277, 8287, 8297, 8307, 8317, 8327, 8337, 8347, 8357, 8367, 8377, 8387, 8397, 8407, 8417, 8427, 8437, 8447, 8457, 8467, 8477, 8487, 8497, 8507, 8517, 8527, 8537, 8547, 8557, 8567, 8577, 8587, 8597, 8607, 8617, 8627, 8637, 8647, 8657, 8667, 8677, 8687, 8697, 8707, 8717, 8727, 8737, 8747, 8757, 8767, 8777, 8787, 8797, 8807, 8817, 8827, 8837, 8847, 8857, 8867, 8877, 8887, 8897, 8907, 8917, 8927, 8937, 8947, 8957, 8967, 8977, 8987, 8997, 9007, 9017, 9027, 9037, 9047, 9057, 9067, 9077, 9087, 9097, 9107, 9117, 9127, 9137, 9147, 9157, 9167, 9177, 9187, 9197, 9207, 9217, 9227, 9237, 9247, 9257, 9267, 9277, 9287, 9297, 9307, 9317, 9327, 9337, 9347, 9357, 9367, 9377, 9387, 9397, 9407, 9417, 9427, 9437, 9447, 9457, 9467, 9477, 9487, 9497, 9507, 9517, 9527, 9537, 9547, 9557, 9567, 9577, 9587, 9597, 9607, 9617, 9627, 9637, 9647, 9657, 9667, 9677, 9687, 9697, 9707, 9717, 9727, 9737, 9747, 9757, 9767, 9777, 9787, 9797, 9807, 9817, 9827, 9837, 9847, 9857, 9867, 9877, 9887, 9897, 9907, 9917, 9927, 9937, 9947, 9957, 9967, 9977, 9987, 9997, 10007, 10017, 10027, 10037, 10047, 10057, 10067, 10077, 10087, 10097, 10107, 10117, 10127, 10137, 10147, 10157, 10167, 10177, 10187, 10197, 10207, 10217, 10227, 10237, 10247, 10257, 10267, 10277, 10287, 10297, 10307, 10317, 10327, 10337, 10347, 10357, 10367, 10377, 10387, 10397, 10407, 10417, 10427, 10437, 10447, 10457, 10467, 10477, 10487, 10497, 10507, 10517, 10527, 10537, 10547, 10557, 10567, 10577, 10587, 10597, 10607, 10617, 10627, 10637, 10647, 10657, 10667, 10677, 10687, 10697, 10707, 10717, 10727, 10737, 10747, 10757, 10767, 10777, 10787, 10797, 10807, 10817, 10827, 10837, 10847, 10857, 10867, 10877, 10887, 10897, 10907, 10917, 10927, 10937, 10947, 10957, 10967, 10977, 10987, 10997, 11007, 11017, 11027, 11037, 11047, 11057, 11067, 11077, 11087, 11097, 11107, 11117, 11127, 11137, 11147, 11157, 11167, 11177, 11187, 11197, 11207, 11217, 11227, 11237, 11247, 11257, 11267, 11277, 11287, 11297, 11307, 11317, 11327, 11337, 11347, 11357, 11367, 11377, 11387, 11397, 11407, 11417, 11427, 11437, 11447, 11457, 11467, 11477, 11487, 11497, 11507, 11517, 11527, 11537, 11547, 11557, 11567, 11577, 11587, 11597, 11607, 11617, 11627, 11637, 11647, 11657, 11667, 11677, 11687, 11697, 11707, 11717, 11727, 11737, 11747, 11757, 11767, 11777, 11787, 11797, 11807, 11817, 11827, 11837, 11847, 11857, 11867, 11877, 11887, 11897, 11907, 11917, 11927, 11937, 11947, 11957, 11967, 11977, 11987, 11997, 12007, 12017, 12027, 12037, 12047, 12057, 12067, 12077, 12087, 12097, 12107, 12117, 12127, 12137, 12147, 12157, 12167, 12177, 12187, 12197, 12207, 12217, 12227, 12237, 12247, 12257, 12267, 12277, 12287, 12297, 12307, 12317, 12327, 12337, 12347, 12357, 12367, 12377, 12387, 12397, 12407, 12417, 12427, 12437, 12447, 12457, 12467, 12477, 12487, 12497, 12507, 12517, 12527, 12537, 12547, 12557, 12567, 12577, 12587, 12597, 12607, 12617, 12627, 12637, 12647, 12657, 12667, 12677, 12687, 12697, 12707, 12717, 12727, 12737, 12747, 12757, 12767, 12777, 12787, 12797, 12807, 12817, 12827, 12837, 12847, 12857, 12867, 12877, 12887, 12897, 12907, 12917, 12927, 12937, 12947, 12957, 12967, 12977, 12987, 12997, 13007, 13017, 13027, 13037, 13047, 13057, 13067, 13077, 13087, 13097, 13107, 13117, 13127, 13137, 13147, 13157, 13167, 13177, 13187, 13197, 13207, 13217, 13227, 13237, 13247, 13257, 13267, 13277, 13287, 13297, 13307, 13317, 13327, 13337, 13347, 13357, 13367, 13377, 13387, 13397, 13407, 13417, 13427, 13437, 13447, 13457, 13467, 13477, 13487, 13497, 13507, 13517, 13527, 13537, 13547, 13557, 13567, 13577, 13587, 13597, 13607, 13617, 13627, 13637, 13647, 13657, 13667, 13677, 13687, 13697, 13707, 13717, 13727, 13737, 13747, 13757, 13767, 13777, 13787, 13797, 13807, 13817, 13827, 13837, 13847, 13857, 13867, 13877, 13887, 13897, 13907, 13917, 13927, 13937, 13947, 13957, 13967, 13977, 13987, 13997, 14007, 14017, 14027, 14037, 14047, 14057, 14067, 14077, 14087, 14097, 14107, 14117, 14127, 14137, 14147, 14157, 14167, 14177, 14187, 14197, 14207, 14217, 14227, 14237, 14247, 14257, 14267, 14277, 14287, 14297, 14307, 14317, 14327, 14337, 14347, 14357, 14367, 14377, 14387, 14397, 14407, 14417, 14427, 14437, 14447, 14457, 14467, 14477, 14487, 14497, 14507, 14517, 14527, 14537, 14547, 14557, 14567, 14577, 14587, 14597, 14607, 14617, 14627, 14637, 14647, 14657, 14667, 14677, 14687, 14697, 14707, 14717, 14727, 14737, 14747, 14757, 14767, 14777, 14787, 14797, 14807, 14817, 14827, 14837, 14847, 14857, 14867, 14877, 14887, 14897, 14907, 14917, 14927, 14937, 14947, 14957, 14967, 14977, 14987, 14997, 15007, 15017, 15027, 15037, 15047, 15057, 15067, 15077, 15087, 15097, 15107, 15117, 15127, 15137, 15147, 15157, 15167, 15177, 15187, 15197, 15207, 15217, 15227, 15237, 15247, 15257, 15267, 15277, 15287, 15297, 15307, 15317, 15327, 15337, 15347, 15357, 15367, 15377, 15387, 15397, 15407, 15417, 15427, 15437, 15447, 15457, 15467, 15477, 15487, 15497, 15507, 15517, 15527, 15537, 15547, 15557, 15567, 15577, 15587, 15597, 15607, 15617, 15627, 15637, 15647, 15657, 15667, 15677, 15687, 15697, 15707, 15717, 15727, 15737, 15747, 15757, 15767, 15777, 15787, 15797, 15807, 15817, 15827, 15837, 15847, 15857, 15867, 15877, 15887, 15897, 15907, 15917, 15927, 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17367, 17377, 17387, 17397, 17407, 17417, 17427, 17437, 17447, 17457, 17467, 17477, 17487, 17497, 17507, 17517, 17527, 17537, 17547, 17557, 17567, 17577, 17587, 17597, 17607, 17617, 17627, 17637, 17647, 17657, 17667, 17677, 17687, 17697, 17707, 17717, 17727, 17737, 17747, 17757, 17767, 17777, 17787, 17797, 17807, 17817, 17827, 17837, 17847, 17857, 17867, 17877, 17887, 17897, 17907, 17917, 17927, 17937, 17947, 17957, 17967, 17977, 17987, 17997, 18007, 18017, 18027, 18037, 18047, 18057, 18067, 18077, 18087, 18097, 18107, 18117, 18127, 18137, 18147, 18157, 18167, 18177, 18187, 18197, 18207, 18217, 18227, 18237, 18247, 18257, 18267, 18277, 18287, 18297, 18307, 18317, 18327, 18337, 18347, 18357, 18367, 18377, 18387, 18397, 18407, 18417, 18427, 18437, 18447, 18457, 18467, 18477, 18487, 18497, 18507, 18517, 18527, 18537, 18547, 18557, 18567, 18577, 18587, 18597, 18607, 18617, 18627, 18637, 18647, 18657, 18667, 18677, 18687, 18697, 18707, 18717, 18727, 18737, 18747, 18757, 18767, 18777, 18787, 18797, 18807, 18817, 18827, 18837, 18847, 18857, 18867, 18877, 18887, 18897, 18907, 18917, 18927, 18937, 18947, 18957, 18967, 18977, 18987, 18997, 19007, 19017, 19027, 19037, 19047, 19057, 19067, 19077, 19087, 19097, 19107, 19117, 19127, 19137, 19147, 19157, 19167, 19177, 19187, 19197, 19207, 19217, 19227, 19237, 19247, 19257, 19267, 19277, 19287, 19297, 19307, 19317, 19327, 19337, 19347, 19357, 19367, 19377, 19387, 19397, 19407, 19417, 19427, 19437, 19447, 19457, 19467, 19477, 19487, 19497, 19*

