

Action Plan for DOE

Improve Performance of Electrical Safety at Fermilab

Report of the IPES4 *Ad Hoc* Committee

January 18, 2005

Task IPES4 DEVELOP A PROGRAM FOR CREATING ACCESSIBLE SINGLE LINE DRAWINGS FOR THE AC POWER DISTRIBUTION SYSTEM

The IPES4 *Ad Hoc* Committee

At the September 15, 2004 meeting of the Electrical Safety Subcommittee (ESS), Chair Stan Orr appointed Jim Garvey to serve as Chair of the IPES4 *Ad Hoc* Committee to consider and make recommendations for a program to create single line drawings for the AC Power Distribution System at Fermilab. Jim is a former ESS Chair and has been a long standing and active member of the Subcommittee. Thereupon Jim asked and received agreement of Bob Ducar (AD), Al Flowers (FESS), Mike Nunez (FESS) and Joe Pathiyil (FESS) to assist in the work of the Committee. Bob, also a former ESS Chair, and Joe are also current members of the ESS. The initial charge to the Committee is formed in the original statement of the Action Plan submitted to and accepted by DOE and is repeated here for completeness.

Single line drawings for the Fermilab High Voltage Distribution System that generally involve services outside of Laboratory structures are current and well maintained. The lack of availability of accurate and up-to-date single line electrical drawings for interior AC Power Distribution Systems (generally operating at 480 VAC or lower) has long been bantered about in the Electrical Safety Subcommittee. Such drawings generally exist but exhibit varying degrees of completeness and format. Said drawings are not centrally available. Efficient methods of updating these drawings have not been established. Maintenance and modification activities are compromised. Calculation of available fault current at points within the distribution system is also compromised with the implication not being able to properly specify adequate interrupting current of equipment or of necessitating less than sensible requirements for arc flash hazard as proscribed by NFPA 70E. Circuit breaker coordination would be more readily facilitated with proper drawing availability.

The Electrical Safety Subcommittee Chair shall establish an *Ad Hoc* Committee for purposes of proposing methods and means of establishing the above described program. The Committee shall also prepare a model single line drawing from a recent new construction activity so as to capture essential

elements of the desired drawings. Areas that should be considered here include recently constructed MI-31, MI-65 and/or MINOS Service Buildings. It is expected that generation of the sample single line drawings will be assisted by FESS Engineering Drafting support personnel. The Committee shall provide the ESS with a written report of its proposals together with one or more developed single line drawings for review.

The Committee has met on three occasions to form related findings and recommendations for consideration by the ESS. The results of those deliberations and the work of individual members of the Committee are presented herewith.

Related Findings and Recommendations

The Committee is in unanimous agreement with the statements of the first paragraph of the Committee's charge. The consistent efforts of the FESS Engineering and Infrastructure Management Groups in maintaining accurate single line drawings for the Fermilab High Voltage Distribution System is recognized with due credit to Joe Pathiyil and Al Flowers. Discussions of the need for accurate and up-to-date single line electrical drawings for interior AC Power Distribution Systems operating at voltages of 480 VAC and lower resonated strongly amongst members of the Committee. While not completely mentioned in the charge, the availability of proper drawings has important safety aspects. These include accommodating safe maintenance, safe working conditions and safe operation of the electrical plant. There was full agreement that ready availability of proper drawings also leads to increased efficiencies for both system component repair and planned system modifications. These potential efficiencies are thought to be quite real at various levels within the Laboratory. These include increasing reliability and minimizing downtime for the accelerator and experimental plant, facilitating timely repair by both FESS Operations personnel and Division/Section Electrical Coordinators, and reduction of design time required for modifications to or significant expansions to AC power systems by D/S Electrical Coordinators, FESS Engineering, or outside A&E firms performing work for the Laboratory. Though difficult to quantify, these efficiencies lead to real cost savings and increased plant availability.

The Committee also cautions that the current situation with regard to single line drawings is not as bleak as one might be led to believe. The efforts of the various D/S Electrical Coordinators have generally provided a very good base of drawings. Indeed, these Coordinators are charged (ref. FESHM Chapter 5042) to generate and maintain, with the assistance of FESS Engineering, up-to-date single line electrical drawings of the AC Electrical Power Distribution System in their area of jurisdiction. Nonetheless, these efforts are hobbled by the various Divisions and Sections of the Laboratory's organizational structure and are accordingly realized with a variety of style. As stated or implied, there is presently a lack of completeness, consistency, availability and unifying oversight that a proposed Program would serve to remedy.

With all of this said, the Committee views the establishment of a Program to create accessible single line electrical drawings (SLEDs) of the Laboratory's AC Power Distribution System as an essential activity to be undertaken. Existing efforts have been successful to a degree, but not to the extent desired.

