ORDER

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

6950.27

10/3/94

Including CHG 1
Dated 1/23/03

SUBJ: SHORT CIRCUIT ANALYSIS AND PROTECTIVE DEVICE COORDINATION STUDY

1. PURPOSE. This order directs the accomplishment of short circuit analysis and protective device coordination studies for facility power systems. These power engineering studies are necessary to minimize unscheduled facility outages caused by unanticipated operation of protective devices. Failure of improperly applied power protective devices are a safety hazard to installation and maintenance personnel. Application of uncoordinated protective devices also degrades the reliability and availability of facility power systems.

2. DISTRIBUTION. This order is distributed to division level within the Program Manager for Advanced Automation, Program Directors for Automation, Communication and Aircraft Acquisition, Navigation and Landing, Surveillance, Weather and Flight Service Systems, NAS Operations, Operational Support, Requirements and Life-Cycle Management, NAS Transition and Implementation, and Facility System Engineering Service; to office level at the Aeronautical Center; to the division level in Engineering, Test, and Evaluation Service at the FAA Technical Center; to the division level in the regional Airway Facilities divisions; and to all Airway Facilities field offices with standard distribution.

3. BACKGROUND. The National Electrical Code, 240-12, Fine Print Note (FPN) states in part: "Coordination is defined as properly localizing a fault condition to restrict outages to equipment affected, accomplished by choice of selective fault protective devices." The lack of a proper short circuit and coordination study can place a facility in serious risk of a major shutdown. This has been illustrated by a major facility/service interruption that occurred at a level V airport traffic control tower/terminal radar approach control facility (ATCT/TRACON). This interruption occurred during the installation of electronic equipment connected to the critical electrical power distribution system. The equipment involved had a factory wiring error. When energized, it caused a series of events resulting in the tripping of several circuit breakers, including the main protection of the critical power system. If these devices had been properly coordinated, only the equipment's branch circuit protective device would have opened. This outage had a major impact on the air traffic control system due to the loss of the entire terminal control area.

4. IMPLEMENTATION.

a. A short circuit analysis and protective device coordination study of the facility power distribution system shall be accomplished in accordance with the National Electrical Code and FAA standard, FAA-STD-032, Design Standards for

Distribution: A-W(AP/NA/NC/NN/NR/NW/OP/OS/LM/NS/FE)-2; A-Y-2; A-Z(CN)-2; A-X(AF)-3; A-FAF-0(STD)

Initiated By: ~~ANS-500~~ AOS-100

National Airspace System Physical Facilities, prior to construction of new facilities or major equipment additions or modifications to existing facilities. This shall be accomplished:

(1) As part of the initial design package.

(2) Whenever existing facilities are undergoing major modifications to the facility power system (i.e., installation of uninterruptible power supply (UPS), installation or replacement of engine-generator, refurbishment of facility power distribution system, replacement of service transformer, etc.)

(3) Whenever major electronic/electrical equipment installations are accomplished.

b. These studies should be accomplished on existing facilities not meeting the criterion above as resources permit. The goal is to have a power distribution system serving National Airspace System (NAS) facilities that is properly rated and will provide selective fault isolation.

5. RESPONSIBILITIES.

a. All Project Implementation Plans (PIP) shall incorporate the requirement to perform a short circuit and coordination study. Accomplishment of this requirement will be a joint responsibility of the regional facilities and equipment (F&E) staffs and appropriate program offices. The Engineering and Environmental Safety Division, ANS-500, will have oversight responsibility on this effort.

b. Only qualified engineers shall do a short circuit and coordination study of the power distribution system they design as part of their service. The study shall be used as the basis for specifying the rating and selecting the type of protective devices. To ensure that this requirement is met, the statement of work (SOW) shall include a power system study. A recommended SOW for this purpose is included in Appendix 1, Recommended Statement of Work for Power System Study.

c. Deficiencies identified as a result of the study on existing facilities will be corrected under the project being designed. If they are of such magnitude that implementation of necessary corrective measures can not be funded, they will become the basis of future facility upgrades under CIP 46-07, Power Systems Sustained Support.