BURNOUT OVEN WINDING REMOVAL METHOD

*Fact Sheet
Draft of 2/18/97*

Description: The motor stator is placed in a burnout oven that is set for a maximum recommended temperature of 345°C (650°F). It is kept at this temperature until all of the varnish and insulating materials are turned to ash (8 hours or more, depending on motor size). The windings are then pulled using a mechanical or hydraulic puller.

Cost:

Approximate Motor Size	up to 100 HP	up to 200 HP	up to 500 HP
Dimensions	100cm x 100cm x 112cm	100cm x 130cm x 112cm	130cm x 160cm x 142 cm
Uninstalled cost*	\$18,750	\$19,750	\$23,350

*Prices include electronic temperature monitoring and water suppression system, with battery backup in case of power failure.

Advantages:

- ▶ **Turnaround time.** Multiple motors can be fired at once (depending on the size of the motors).
- ▶ **Health.** No special handling or training is required for shops using this method.
- ▶ **Endorsement.** The Electrical Apparatus Service Association recommends this method as the standard for stripping of motor windings while maintaining motor efficiency.

Disadvantages:

- ▶ **Technical.** If the temperature exceeds the recommended 345°C, damage to the stator core and frame may result, reducing motor efficiency and mechanical reliability.
- ▶ **Environmental.** Gasses and other byproducts are exhausted through a smoke stack into the atmosphere.
- ▶ **Cost.** The burnout ovens may be prohibitively expensive for small rewind shops. Provision of financing may be required to encourage purchase of the burnout ovens by small- and medium-sized shops whose volume of business may not warrant such a large capital investment.

~~COIL PULLER WITH GAS OR PROPANE WARMING~~ WINDING REMOVAL METHOD

Fact Sheet
Draft of 2/18/97

Description: Using natural gas- or propane-fired jets held 15-25 cm away from the motor core, the back iron and insulation is warmed until the windings become soft and pliable (approximately 100°C above the insulation class of the varnish insulation). The motor is held on a platform above a stationary flame, to avoid bringing the flame too close to the motor and thus damaging the core. Coils and insulation are then removed using a slow, steady hydraulic pull. This is accomplished using a rotating table with a special set of clamps, a specially design hydraulic cylinder, and coil clamps. Stripping temperature is kept below the melting point of the Mylar in the slot paper insulation.

Cost: \$5,400-\$TBD (uninstalled). Includes platform for holding motors while warmed and pulled, hydraulic mechanism for pulling, and flame apparatus.

Advantages:

- **Technical.** Temperatures remain low, maintaining the original magnetic properties of the stator core and minimizing the risk of damage. Keeping temperatures below the melting point of the insulation allows it to be removed with the coils, greatly reducing cleaning time.
- **Speed.** This method requires only 2.5 to 4 hours to complete.
- **Environmental.** There are no airborne byproducts or disposal problems.
- **Cost.** Though this method is more expensive than the chemical method, it is far less expensive than the purchase of a burnout oven. Small shops could be offered financing or incentives to purchase the apparatus.
- **Health.** No special handling or training is required for shops using this method.

Disadvantages:

- **Technical.** If the hydraulic pull method is not used correctly or a mechanical pull is used instead, core damage may result when core laminations are pulled apart.
- **Turnaround time.** Only one motor can be warmed or pulled at once. However, larger shops may be able to purchase multiple assemblies in order to process several motors at a time.

Methods of Stripping Motor Windings

BLOW TORCH WINDING REMOVAL METHOD

Fact Sheet
Draft of 2/18/97

*DROP
IN TOGETHER.*

Description: Using a propane-fired blow torch, insulation and varnish are burned out of the motor stator. The windings, varnish, and insulation are reduced to ash. *SOFTENED TO THE POINT WHERE THE WINDING CAN BE REMOVED EASY*

Cost: Negligible. Requires use of a blow torch which most shops already own.

Advantages:

- ▶ **Cost.** This method is the most common used in shops today, and as such requires no additional investment in training or equipment.
- ▶ **Speed.** This method requires only 0.5 to 1 hour to complete.

Disadvantages:

- ▶ **Technical.** Hand-held nature of the torch method causes uncontrolled and fluctuating temperature in motor core. High temperatures and direct contact between flame and stator can cause severe burning and damage to motor core, resulting in efficiency losses in the rewound motor.
- ▶ **Health.** Use of this method causes emission of toxic particles and gases hazardous to the human respiratory system. Extreme heat makes motors unsafe for handling.