The Committee recommends that the SLED Program be based in FESS and specifically in the Infrastructure Management Group (IMG). In coming to this conclusion, several factors combined to indicate FESS as the natural choice. Electrical designs for new facilities, such as NuMI and MI-31, have been specified through the services of FESS Engineering - often in collaboration with outside A&E firms. Associated as-built drawings are captured in the FESS documentation system. FESS Operations is closely involved with the maintenance and repair of installed electrical plant and supporting non-technical utilization equipment. FESS services are clearly established as site-wide. FESS has also demonstrated a high level of computer CAD proficiency that is viewed as essential for the drafting of SLEDs. FESS has mastered WEB based mechanisms for the posting of useful information for site-wide utility. The IMG is believed to be closely involved with this effort. Finally, AC Electrical Power Distribution Systems are generally viewed as "infrastructure". These factors sum to a capability that is truly unique to the existing Laboratory organizational structure and well matched to the Committee's recommendation.

The Committee emphasizes that the SLED Program be "based" in FESS. By this statement the Committee does not imply FESS to be solely responsible for the Program. Rather, the Committee intends that FESS provides primary oversight and coordination of a truly collaborative effort between FESS and D/S Electrical Coordinators. It is fully acknowledged that the various Divisions and Sections, as landlords of buildings on site, are responsible for the interior AC Power Distribution Systems of those Buildings and for the maintaining of current drawings. Modifications to these systems have often been executed independently of FESS by the landlords to accommodate day-to-day and programmatic needs. It is recognized that landlord-building assignments can change over time and that associated documentation is not always passed on. The proposed Program is not intended to fundamentally change this order, but rather enhance it for greater benefit. Though the proposed Program is based in FESS, the responsibility for making sure that the generated drawings are accurate and complete rests solely with the D/S Electrical Coordinators.

Implementation of the SLED Program is thought to be relatively straight forward. D/S Electrical Coordinators determine a particular building or area to be documented. Current SLED information is forwarded by the Coordinator to FESS for drafting to the desired format. The SLED information may be forwarded in a variety of formats ranging from computer files to sketches. FESS may be involved in searching archived construction files if current SLED information is lacking in whole or part. Once drafted, the SLED drawing is made available to the Coordinator for checking. When this likely iterative process is complete, the finished SLED drawing is posted in PDF format on the WEB and a paper copy is provided to the Coordinator. The Committee hopes this process can be implemented with a minimum of bureaucratic and paperwork overhead. The Committee is reluctant to draft a detailed Program Plan, rather suggesting that the above loosely outlined procedure be first given a chance to work. Details of execution are best developed by those actually doing the work with modest input from management and also from the ESS as necessary.

Drafting of SLEDs by Division/Section electrical drafting resources is not precluded. When so done, it is essential that developed drawings use either the same or acceptably

compatible CAD software that FESS uses. Drawing format and symbology should follow that employed by FESS and that which is recommended in part by this Committee. However generated, FESS is to remain as the "owner" of developed SLED drawings and is fully authorized to make necessary changes to such submissions to achieve the desired level of consistency. As previous stated and for emphasis, D/S Electrical Coordinators are responsible for seeing that the generated drawings are accurate and current.

Committee member Al Flowers has generated a sample generic SLED for consideration and review by the Committee and the ESS. It is included with this report. The Committee fully realizes that the availability of single line electrical drawings is a first and absolutely necessary step of determining available fault currents for as-built distribution systems. While a SLED is essentially a block diagram of transformers, switches and panelboards, the Committee is also requiring depiction of motor loads of 100 horsepower or more or the parallel equivalent because of their potential contribution as generators to system fault currents.

As evidenced by the sample drawing, a number of conventions are suggested. The most important is a vertical orientation of system components in accord with voltage, with higher voltage equipment at the top of the drawing. An intended attribute of the drawing is to convey pictorially the various levels of available fault currents. With this in mind, a proper reading of the SLED conveys qualitative safety information for personnel performing electrical work activities on the described system. The highest level of the drawing may indicate the source of power and associated switchgear. Typically this is equipment external to a building, providing 480 VAC three phase power. The next level should solely indicate the primary panelboard(s) from which all interior equipment is fed. This level is followed by depiction of 480 VAC panelboards or motor control centers fed from the primary panelboard, motor loads of 100 horsepower or more, and possibly the major pieces of building or technical utilization equipment. Next is a level that depicts 480 to 120/208 VAC transformers. The last level is for 120/208 VAC panelboards. Many systems are geographically distributed, as exemplified in the MI-65 drawing with equipment at ground level, at the mezzanine and underground. Such major areas should be distinguished by dashed lines. Panelboards with panel main breakers or power meters should be so indicated. Documentation of individual panelboard schedules is not in the scope of this effort. Responsibility for these schedules remains with the D/S Electrical Coordinators.

