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DRAFT REGULATORY GUIDE

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DRAFT REGULATORY GUIDE DG-1153

(Proposed Revision 1 of Regulatory Guide 1.93, dated December 1974)

AVAILABILITY OF ELECTRIC POWER SOURCES

A. INTRODUCTION

In Title 10, Part 50, of the *Code of Federal Regulations* (10 CFR Part 50), "Domestic Licensing of Production and Utilization Facilities," Section 50.36(c)(2) [10 CFR 50.36(c)(2)] requires that the technical specifications (TSs) include the limiting conditions for operation (LCO), which are defined as the lowest functional capability or performance levels of equipment required for safe operation of the facility. Furthermore, when an LCO of a nuclear reactor is not met, the licensee shall shut down the reactor or follow any remedial action the TSs permit until the condition can be met.

This regulatory guide describes the operating procedures and restrictions that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for implementation if the available electric power sources are less than the LCO. This regulatory guide is applicable to single- and multi-unit plants.

With respect to available electric power sources, the LCO establish the required capability of the electric power system that satisfies General Design Criterion (GDC) 17, "Electric Power Systems," as set forth in Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, by including the following electric power sources:

(1) two physically independent circuits from the offsite transmission network, each of which is either continuously available or can be made available within a few seconds following a loss-of-coolant accident (LOCA)

(2) redundant onsite alternating current (ac) power sources

(3) redundant onsite direct current (dc) power sources to maintain core cooling, containment integrity, and other vital safety functions

This regulatory guide is being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. It has not received staff review or approval and does not represent an official NRC staff position.

Public comments are being solicited on this draft guide (including any implementation schedule) and its associated regulatory analysis or value/impact statement. Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Rules and Directives Branch, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001. Comments may be submitted electronically through the NRC's interactive rulemaking Web page at http://www.nrc.gov/what-we-do/regulatory/rulemaking.html. Copies of comments received may be examined at the NRC's Public Document Room, 11555 Rockville Pike, Rockville, MD. Comments will be most helpful if received by **December 9, 2006**.

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For nuclear power plants that are not licensed in accordance with GDC 17, the updated final safety analysis report provides the applicable design criteria. This report sets forth criteria similar to GDC 17, which requires that an offsite power system be provided to ensure the continued functioning of certain structures, systems, and components in the event of anticipated operational occurrences and postulated events.

Operating nuclear power plants for which only one of the two required offsite circuits can be made available within a few seconds following a LOCA must justify the delayed offsite circuit availability to support the core cooling systems. However, the restrictions imposed on such plants regarding the loss of required sources would generally be more stringent than those recommended in this regulatory guide.

The NRC issues regulatory guides to describe to the public methods that the staff considers acceptable for use in implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations, and compliance with regulatory guides is not required. The NRC issues regulatory guides in draft form to solicit public comment and involve the public in developing the agency's regulatory positions. Draft regulatory guides have not received complete staff review and, therefore, they do not represent official NRC staff positions.

This regulatory guide contains information collections that are covered by the requirements of 10 CFR Part 50 which the Office of Management and Budget (OMB) approved under OMB control number 3150-0011. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

Electric loads important to safety in a nuclear power plant are served by an electric power system pursuant to GDC 17. Nuclear power plants with more power sources than GDC 17 requires may be able to withstand the loss of one or more sources and still satisfy the LCO. However, during the normal course of operation, any nuclear power plant may lose power sources to the extent that the LCO are not met. This regulatory guide addresses such cases.

The TSs of operating nuclear power plants include the operational restrictions resulting from the loss of power sources. In general, plant TSs require the operability of the offsite power system as a part of the LCO and specify actions to be taken when the offsite power system is inoperable. Plant operators should be aware of (1) the capability of the offsite power system to supply power during operation, and (2) situations that can result in a loss of offsite power or inadequate voltage following a trip of the plant or other transmission contingencies identified by the grid operator. If the offsite power system is not capable of providing the requisite power in either situation, the system should be declared inoperable and pertinent plant TS provisions should be followed.