APPENDIX F

LIST OF MANUFACTURERS AND SUPPLIERS

Manufacturers and suppliers of the following materials were contacted to determine the proper companies and subsidiaries that can provide materials to Ghana.

Companies were contacted to ascertain the sales of the following equipment to Ghana:

- Electrical Motors and Drives – a sample letter is shown in Fig. F-1;
- Magnet Wires – a sample letter is shown in Fig. F-2; and
- Electrical Insulation for Low-Voltage Motors – a sample letter is shown in Fig. F-3.

The letters sent to manufacturers and suppliers netted six responses. These responses and the associated literature sent are listed below:

- 1) GE International – See letter in Fig. F-4.
- 2) 3M International Business – See letter in Fig. F-5. From 3M were included catalogs of their complete line of electrical products. These catalogs are included with this report. The catalogs are:
 - 3M Electrical Products;
 - 3M Electrical, Electronic and Specialty Tapes;
 - Scotch™ Brand Polyester Film Tapes;
 - 3M Heat-Shrinkable Molded Shapes; and
 - 3M Scotchlok™ Terminals and Tools.
- 3) H. P. Reid Company, Inc. – See letter in Fig. F-6. From H. P. Reid we received the following catalog;
 - H.P. Reid Precision Engineered Wire.
- 4) Essex Group, Inc. – See letter in Fig. F-7.
 - Essex Magnet Wire Product and Application Data; and
 - Essex Magnet Wire Engineering Data.
- 5) Western Filament, Inc. – See letter in Fig. F-8. From Western Filament, we received the following catalogs:
 - Stator Lacing Tapes and Cords;
 - Expandable Sleeving Products; and
 - Western filament Distributor Pricing List.
- 6) MagneTek sent three electric motor and drive catalogs. They are:
 - MagneTek Commercial-Industrial Motor/Drive Catalog. Bulletin 943, Spring 1997;
 - MagneTek IEC and NEMA 3 Phase Induction Motors; and
 - MagneTek Replacement Motor Manual 497.

OAK RIDGE NATIONAL LABORATORY

MANAGED BY LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE U.S. DEPARTMENT OF ENERGY
JOHN S. HSU, PH.D., P.E.
BUILDING 9104-2, MS-8038
POST OFFICE BOX 2009
OAK RIDGE, TN 37831-8038

PHONE: (423) 241-5045
FAX: (423) 241-6124
EMAIL: hsujs@ornl.gov

April 30, 1998

Baldor
Attn: Sales Manager
P.O. Box 2400, Dept. TR
Fort Smith, Arizona 72902

Dear Sir or Madam:

Sales of Electric Motors and Drives in Ghana

Under a contract between the Oak Ridge National Laboratory and the Government of Ghana, Africa, I spent nearly three weeks in Ghana conducting feasibility studies for improving electric motor service centers. The hope among Ghanaian people toward the United States is genuinely high.

One important function that the motor service centers will have to do is promote the replacement of old drives with higher-efficiency motors or adjustable-speed drives. It seems that there is not a single sales representative of any American motor company available in Ghana.

Please let me know the answers to the following questions:

How would a dealer in Ghana buy electric motors and adjustable-speed drives from your company?
What are the terms of payment for your exported motors and adjustable-speed drives to Ghana? and
Is it possible for you to send me two sets of your electric motor and adjustable-speed drive catalogs
(the three-phase line voltage is 415 volts and the frequency is 50 Hz in Ghana)?

Thank you for your early reply to the questions.

Yours truly,

John S. Hsu

John S. Hsu

JSH:pja

Enclosure

c: D. Adams
M. Olszewski
File-NoRC

Figure F-1

ornl - *Bringing Science to Life*
F-2

OAK RIDGE NATIONAL LABORATORY

MANAGED BY LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE U.S. DEPARTMENT OF ENERGY
JOHN S. HSU, PH.D., P.E.
BUILDING 9104-2, MS-8038
POST OFFICE BOX 2009
OAK RIDGE, TN 37831-8038

PHONE: (423) 241-5045
FAX: (423) 241-6124
EMAIL: hsujs@ornl.gov

April 30, 1998

Westinghouse Electric Corporation
Attn: Sales Manager
Westinghouse Building
11 Stanwix Street
Pittsburgh, Pennsylvania 15222

Dear Sir or Madam:

Sales of Magnet Wires in Ghana

Under a contract between the Oak Ridge National Laboratory and the Government of Ghana, Africa, I spent nearly three weeks in Ghana conducting feasibility studies for improving electric motor service centers. The hope among Ghanaian people toward the United States is genuinely high.

One important need for the motor service centers in Ghana is to improve the accessibility of quality copper magnet wires at reasonable prices. It seems that there is not a single sales representative of any American magnet wire company available in Ghana.

Please let me know the answers to the following questions:

How can a dealer in Ghana buy magnet wires from your company?
What are the terms of payment for your exported magnet wires to Ghana? and
Is it possible for you to send me two sets of your magnet wire catalogs?

Thank you for your early reply to these questions.

Yours truly,

John S. Hsu

John S. Hsu

Enclosure

JSH:pja

c: D. Adams
M. Olszewski
File-NoRC

Figure F-2

ornl - *Bringing Science to Life*

OAK RIDGE NATIONAL LABORATORY

MANAGED BY LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
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JOHN S. HSU, Ph.D., P.E.
BUILDING 9104-2, MS-8038
POST OFFICE BOX 2009
OAK RIDGE, TN 37831-8038

PHONE: (423) 241-5045
FAX: (423) 241-6124
EMAIL: hsujs@ornl.gov

April 30, 1998

Acton Technologies, Inc.
Attn: Sales Manager
101 Thompson Street
Pittston, Pennsylvania 18640

Dear Sir or Madam:

Sales of Electric Insulation for Low-Voltage Motors in Ghana

Under a contract between the Oak Ridge National Laboratory and the Government of Ghana, Africa, I spent nearly three weeks in Ghana conducting feasibility studies for improving electric motor service centers. The hope among Ghanaian people toward the United States is genuinely high.

One important need for the motor service centers in Ghana is to improve the accessibility of quality electric insulation at reasonable prices. It seems that there is not a single sales representative of any American electric insulation company available in Ghana.

Please let me know the answers to the following questions:

- How can a dealer in Ghana buy electric insulation from your company?
- What are the terms of payment for your exported electric insulation to Ghana? and
- Is it possible for you to send me two sets of your electric insulation catalogs?

Thank you for your early reply to these questions.

Yours truly,

John S. Hsu

Enclosure

JSH:pja

c: D. Adams
M. Olszewski
File-NoRC

Figure F-3

ornl - *Bringing Science to Life*

FAX

To: OAK RIDGE NATIONAL LABORATORY **From:** SHERIF MARZOUK - GE CAIRO

Attn: MR. JOHN HSU

CC: MR. WAFIK RAMSEY

Fax: 423-241-6124

Date: June 1, 1998

Re: SALES OF ELECTRIC INSULATION FOR LOW VOLTAGE MOTORS IN GHANA

Dear Sir,

Thank you for your letter of April 30/98 addressed to GE Fairfield, Connecticut which I received on May 13/98. The following companies are manufacturing and selling motor insulation.