As mentioned, the creation of the single line drawing is a first step that affords determination of available fault currents. Additional information required for such determinations includes conductor quantities and sizes, lengths of installed conductors, types of circuit breakers at selected locations, conduit types and sizes, and transformer impedances. While this information could potentially be included in the SLED, the Committee suggests this information be carried in layers to the primary SLED drawing. If available, this information should be provided either by the Coordinator or from FESS archives. However, unavailability of such information should not impair creation of the primary SLED drawing. As earlier mentioned, this whole process is expected to be iterative.

For the proposed Program to be successful, D/S management must be involved. The roles and responsibilities of the D/S Electrical Coordinators must be made clear and supported as necessary. The Committee suggests that there be a single Electrical Coordinator named from each Division and Section to serve as a point of contact for the purposes of the proposed Program. (Certain Divisions presently have more than one Electrical Coordinators.) That Coordinator must be advised of and authorize modifications to the AC Power Distribution Systems within his or her jurisdiction. The Committee also suggests naming of an Electrical Coordinator for each major construction project so that new facilities are delivered with accurate as-built SLEDs.

The Committee fully realizes that the proposed Program will require resources. Preferably these resources are existing and re-directed rather than new. The Committee very much appreciates the difficulty of supporting the proposed Program at a time when Laboratory personnel are being asked to do more with less. FESS is viewed as especially hard pressed to provide immediate oversight of this electrical activity. The yet to be presented recommendations of the IPES3 *Ad Hoc* Committee may serve to help resource issues if implemented. There is a lot of up-front effort, especially in drafting. In particular, electrical drafting resources will be required here. The Committee does not impose a deadline for the work at hand because the work will be on-going. As the Program is started, progress should be monitored to assure that assigned resources are adequate. The Committee suggests that member Al Flowers is exceptionally well credentialed and positioned in the FESS IMG to guide the proposed Program to a good start. As a first step, the Committee suggests that he develop a SLED drawing for the newly constructed MI-65 facility.

Finally, the Committee recommends that the FESS IMG efforts be in-house funded by FESS rather than invoke a charge-back to the various Divisions and Sections. Allowing charge backs will end up killing this initiative in its infancy. FESS buy-in to the proposed Program is vital and is hoped to be forthcoming given the benefits of efficiency to FESS and the Laboratory as a whole.

In summary and in accord with the above, the IPES4 *Ad Hoc* Committee presents the following specific actions and assignments to the Electrical Safety Subcommittee for due consideration. The Committee will continue to work with the ESS in formulating a final document for transmittal to the Associate Director for Operations for consideration, approval and assignment.

1. The Associate Director for Operations shall, upon due consideration and consultation with both the Electrical Safety Subcommittee and FESS management, endorse the proposed Program to provide accurate, consistent and readily accessible single line electrical drawings for the whole of the Laboratory's AC Electrical Power Distribution System so as to support safe maintenance, safe working conditions and safe operation and modification of the electrical plant.. If the proposed Program is not acceptable as presented, the Associate Director for Operations shall delineate unacceptable aspects of the proposed Program and charge and work with the ESS to further develop a proposed Program that is acceptable. Assignment: Associate Director for Operations.

2. The Associate Director for Operations shall consult with and direct FESS management to support the proposed Program as outlined in this document or as subsequently modified. Assignment: Associate Director for Operations.
3. The IPES4 *Ad Hoc* Committee shall continue to develop a sample single line electrical drawing for the MI-65 Service Building AC Power Distribution System. This drawing will serve as a model for subsequent SLEDs in terms of layout and symbology. Assignment: IPES4 *Ad Hoc* Committee.
4. At the instruction of the Associate Director for Operations, Division/Section Heads shall affirm the role of their Electrical Coordinator(s) as outlined in FESHM Chapter 5042 and shall designate a single Coordinator to serve as the primary contact with FESS so as to realize the proposed Program. Assignment: Associate Director for Operations and Division/Section Heads.
5. At the instruction of the Associate Director for Operations, Division/Section Heads shall assure that their Electrical Coordinator(s) be knowledgeable of any modifications to AC Electrical Power Distribution Systems under their jurisdiction. Assignment: Associate Director for Operations and Division/Section Heads.
6. The Associate Director for Operations shall direct that a competent Electrical Coordinator be named for each major construction project at the Laboratory. Establishment of this directive may require modification of attendant ES&H and/or FESS policies. Assignment: Associate Director for Operations and possibly ES&H Section and/or FESS.
7. The Chair of the Electrical Safety Subcommittee shall report periodically to the Laboratory Safety Committee as to the current status and progress of the realized SLED Program. Assignment: Electrical Safety Subcommittee Chair.