6. DELIVERABLES. The study shall be a part of the design data summary handbook in accordance with FAA-STD-032. A copy of the study will be provided to the installation contractor. If changes or deviations from the approved design are made, the installation contractor shall revise affected portions of the study to reflect those changes or deviations. Installation contract specifications shall require the contractor to prepare and submit those revised portions of the study. Additionally, the contract specifications shall require the contractor to submit, as a minimum, one hard copy and one computer diskette (soft copy) in the current FAA-approved format.

7. SUBSYSTEMS AND EQUIPMENT. Protective devices within the equipment or subsystems and the interface to the facility power distribution system shall also be coordinated. This requirement is incorporated in the last edition of Specification FAA-G-2100, General Specification for Ground Based Electronic Equipment. This requirement shall be accomplished by appropriate program offices and coordinated with regional engineers.

8. BASELINED DOCUMENTATION. The study shall become a part of Section IV of the Facility Reference Data File (FRDF). If the power distribution system is changed in any way the baselined study shall be updated. This includes any branch or feeder breaker replacement.

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Director, NAS Transition and
Implementation

APPENDIX 1. RECOMMENDED STATEMENT OF WORK (SOW) POWER SYSTEM STUDY

GENERAL.

The performance and reliability of an electrical power system can change significantly as electrical loads increase, as the characteristics of loads change, or as the power supplier's system changes. These changes may result in components being applied beyond their ratings and/or no longer providing protection to equipment and the system. The goal is to have a power distribution system serving NAS facilities that is properly rated and will provide selective fault isolation.

This SOW is designed to obtain engineering studies that identify these problems and recommends solutions.

The design of the electrical power distribution shall include a complete power system study in accordance with FAA-STD-032, Design Standards for National Airspace System Physical Facilities. The study shall include short circuit analysis, protective device coordination, voltage drop analysis, and sizing of stand-by diesel engine-generator and utility service.

SHORT CIRCUIT AND PROTECTIVE DEVICE COORDINATION STUDY.

1. GENERAL REQUIREMENTS.

1.1 The purpose and intent of this study are to:

a. Determine if protective equipment and components are applied within their nameplate ratings.

b. Determine settings needed on adjustable protective devices to protect system components and maximize system availability.

c. Identify changes that are necessary for proper application and protection.

1.2 Whether the study is by contract or consultant it shall be conducted by an engineer with 3 or more years experience on this type of study. Electrical engineering design experience in large hospitals, life safety systems, and/or large computer and telecommunications facilities are preferred. The engineer shall be available to share opinions related to significant recommendations. The engineer shall have proven computer programs for making single-phase and three-phase fault duty calculations. A listing of previous study jobs completed and resume of the engineer shall be available for review. A previous study report shall be available for review to illustrate the type of report that will be supplied.

APPENDIX 1. RECOMMENDED STATEMENT OF WORK (SOW) POWER SYSTEM STUDY CONTINUED

1.3 The study work shall be conducted under the applicable standards of the American National Standards Institute (ANSI), Institute of Electrical and Electronic Engineers (IEEE), and the National Electric Code (NEC). Specifically the following standards shall apply:

a. IEEE C37.010-1979, IEEE Standard Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (includes Supplement C37.010d) (ANSI).

b. IEEE C37.13-1981, IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures (ANSI).

c. IEEE C37.5-1979, IEEE Guide for Calculation of Fault Currents for Application of AC High-Voltage Circuit Breakers Rated on a Total Current Basis (ANSI).

d. IEEE Std 141-1986, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (ANSI).

e. IEEE Std 242-1986, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (ANSI).

1.4 The basic scope of the study is the facility power system from the power supplier's primary service through the main secondary distribution system up to the branch circuit protective devices.

1.5 For existing facilities, the engineer shall visit the site to become familiar with and obtain data of all components, devices, and equipment in the system.

WORK ELEMENTS.