1) Essex Brownell	Tel: 800-774-4643	Fax: 219-461-4444
2) Ha Holden	Tel: 800-328-4662	Fax: 612-577-5550
3) Electrical Ins. Supply	Tel: 513-771-4073	

Kindly call one of these suppliers for the subject project in Ghana.

Thanks & Best Regards,

Sherif Marzouk
AREA SALES MANAGER
GE- CAIRO /dk
Tel: 202-305-5470 / 2
Fax: 202-305-9626

****NEW ADDRESS****

General Electric International Operations
Industrial Control Systems
TEL: 202-305-5470 or 72 / FAX: 202-305-9626
54 LEBANON STREET - 11TH FLOOR
MOHANDESEEN, CAIRO - EGYPT

Figure F-4

FAX

Date 5/19/98

Number of pages including cover sheet 1

TO: JOHN HSU
OAK RIDGE NATIONAL
LABORATORY

Phone 423/241-5045
Fax Phone 423/241-6124

FROM: KRISTINE OLESON
3M INTERNATIONAL BUSINESS
DEVELOPMENT
3M COMPANY
2860 BANKERS INDUSTRIAL DR
ATLANTA, GA 30360

Phone 770-242-2418 or 800/243-3636 x4
Fax Phone 770-242-2407 or 800/932-0274

CC:

REMARKS: ☐ Urgent ☐ For your review ☐ Reply ASAP ☐ Please Comment

MR. HSU,

IN RESPONSE TO YOUR PHONE MESSAGE, THE FOLLOWING IS THE CONTACT NAME AND COMPANY NAME FOR OUR DISTRIBUTOR OF ELECTRICAL PRODUCTS IN GHANA:

CONTACT: FIDEL JONAH
CITLAND INTERNATIONAL
DANKWA CIRCLE
OSU ACCRA GHANA

PHONE - 021-761185

MR. JONAH MOBILE PHONE - 024-345156

PLEASE CONTACT TREVOR KING OF CITLAND HERE IN THE UNITED STATES FIRST, HOWEVER, AS HE WOULD LIKE TO SPEAK WITH YOU CONCERNING QUANTITY AND OTHER ASPECTS OF YOUR REQUIREMENTS. MR. KING IS THE PRESIDENT OF CITLAND AND HIS OFFICE IS LOCATED IN ATLANTA, GA AND HE CAN BE REACHED AT 770/955-1655. HE OPENED THE GHANA DISTRIBUTORSHIP FOR 3M ELECTRICAL PRODUCTS AND HAS THE ABILITY TO STOCK INVENTORY OF 3M PRODUCTS IN GHANA SHOULD YOU SO DESIRE.

I AM SENDING YOU OUR COMPLETE LINE OF ELECTRICAL PRODUCTS (TWO SETS) PER YOUR REQUEST AND PLEASE DO NOT HESITATE TO CONTACT ME SHOULD YOU HAVE ANY QUESTIONS!!

BEST REGARDS,

KRISTINE

ENCLOSED 7

Kristine Oleson
Sales Representative

3M Export
2860 Bankers Industrial Drive
Atlanta, GA 30360-2764
770 242 2418
800 243 3636 Customer Service
800 932 0274 Facsimile

H.P. REID CO., INC.

a KANTHAL company

P.O. BOX 352440

PALM COAST, FL 32135-2440

(904) 445-2000 • FAX (904) 446-2244

SHIPPING: 1 INDUSTRY DRIVE

PALM COAST, FL 32137

May 5, 1998

Mr. J. S. Hsu
OAK RIDGE NATIONAL LABORATORY
P. O. Box 2009
Bldg. 9102-1, MS-8038
Oak Ridge, TN 37831

Ref: New HP Reid Catalog

Dear Mr. Hsu :

We are pleased to send you a copy of our new catalog that describes HP Reid's capabilities for manufacturing fine and ultrafine diameter precision wire. Also included in the catalog are convenient technical reference charts for NEMA Standards, Voice Coil wire, gold plated copper wire, bonding wire, and Resistance wire. We hope that you will find this reference information useful to you in your work.

We are also in the process of setting up a website (www.hpreid.com) with this same technical reference information. Targeted date for being on-line with the website is May 15, 1998.

HP Reid is proud of its 16-year history of assisting customers in advancing the state-of-the-art in their fields of technology. Now that HP Reid is part of the worldwide Sandvik group of Companies, we are better able to support our customers with leading edge research capabilities and investment in new production capabilities.

Please contact me to discuss how HP Reid can help on your next program which involves specialty custom wire.

Very Best Regards,

Rob Specht
Vice President Marketing

RS:cjc

Fine Wire . . . at its finest

ROBERT C. SPECHT
VICE PRESIDENT OF MARKETING

H.P. REID CO., INC.
1 COMMERCE BLVD. - P.O. BOX 352440
PALM COAST, FL 32135-2440
(904) 445-2000 • (800) 772-9473
FAX: (904) 446-2244
E-MAIL: Rob.Specht@HPReid.com

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Figure F-6

Fine Wire . . . at its finest.

F-7

May 5, 1998

Mr. John S. Hsu
Oak Ridge National Laboratory
Building 9104-2, MS-8038
Post Office Box 2009
Oak Ridge, TN 37831-8038

Dear John:

Thank you for your letter dated April 30th with your inquiry about magnet wire availability in Ghana. I am pleased to provide the following answers to your questions:

- 1) We currently do not have a sales representative or distributor to handle sales of magnet wire in Ghana. However, we do have an international sales person here in our corporate offices in Fort Wayne, Indiana who handles all international type inquiries. Her name is Ms. Dee Torrez. Her direct telephone number is 219/461-4444, and her fax number is 219/461-4531. All inquiries for magnet wire information, pricing, specifications, and other issues can be directed to Dee. We will handle all orders for Ghana from here. We would need the appropriate freight forwarder and containerization information prior to shipping.
- 2) The terms of payment for companies outside of the United States without a formal credit approval would be cash in advance or letter of credit from an authorized banking institution.
- 3) I am pleased to provide two copies of our Magnet Wire catalogs as well as two engineering handbooks on Magnet Wire. If you desire more of these, please let me know:

Thanks for your interest in Essex Magnet Wire, and we look forward to being of service to you and the companies in Ghana in the future.

Sincerely,
Essex Group, Inc.

Philip L. Gordon
Philip L. Gordon
Magnet Wire Marketing Mgr.

Cc: D. Torrez

Phone: 970-241-8780
FAX: 970-241-8682

western filament, inc.

630 HOLLINGSWORTH DRIVE • GRAND JUNCTION, COLORADO 81505

5/15/98

John S. Hsu
Oak Ridge National Laboratory
Building 9104-2, MS-8038
Post Office Box 2009
Oak Ridge, TN 37831-8038

Dear Mr. Hsu:

Thank you for your interest in our products. Most of our products we produce are for lacing and tying. We also sell expandable sleeveings. I am including two sets of brochures for your use. Please let me know if you have any questions regarding our products.