The operational restrictions in the TSs are based on the following three assumptions:

(1) The LCO of nuclear power plants are met when all electric power sources required by GDC 17 are available at the required voltage and capacity for the nuclear station and capable of withstanding a system contingency such as (a) a single failure involving loss of generation by the nuclear unit, any other critical generation source, or loss of power from a transmission system element, or (b) a double failure involving a loss of power from the transmission network and the loss of one train of onsite ac power.

(2) Under certain conditions, it may be safer to continue operation at power for a limited time, rather than to effect an immediate shutdown upon loss of some required electric power sources. Such decisions should be based on an evaluation that balances the risks associated with immediate shutdown against those associated with continued operation. If, on balance, immediate shutdown is the safer course, the plant should promptly be brought to an orderly shutdown. For example, the risks associated with immediate shutdown upon loss of the onsite ac power source during a period of light transmission system load with high operating reserve would tend to be less than those resulting from shutdown during a peak load period with less operating reserve because the electrical grid may be able to accommodate a loss of power generation. If, on balance, continued power operation is the safer course, the period of continued operation should be used to restore the lost power system elements (generation, transmission, and capacitor banks) and prepare for orderly shutdown, provided, of course, that these activities do not risk further degradation of the electric power system or in any way jeopardize the plant's safety.

(3) If the LCO cannot be achieved, the plant should be brought to an orderly shutdown after the time allowed for continued power operation has elapsed. The premise of this assumption is that the time allowed for continued operation could have been used to enhance the safety of the imminent shutdown. For example, the dispatcher could take such systemwide actions as increasing generation at other plants or dropping selected loads to ensure that the shutdown does not cause power grid instability or inadequate offsite power voltage. In addition, if the loss of power sources beyond the LCO were to occur during a peak load period, the time allowed for continued operation could be used to defer the shutdown to an off-peak period when the electric grid has sufficient operating reserve to accommodate a loss of generation.

To develop the bases for specific regulatory guidance, six levels of power system degradation are described below, in order of increasing severity.

The Available Offsite AC Power Sources Are One Less Than the LCO

This degradation level means that one of the required offsite ac sources is not available and, thus, the offsite ac power system has no redundancy. However, the offsite power system retains full capability to effect safe shutdown and mitigate the effects of a design-basis event. Operation could, therefore, safely continue if the availability of the remaining power sources is verified; however, since the system is degraded below the LCO, a time limit on continued operation is warranted. Operating experience indicates that the availability and reliability of a typical offsite power source are higher than those of a typical onsite ac source. Thus, if risk is evaluated in terms of availability and capability, the risk associated with the loss of an offsite power source (the source with higher availability) would appear to be more severe than that associated with the loss of an onsite ac supply (the source with lower availability). However, this apparent difference in severity is usually offset by maintainability considerations; that is, the time required to detect and restore an unavailable offsite source is generally much less than that required to detect and restore an unavailable onsite ac source, especially when the grid operator utilizes real-time contingency analysis.

Based on these considerations, a general distinction does not appear to be warranted for operating restrictions associated with the loss of an offsite source versus the loss of an onsite ac source. However, the loss of an offsite source resulting from an event associated with extensive consequences, such as a severe ice storm or forest fire, would have more severe implications than the loss of an onsite ac source. The risks associated with such an offsite loss would be compounded because (1) the maintainability advantage of the offsite sources would be lost, (2) the remaining offsite circuit could be susceptible to the same cause, (3) the consequential trip probability of a number of units would be higher because of the potential loss of loads, and (4) the availability and capability of the offsite power system might be affected. Thus, the loss of an offsite source resulting from such a cause should be treated as equivalent to the loss of *both* required offsite sources.