2. SINGLE-LINE DIAGRAMS.

2.1 The engineer shall prepare a single-line diagram of the power system. This diagram shall identify all components considered in the study and the ratings of all power devices. This includes, but is not limited to, transformers, circuit breakers, relays, fuses, busses, and cables. Reference numbers shall be used on the diagram related to key items in the report. ANSI device function numbers shall be used on protective relays.

3. SHORT CIRCUIT STUDY.

3.1 A short circuit study shall be performed which shows the momentary and interrupting fault duties on each bus shown on the single-line diagram. A computer shall be used to perform calculations on all three-phase faults. In addition, an impedance listing shall be prepared showing bus-to-bus impedance values reduced to a common MVA base referenced to a single-line diagram for ease in reviewing data.

APPENDIX 1. RECOMMENDED STATEMENT OF WORK (SOW) POWER SYSTEM STUDY (CONTINUED)

3.2 Study each over-current device related to the calculated duty and recommend changes when appropriate.

4. COORDINATION STUDY.

4.1 For each new or modified power distribution system design, a comprehensive protective device coordination study covering all devices and power sources identified on the single-line diagram shall be completed. Settings for all adjustable protective devices shall be documented on the single-line diagram provided to the FAA. Where consultant engineers are providing the design, ensure that the contract document clearly requires coordination as stated in this order. The coordination study is required for: 1) The initial design of a new power system, 2) When a change to a design baseline is made during the engineering change process (ECP), which may result in configuration management changes, 3) When an National Change Proposal (NCP) is requested which directly effects the power system, and 4) During major power system modifications are made to existing facilities. The goal is to have a power distribution system serving NAS facilities that is properly rated and will provide selective fault and overload isolation.

a. Table 1 is provided as a reference for engineering consideration when applying selective coordination.

b. Appendix 2, Coordination Guidelines, provides general principles to assist in the coordination process.

Table 1
Selective Coordination Matrix

	Critical (EG&UPS)	Essential	Non Essential
New Design	Mandatory	Mandatory	Not Required (See note 2)
Major Modification to Existing Facility (Note 3)	Recommended (See Note 1)	Recommended (See Note 1)	Not Required (See Note 2)

NOTE:

1. In instances where the coordination study reveals that full coordination is not feasible and sufficient funds are not available, identify the deficiencies to the Funds Administrator in the form of the short circuit protective device coordination study and written correspondence for future funding consideration.
2. Overloads of long duration shall coordinate for these systems. In no case shall faults on these circuits be allowed to effect over-current protective devices that feed essential and critical systems.
3. Major Modification is defined as the replacement or addition of an engine generator or UPS system and or the addition of Power Distribution Units (PDU's).

APPENDIX 1. RECOMMENDED STATEMENT OF WORK (SOW) POWER SYSTEM STUDY (CONTINUED)

4.2 Study the application of devices versus system needs and recommend new or additional devices that are needed for adequate protection.

4.3 Prepare time/current coordination curves to illustrate the protection and coordination achieved with the recommended settings of protective devices. These curves shall reflect the following (where applicable):

a. Appropriate National Electric Code protection points.

b. Appropriate ANSI protection points.

c. Magnetizing inrush points of transformers.

d. One-line diagram of the system identifying the device plotted.

e. Short circuit current levels used for coordination.

f. Through-fault protection curves for liquid immersed transformers.

5.0 REPORTING.

5.1 The engineer shall submit three bound copies of the coordination study shall be provided. The study shall contain the following information:

a. An executive summary, which identifies all significant design shortfalls and recommended solutions.

b. A tabulation of all protective devices identified with in the design as identified on the one-line diagram, with their ratings compared to their respective fault duty as calculated in the study.

c. A tabulation of the settings recommended on all adjustable protective devices with references to the single-line diagram and coordination curves.

d. Copies of all time/current coordination curves developed in the study.

e. An analysis of design shortfalls that lead to specific recommendations included in the executive summary.

f. The single-line diagram of the system studied, including description of all ratings and identifications described therein.

g. Copies of all results in electronic format, referenced to the single-line diagram and the impedance listing.