We would be willing to sell to you directly. Our terms would be check or bank transfer in advance. Again, I thank you for your interest and I look forward to serving you in the future.

Best Regards,

Charlotte Vecchia
Inside Sales

Figure F-8

APPENDIX G

MANUFACTURING ELECTRIC FANS IN GHANA

As mentioned earlier in this report, contact was made with numerous companies in the United States to assess any interest in regard to manufacturing electric motors in Ghana. An example of the letter sent is given in Fig. G-1. Only one response requesting additional information was received. This response is given in Fig. G-2.

OAK RIDGE NATIONAL LABORATORY

MANAGED BY LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE U.S. DEPARTMENT OF ENERGY
JOHN S. HSU, PH.D., P.E.
BUILDING 9104-2, MS-8038
POST OFFICE BOX 2009
OAK RIDGE, TN 37831-8038

PHONE: (423) 241-5045
FAX: (423) 241-6124
EMAIL: hsujs@ornl.gov

April 27, 1998

Action-Aire, Inc.
Attn: Managing Director
66 Grant Avenue
Carteret, New Jersey 07008

Dear Sir or Madam:

Manufacturing Electric Fans in Ghana

Under a contract between the Oak Ridge National Laboratory and the Government of Ghana, Africa, I spent nearly three weeks in Ghana conducting feasibility studies for improving their electric motor service centers. The hope among Ghanaian people toward the United States is genuinely high. Ghana is a relatively stable country, English is the official language, the minimum wage is less than one U.S. dollar a day, the estimated unemployment rate is above 30 percent, and public schools are tuition free up to the university level. Although Ghana has only 18 million people, it is a reasonably good business location for the African market. There are a lot of imported electric fans in the market but it seems that there is not a single ceiling fan and table fan manufacturer in Ghana.

My study concludes that there is a need for Ghana to start establishing a basic electric motor manufacturing industry. Because of the market potential, manufacturing electric fans may be the first step to meet this need. The Ghanaian Government is very keen on attracting foreign companies to invest in Ghana. Incentive tax breaks are part of the package.

Please let me know if you are interested in getting more information for establishing a manufacturing branch of electric fans in Ghana.

Yours truly,

John S. Hsu

JSH:pja

Enclosure

c: D. Adams
M. Olszewski
File-NoRC

Figure G-1

ornl - *Bringing Science to Life*

Action Aire, Inc.

66 Grant Avenue Carteret, NJ 07008

Tel: 732-541-4441 732-969-9494

Fax: 732-541-5121 732-969-3905

October 22, 1998

Oak Ridge National Laboratory
Building 9104-2, MS-8038
P/O Box 2009
Oak Ridge, Tn 37831-8038

Attn: John S. Hsu

Dear Mr. Hsu,

The correspondence (of April 27th) you sent us regarding Ghana arrived at my desk yesterday. Yes, we are interested in receiving additional information. Kindly mail to my attention.

Yours truly,

Allen E. Walters
Vice President

Figure G-2

APPENDIX H
EASA PACKAGE AND BROCHURES
AND
ADDITIONAL CONTACTS WITH EASA

Included is a large folder from EASA describing the organization, its functions as well as an application for membership. Note that EASA is the main organization in the US representing the electrical apparatus sales and repair industry.

Contact was made with EASA on behalf of Ghana via two letters dated April 29, 1998, and May 18, 1998. These are shown in Figs. H-1 and H-2, respectively. Specific request was made to make request the use of EASA training materials (especially EASA training films). EASA's reply is shown in Fig. H-3, indicating the availability of EASA materials to members only. A list of the EASA training films is provided in Fig. H-4.

OAK RIDGE NATIONAL LABORATORY

MANAGED BY LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE U.S. DEPARTMENT OF ENERGY
JOHN S. HSU, Ph.D., P.E.
BUILDING 9102-1, MS-8038
POST OFFICE BOX 2009
OAK RIDGE, TN 37831-8038

PHONE: (423) 241-5045
FAX: (423) 241-6124
EMAIL: hsujs@ornl.gov

April 29, 1998

Ms. Linda Raynes
Acting Executive Vice President
Electrical Apparatus Service Association, Inc.
1331 Baur Boulevard
St. Louis, Missouri 63132

Dear Ms. Raynes:

Electric Motor Service Centers in Ghana

Under a contract between the Oak Ridge National Laboratory and the Government of Ghana, Africa, I spent nearly three weeks in Ghana conducting feasibility studies for improving their electric motor service centers. The facility and equipment in their service centers are poor, there is no standard to follow for repair work, and the low revenue of service centers also prevents advancement. However, the hope among Ghanaian people toward the United States is genuinely high.

I have talked to Mr. David Gebhart and understand that the service centers in Ghana can join EASA as a member. Please let me know the answers to the following questions.

The current level of the service centers in Ghana is low; does EASA have a certification requirement? *No*
Is it all right for the Ghanaian Government to use EASA's training material and to certify those who pass the training and follow EASA's recommendations in actual service jobs? *Yes, if they are certified by EASA*
Is it possible to send me the catalogs of your training films and the technical instructions with their price lists? *Yes, if they are certified by EASA*
I also learned from Mr. Gebhart that EASA has a list of recommended facility and equipment for service centers. Is it possible to send me a copy of this list? *Yes*
I also would like to study the EASA/Mexico training program that was mentioned by Mr. Gebhart and see what may be applicable for Ghana. Is it possible to send me a copy of that program? *Yes*

Thank you for your early reply to these questions.

Yours truly,

John S. Hsu

JSH:pja

c: D. Adams
M. Olszewski
File-NoRC

Figure H-1

ornl - Bringing Science to Life

OAK RIDGE NATIONAL LABORATORY

MANAGED BY LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE U.S. DEPARTMENT OF ENERGY
JOHN S. HSU, PH.D., P.E.
BUILDING 9102-1, MS-8038
POST OFFICE BOX 2009
OAK RIDGE, TN 37831-8038

PHONE: (423) 241-5045
FAX: (423) 241-6124
EMAIL: hsujs@ornl.gov

May 18, 1998

Ms. Linda Raynes
Acting Executive Vice President
Electrical Apparatus Service Association, Inc.
1331 Baur Boulevard
St. Louis, Missouri 63132

Dear Ms. Raynes:

EASA training materials to be used in Ghana

Under a contract between the Oak Ridge National Laboratory and the Government of Ghana, Africa, I spent nearly three weeks in Ghana conducting feasibility studies for improving their electric motor service centers. The facility and equipment in the service centers of Ghana are poor. There is no standard to follow for repair work, and the low revenue of service centers also prevents the advancement of service centers in Ghana. However, the hope among Ghanaian people toward the United States and the industrialized countries is genuinely high. I was impressed about how hard the Ghanaian people have to work in order to improve their living standards. They need technical assistance.

I wondered whether you would grant permission to the Ghanaian Government to use EASA's training materials. The government may certify those who pass the training and follow EASA's recommendations in actual service jobs.

Thank you for your early reply to this inquiry. Should you need additional information, please don't hesitate to call.

Yours truly,

John S. Hsu

JSH:pja

c: D. Adams
M. Olszewski
File-NoRC

Figure H-2

ornl - *Bringing Science to Life*

ELECTRICAL APPARATUS SERVICE ASSOCIATION

INTERNATIONAL HEADQUARTERS: 1331 BAUR BOULEVARD • ST. LOUIS, MISSOURI 63132 • 314-993-2220 • FAX: 314-993-1269

Reliable Solutions Today!

Via Fax, Page 1 of 1
Fax #: 423-241-6124

October 21, 1998

Dr. John S. Hsu
Building 9102-1, MS-8038
Post Office Box 2009
Oak Ridge, TN 37831-8038

Dear Dr. Hsu:

I tried call you but have had no success yet. I thought I would send this fax and then attempt to contact you again. My sincere apologies for the tardiness in response to your inquiries; we thought that a letter had been sent to you immediately after the 1998 June convention in Orlando, but were not able to locate it. Apparently this is something that slipped through the cracks. Again, our apologies for the unfortunate oversight.

Your letter of May 18, 1998 was brought in front of the EASA Board of Directors at their June meeting. While there was much empathy for the Ghanaian people's need for technical expertise and after much discussion, the Board of Directors felt they could not violate EASA Association's bylaws regarding supplying EASA materials to nonmembers. The Board suggested that the government of Ghana apply for EASA's Allied membership, which would enable the government to receive all EASA materials at member prices.

A membership packet will be sent to you via mail. We hope that this is helpful.

Sincerely,

Anne Vogel
Executive Secretary

Figure H-3

EASA TRAINING FILMS

1. **Taking Winding Data From A Three-Phase Induction Motor.**
Teaches how to determine type of connection, number of parallel circuits, turns per coil, wire size, span and groups. Shows step-by-step way to properly record all information. (27:38)
2. **Disassembly Of A Three-Phase Induction Motor.**
Shows step-by-step disassembly of a TEFC motor with the proper tools to use, how to mark parts for proper reassembly, how to remove ball bearings from shaft. Details things not to do. Does not include stripping. (22:13)
3. **Machine Winding Three-Phase Random Wound Coils.**
Teaches procedures for winding diamond and round-nosed coils. Includes determining coil dimensions from a bare core and winding multiple groups at one time. (17:30)
4. **Winding A Three-Phase Stator.**
Teaches step-by-step proper insertion of three-phase winding. What tools and insulation to use, including proper positioning of center sticks, wedges, phase insulation and fillers. Points out improper methods of winding. (25:55)
5. **Assembly Of A Three-Phase Induction Motor.**
Step-by-step method of assembling the motor. Describes the tools used and those not used. Shows how to align parts as marked in disassembly, Includes Installation of ball bearings to the shaft. (19:50)
7. **Manufacturing Form Coils.**
Shows how to determine loop dimensions, winding the loop, insulating it and spreading the coils, along with determining the dimensions of the spread coil. (15:50, 11:10)
8. **Winding Stators With Formed Coils.**
Describes the procedures for inserting a formed coil into a stator. Shows proper tools and various wedging methods. Includes connecting the coils and insulating the connections. (20)
9. **Taking Data From A Single-Phase Stator.**
Shows step-by-step procedure for properly determining and recording the type of connection, number of parallel circuits, turns per coil, wire size, span and groups, and how to distinguish between running and starting windings. (16)
10. **Disassembly Of A Single-Phase Capacitor Motor.**
Step-by-step disassembly of a capacitor motor, both ball bearing and sleeve bearing. Includes bearing removal (both types), plus operation and replacement of various types of starting switches and governors. Stripping not included. (12:33)
11. **Winding Single-Phase Concentric Coils.**
Shows method of winding concentric coils, which includes determining the coil width for the various size coils within each group, how to set the concentric winding head and select the proper grooves for winding the coils. Also shows how to wind coils using the Holden Head (15
12. **Winding A Single-Phase Stator.**
Shows proper procedures for inserting concentric coils into a single-phase stator. Shows tools and insulations and points out relationship between running and starting winding coils (1

(Continues on reverse side.)

Figure H-4

H-5

13. **Assembly Of A Single-Phase Capacitor Motor.**
Step-by-step assembly of a capacitor motor including installation of both ball and sleeve bearings. Shows tools needed and how to align parts marked during disassembly. (13:30)
14. **Taking Data From A Hand-Wound D-C Armature.**
Describes the correct procedure for taking data from hand-wound d-c armatures. Shows how to record the data on typical d-c data sheets, and explains the terminology used describing d-c data. Points out differences between lap and wave windings. (16:50)
15. **Hand-Winding A D-C Armature.**
Provides step-by-step instructions on winding a d-c armature, including how to install end fibres and slot liners, how to wind and shape the armature coils and how to make the commutator connections. (20)
16. **Disassembly Of A D-C Machine.**
Shows step-by-step disassembly of a d-c motor and the tools to use. Demonstrates how to mark parts, and how to label and record connections for use in assembly. Also explains how to check for shorts or opens in field and armature windings, how to test run the motor, and how to inspect parts for damage and wear. (19)
17. **Assembling A D-C Machine.**
Step-by-step procedure for assembling a d-c motor. Includes field coil insertion, connection and polarity checks. Also shows how to install bearings, how to seat brushes and set the neutral position, how to check windings with a megohmmeter, and how to make connections. (17:50)
18. **Random-Winding D-C Field Coils.**
Illustrates procedures for manufacturing random-wound interpole and main field coils for d-c machines. Covers everything from removing old coils and taking data to installing and connecting new coils, including how to construct winding forms and jigs, how to shape coils to conform with the curvature of the field frame and how to insulate field coils. Both "wet" and "dry" winding techniques are illustrated. (19)
19. **Layer-Winding D-C Field Coils.**
Covers all necessary steps for layer winding d-c field coils, how to layer-wind a shunt field coil, how to reinsulate an interpole field coil, and how to install large field coils in the frame.
20. **Testing Three-Phase A-C Motors Rated 600 Volts Or Less.**
Outlines the basic steps and procedures commonly used for testing three-phase, a-c motors rated 600 volts or less, including preliminary insulation resistance, continuity and no-load tests, as well as the single-phase test for rotors. Also explains how to test components once the motor has been disassembled; these procedures include surge-comparison, polarization index, growler and d-c high-potential tests, as well as the "loop" test for stator cores. Additionally, examines performance of final insulation resistance, no-load, vibration and dynamometer tests on repaired or rewound motors. (22:50)
21. **Testing D-C Machines.**
Part 1 deals with "Initial Inspection & Preliminary Testing"; Part 2 concentrates on "Used Armature Windings"; and Part 3 covers "Cores, Commutators & Rewound Armatures." Parts 4 and 5 explain how to test "Field Windings" and how to perform "Final Tests." (46:50, 31:50)

889EA6C

Electrical Apparatus Service Association, Inc.