5.2. The coordination study shall be completed and submitted to FAA within a mutually agreed time. A copy of the approved report shall be included as part of the Design Data Handbook in accordance with FAA-STD-032.

APPENDIX 2. COORDINATION GUIDELINES

Selective coordination is both an art and a science. A perfectly coordinated system can not always be accomplished. It is the responsibility of the design engineer to maximize coordination to the extent practical. The following guidelines will assist in the process:

1. Minimize the number of protective devices between the main service disconnect and the last protective device. The use of an un-fused disconnect and elimination of main breakers at branch panel boards will assist in this process. However, in all cases a coordinated electrical system must comply with the National Electrical Code (NEC).

2. Consider using larger ampere frame circuit breakers to facilitate proper coordination. Ensure that available space limitations can accommodate physical circuit breaker sizes.

3. Consider the use of electronic programmable type circuit breakers.

4. 480 VAC for the distribution system voltage and derivation of smaller use voltages will aid in power system design.

5. Use the protective device coordination study to design a coordinated distribution system.

6. Use National standard designs as indicated in the Critical Power Distribution System Program Implementation Plan (P6980.00) wherever possible.

7. Verify short circuit ratings of components used in the electrical distribution systems are adequate for the application.

8. Elevators shall be coordinated in accordance with the National Electric Code.

9. Examination of the load's power continuity requirements shall be taken into account. As an example, if an interruption in a chiller motor on the essential bus of a manned facility will not effect the NAS, coordination may have less stringent requirements. If the power feeds equipment that directly controls the landing of airplanes, coordination must be followed to the extent possible.

10. When difficulty is encountered consult with appropriate regional or national authorities.

11. Protection always comes before coordination.

12. In instances of unmanned facilities where substantial time may elapse before a loss of power is identified, coordination is recommended.

13. Ground fault protection should be accomplished for circuits in accordance with the NEC. In these cases, the ground fault system should have a separate coordination study and analysis performed.

CHANGE

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

6950.27, CHG 1

1/23/03

SUBJ: SHORT CIRCUIT ANALYSIS AND PROTECTIVE DEVICE COORDINATION STUDY

1. PURPOSE. This change transmittal incorporates and clarifies in Appendix 1, Recommended Statement Of Work (SOW) Power System Study, the requirement for selective coordination of the facility power distribution system

2. DISTRIBUTION. This order is distributed to the division level in Airway Facilities and the Office of Communication, Navigation, and Surveillance System in Washington; to the Logistics Center and the Academy at the Aeronautical Center; to branch level at ATC Engineering and Test Division, CNS Engineering and Test Division; NAS System Engineering and Analysis Division; and Facility Services and Engineering Division at the Technical Center; to all regional Airway Facilities divisions and NAS Implementation Offices; and to all Airway Facilities field offices with a standard distribution.

3. EXPLANATION OF CHANGES. The goal of a short circuit and coordination study is to have selective coordination. This is an unclear mandate in this directive. This change clearly delineates the requirement for protective device coordination (PDC) in a distribution system. Appendix 1, Page 3 addresses PDC considerations as applied to FAA electrical system classification; i.e., essential, nonessential, and critical. Appendix 2, Coordination Guidelines, was added to provide general principles to assist in the coordination process.

DISPOSITION OF TRANSMITTAL. This transmittal sheet should be retained until a new directive cancels the basic directive.

PAGE CONTROL CHART

Remove Pages	Dated	Insert Pages	Dated
Appendix 1 3 and 4	10/3/94	Appendix 1 3 thru 5	
		Appendix 2	

Jim Arrasmith
Acting Program Director for Operational Support

Distribution: A-W(AF/ND)-2; A-Z(CT-200/300/500/600)-3 (5 copies each); A-Y(ML/MA)-2; A-X(AF/NI)-3; A-FAF-0 (STD)

Initiated By: AOS-100