1331 Baur Blvd. • St. Louis, MO 63132 • (314) 993-2220

Figure H-4 (cont'd)

APPENDIX I
INFORMATION ON NVLAP
AND
IEEE STANDARD 112

Information is presented on the NVLAP Program in the US. The Department of Commerce, through NIST administers NVLAP. NVLAP programs are established for public and private calibration and testing laboratories including commercial laboratories, manufacturers' in-house laboratories, and federal, state, and local government laboratories. NVLAP accreditation is based on the evaluation of a laboratory's technical qualifications and competence for conducting specific test methods, measurements, and services in specified fields of calibration or testing. It is granted only after a thorough evaluation of the applicant has demonstrated that all NVLAP criteria have been met. A 1996 NIST memorandum on NVLAP is included in Fig. I-1. Additional information on NVLAP can be found in NIST Handbook 150, *Procedures and General Requirements* and NIST Handbook 150-10, *Efficiency of Electric Motors*. Both documents are available for sale through the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402-9325. The front covers of both publications are shown in Figs. I-2 and I-3, respectively.

The front cover of IEEE Standard 112 is shown in Fig. I-4. This report, entitled *IEEE Standard Test Procedure for Polyphase Induction Motors and Generators* was issued in 1996. A correction sheet for this report was issued on January 20, 1998. Copies of this document and other IEEE standards can be purchased. International callers can inquire by calling 1-908-981-0600. To order by fax, call 1-908-981-9667. IEEE standards information can be accessed via the World Wide Web at: <http://standards.ieee.org/>.

January 22, 1996

MEMORANDUM for NVLAP customer laboratories and potential customers

From James L. Cigler, Chief
Laboratory Accreditation Program

Subject: Use of Accredited Calibration Laboratories To Achieve Traceability of Measurements

NVLAP is instituting a policy to bring traceability of measurements into line with international practices and to require that testing and calibration laboratories obtain traceability of measurements either directly from a national laboratory or through other accredited calibration laboratories. This will facilitate and promote broad acceptance of valid calibration and test results and thereby avoid barriers to trade. Use of accredited calibration laboratories is an integral component of mutual recognition agreements.

The National Institute of Standards and Technology administers the National Voluntary Laboratory Accreditation Program (NVLAP) under regulations found in Part 285 of Title 15 of the U.S. Code of Federal Regulations. These regulations are implemented in NIST Handbook 150. NVLAP accreditation is available to commercial calibration and test laboratories, manufacturers' in-house laboratories, university laboratories, and federal, state and local government laboratories. Laboratories located outside the United States may also be accredited if they meet the same requirements as domestic laboratories, with additional specified fees and requirements regarding language and export licenses.

NVLAP offers a series of laboratory accreditation programs (LAPS) which are established on the basis of requests and demonstrated need. Each LAP includes specific calibration fields and associated parameters and/or test standards and related methods and protocols assembled to satisfy the unique needs for accreditation in a field of calibration and/or testing. NVLAP is currently negotiating with the European Cooperation for Accreditation of Laboratories (EAL), Australia, New Zealand, Hong Kong, Canada, Mexico, and India for mutual recognition agreements. These agreements will recognize equivalency of the laboratory accreditation programs of these countries based on implementation of ISO/IEC Guide 25 (or equivalent) in the accreditation of testing and calibration laboratories, and compliance with the requirements of ISO/IEC Guide 58 (or equivalent) as accrediting bodies.

Reliable and accurate testing depends critically on the use of appropriate laboratory instruments that are accurately calibrated. The dependability of calibration relies on measurement traceability to national laboratories (NIST in the United States); this must be demonstrated through calibration by the national laboratory itself or by a calibration laboratory whose traceability to the national laboratory has been validated through an accreditation process. Successful completion of this chain of events can lead to consummation of mutual recognition agreements with other countries. It will be NVLAP's accreditation policy to require this sequence of traceability.

All calibration and testing laboratories desiring to be accredited by NVLAP after December 1, 1996, must demonstrate compliance with these traceability requirements. All calibration and testing laboratories currently accredited by NVLAP must demonstrate compliance with these traceability requirements by the end of December 1997.

This policy will be reflected in the next revision of NIST Handbook 150, *NVLAP Procedures and General Requirements*, dated March 1994. All comments and/or questions related to the implementation of this policy should be addressed to: Chief, National Voluntary Laboratory Accreditation Program, National Institute of Standards and Technology, Building 820, Room 282, Gaithersburg, MD 20899, telephone number (301) 975-4016, fax number (301) 926-2884.

NIST HANDBOOK 150

**National
Voluntary
Laboratory
Accreditation
Program**

**Procedures
and
General
Requirements**

James L. Cigler and Vanda R. White, Editors

March 1994

U.S. Department of Commerce
Ronald H. Brown, Secretary

Technology Administration
Mary L. Good, Under Secretary for Technology

National Institute of Standards and Technology
Arati Prabhakar, Director

Figure I-2

**National
Voluntary
Laboratory
Accreditation
Program**

**Efficiency
of
Electric
Motors**

Lawrence S. Galowin, NIST
Walter J. Rossiter, Jr., NIST
Wiley A. Hall, Retired, NIST

August 1995

U.S. Department of Commerce
Ronald H. Brown, Secretary

Technology Administration
Mary L. Good, Under Secretary for Technology

National Institute of Standards and Technology
Arati Prabhakar, Director

Figure I-3

IEEE Standard Test Procedure for Polyphase Induction Motors and Generators

Circuits and Devices

Communications Technology

Computer

*Electromagnetics and
Radiation*

IEEE Power Engineering Society

Sponsored by the
IEEE Electric Machines Committee

Industrial Applications

*Instrumentation
and Measurement*

*Power Systems
and Energy*

IEEE Std 112-1996

Published by the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, NY 10017, USA.

8 May 1997

SH94503

Figure I-4

I-6

APPENDIX J

ELECTRIC MACHINERY SYSTEMS TEST CENTER AND ROTOR BALANCING FACILITY AT THE OAK RIDGE NATIONAL LABORATORY

The Electric Machinery Systems Test Center is an NVLAP-accredited motor testing facility located in Building 9104-1 at ORNL. This facility is capable of measuring the efficiency of electrical motors ranging from fractional horsepower up to 500 hp. The NVLAP *Certificate of Accreditation* is shown in Fig. J-1. Two of the stands in use are shown in Figure J-2. The one in the foreground uses an AC generator to place a load on the motor and an in-line torque cell to measure the torque output of the motor. It is capable of testing motors in the range of fractional horsepower to 10 hp. Here, the motor being tested is on the left and the AC generator is on the right. The in-line torque cell is in the cage between the motor and generator. The test stand that uses a water-cooled eddy current dynamometer is shown in the background. In Fig. J-3, that stand is more clearly seen. The motor to be tested would be located in the empty space on the left while the dynamometer is on the right. This stand is capable of testing motors of up to 100 hp. In Fig. J-4, a motor testing stand that also utilizes a water-cooled eddy current dynamometer is shown. This facility is capable of testing motors up to 500 hp in size. Here, the motor is on the right and the dynamometer brake is on the left. Another view of this facility is shown in Fig. J-5. The torque cell on the 500 hp test stand is shown in Fig. J-6. The two tanks, that supply cooling water to the three stands, are shown in Fig. J-7.

The control room for the motor test facility is shown in Fig. J-8. At the heart of the control room is the PC-based data acquisition system shown in Fig. J-9. Here, signals from the various stands are displayed, stored, and analyzed. The commercially available software package, LabVIEW™, is used as illustrated in Fig. J-10. A screen representing how data can be displayed in numerical or graphical form using a LABVIEW™ program developed at ORNL is shown in Fig. J-11. The Electric Machinery Systems Test Center Rules of Operation, shown in Fig. J-12, are displayed in the control room.

The three-phase Variac voltage control center is shown in Figs. J-13–J-15. Here, the voltages to each of the three phases of the motor being tested can be set. The microprocessor voltage controller is seen in Fig. J-14 while the Variacs themselves are better shown in Fig. J-15. The resistance divider box, shown in Fig. J-16, is part of the equipment used to measure phase-to-phase and phase-to-neutral voltages. Voltage readouts are displayed as shown in Fig. J-17. Readout devices, such as the Clarke-Hess Phase Meter shown in Fig. J-18, are used to record the phase angle difference between the current waveform and the waveform obtained from a current transformer (CT) in order to obtain data for transducer calibration. In determining total power, the phase angle (or power factor) is used as required by the derivation. Three hall sensors, one for each phase, are shown in Fig. J-19. They are used to measure the current and are generally more accurate than most conventional CTs. The clamp-on CTs, shown in Fig. J-20, are rated for 1000 amps and are used for non-intrusive current measurements for each of the three phases.

Other measuring devices in use are shown on Fig. J-21. The device on the left is a digital readout of the temperature from different types of thermocouples. The temperature readout device on the right is an infrared temperature-measuring device. Accelerometers used to measure the vibration level of a motor in operation are shown in Fig. J-22. The accelerometers are mounted on a motor as illustrated in Fig. J-23. The instrument in Fig. J-24 is a strobe light for measuring motor RPM. The instrument in Fig. J-25 is Fluke 41B Power Harmonics Analyzer. It can measure the power, current, voltage, and phase angle. In addition, it can record the harmonic content of the current and voltage signal for later off-line analysis.

In addition to the Electric Machinery Systems Test Center in Building 9104-1, there exists a Rotor Balancing Facility in Building 2018. This facility dynamically balances motor rotors as illustrated in the following photographs. Figure J-26 is an overall view of the balancing facility. In Fig. J-27, a rotor is being prepared for balancing. Here, a drive belt is attached to the rotor causing it to spin at speeds of from 600 to 900 rpm. The drive motor used to spin the rotor being balanced is shown in the lower right hand part of Fig. J-28. The amount of imbalance is recorded on the instrumentation shown in Figs. J-29 and J-30. During a balancing test, the drive end is first balanced, then the opposite end. This equipment can detect small vibrations, enabling rotors to be balanced to within a $\frac{3}{4}$ mil displacement.

Figure J-1
NVLAP Certificate of Accreditation

Figure J-2
Two Motor Test Stands
Foreground - Up to 10 HP
Background - Up to 100 HP

Figure J-3
Motor Test Stand with Water Cooled Eddy Dynamometer -
Up to 100 HP

Figure J-4
Motor Test Stand with Water Cooled Eddy Dynamometer -
Up to 500 HP

Figure J-5
Another View of Motor Test Stand with Water Cooled Eddy Dynamometer -
Up to 100 HP

Figure J-6
Torque Cell on the 500 HP Test Stand

Figure J-7
Two Storage Tanks For Cooling Water Supply

Figure J-8
Control Room for Electric Machinery Systems Test Center

Figure J-9
Data Acquisition System for Test Center

Figure J-10
Opening Screen for LabVIEW™

Figure J-11
Graphical and Numerical Display of Data on PC Screen

**Electric Machinery Systems Test Center
Rules of Operation
9/12/95**

1. No person shall close a circuit breaker or energize a motor unless they have read and understand all the signs posted in the control room (Rules, Qualified Persons, and Motor On - Off Checklist) and have been briefed on the operation of the facility by the Center Manager and have their name on the list of individuals qualified to operate the Center.
2. After any modification to the facility involving 120 volts or higher, the Center Manager will review the installation before the facility is considered operational and re-energized. This review will be noted in the Center log. All work at 120 volts and higher will be done by an electrician unless the work only consists of plugging in a cable.
3. All 120 and higher voltage connections will be made in grounded boxes or in the grounded aluminum cage. Before the aluminum cage is opened, the circuit breaker feeding the cage will be opened and the feeder will be disconnected.
4. Only low voltage wiring will exit the aluminum cage and connect to the bench instrumentation.
5. The resistor cabinets are to be kept locked during operation. The keys to the cabinets are hanging on the wall.
6. Two individuals are required for work involving any electrical changes to the facility. Any facility configuration changes must be initiated or approved by the Center Manager. Whenever a motor is running, at least one qualified person shall be at the facility, or the motor shall be roped off and signs posted.
7. Whenever an unusual condition occurs during a test, the motor shall be stopped and the test shall be interrupted. The following are examples of unusual conditions: Tour Groups walking up to the motor baseplate, grounds on the 480 Volt distribution system, water on the floor.
8. Please use patience and caution in the operation of the facility. Safety is everyone's responsibility.

**Figure J-12
Electric Machinery Systems Test Center
Rules of Operation**

Figure J-13
Three-Phase Variac Voltage Control Center

Figure J-14
Microprocessor Controller For Voltage Control Center

Figure J-15
Variacs Used in Voltage Control Center

Figure J-16
Box Resistance Dividers for Measuring Voltages

Figure J-17
Voltage Readout Device

Figure J-18
Clark-Hess Phase Meter

Figure J-19
Hall Sensors

Figure J-20
Clamp-On Ammeters

Figure J-21
Temperature Measuring Devices

Figure J-22
Accelerometers

Figure J-23
Accelerometers Mounted on a Motor

Figure J-24
Strobe Light

Figure J-25
Fluke Power Harmonics Analyzer

Figure J-26
Overall View of Balancing Facility

Figure J-27
Rotor Being Prepared For Balancing

Figure J-28
Rotor Balancing Facility and Drive Motor

Figure J-29
Instrument Panel for Rotor Balancing Facility

Figure J-30
Close-up of Display Panel for Rotor Balancing Facility

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2. E. C. Fox
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6. P. A. Jallouk
7. Mr. I. K. Mintah, Acting Executive Director, Technical Wing, Ministry of Mines and Energy, Post Office Box T40, Accra, Ghana
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58. M. Olszewski
59. Dr. Peter Salmon-Cox, Office of Industrial Technologies, 1000 Independence Avenue, FORS, EE-20, Mail Stop 6B-025, Rm. 5F-065, Washington, D.C. 20585
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