The Available Onsite AC Power Sources Are One Less Than the LCO

This degradation level means that one train of the onsite ac power system is not available for safe shutdown or to mitigate the effects of an event. In a single-unit plant, this typically means that one diesel generator is inoperable. In certain multi-unit plants that share onsite ac supplies, this means that the available onsite supply does not have the capacity to mitigate the effects of events in both units.

Since any inadvertent generator trip could potentially result in a total loss of ac power, the time allowed for continued operation should be severely restricted. In the absence of one onsite power source, the intent is twofold:

(1) Avoid the risk associated with immediate shutdown.
(2) Minimize the risk associated with this level of degradation by severely limiting its exposure time.

Licensees should make a concerted effort to restore the onsite ac power source during this restricted time period, and should inform the grid operator to ensure that the offsite power system can accommodate the imminent shutdown.

The Available Offsite AC Power Sources Are Two Less Than the LCO

This degradation level means that the offsite power system cannot effect a safe shutdown and mitigate the effects of an event; however, the onsite ac system is not degraded. Thus, this level generally corresponds to total loss of the immediately accessible offsite power sources.

Because of the normally high availability of offsite sources, this level of degradation may appear to be more severe than the next two degradation levels discussed. However, two factors tend to decrease the severity of this degradation level, compared to the next two. First, the configuration of the redundant onsite ac power system that remains available for this degradation level is not susceptible to a single bus or switching failure, whereas the next degradation level may be susceptible. Second, the time required to detect and restore an unavailable offsite power source is generally much less than that required to detect and restore an unavailable onsite ac power source.

This level of degradation can be caused by a variety of events, including the loss of two offsite circuits, an unavailable electric grid, or any other condition that renders offsite power unavailable for safe shutdown and emergency purposes. Since the onsite power system is not degraded and a loss of offsite power simultaneous with a LOCA was postulated as a design basis, a brief interval of continued operation is justified if an alternative source of ac power, independent of grid condition, is readily available and can act as a substitute train of ac power. (Note that some nuclear power plants are designed to cause an automatic shutdown or initiate load rejection at this level of degradation. Plants designed to cause an automatic shutdown at this level of degradation need no further discussion; however, those that initiate load rejection are considered to remain operating within the context of this regulatory guide.)

The Available Offsite and Onsite AC Power Sources Are Each One Less Than the LCO

This level of power system degradation results from the loss of individual redundancy in both the offsite and onsite ac power systems. However, since power system redundancy is provided by two different sources of power, the reliability and, hence, the safety of this degradation level appears to be slightly higher than that of the previous degradation level. However, the susceptibility of this power system to a single bus or switching failure could offset this apparent improvement. For example, the failure of an emergency power distribution bus that is energized by either the single available offsite circuit or the single available onsite ac supply could render all emergency ac power from that source ineffective. Moreover, if the offsite and onsite power were available to only one train, a bus fault could render all emergency power unavailable.

Based on these considerations, the operating restrictions imposed at this level of degradation should be similar to those of the previous degradation level. However, the allowed operating time should be shortened because the onsite ac power system has been degraded, and a loss of offsite power simultaneous with a LOCA (or any event that causes a generator trip) is a design-basis event.

The Available Onsite AC Power Sources Are Two Less Than the LCO

This degradation level means that the onsite ac power system cannot effect a safe shutdown and mitigate the effects of an accident. In a single-unit plant, this usually means that two diesel generators are inoperable. In multi-unit plants that share onsite ac supplies, this degradation level means that the available onsite supplies, if any, do not have the capacity to mitigate the effects of an event in one unit and safely shut down the other unit(s).

Since the offsite power system is the only source of ac power at this level of degradation, the risk associated with continued operation for a very short time could be less than that associated with immediate shutdown. (Immediate shutdown could cause grid instability resulting in a total loss of ac power.) However, since any inadvertent generator trip could potentially result in a total loss of ac power, the time allowed for continued operation should be severely restricted. In addition, all work that could potentially trip the unit should be suspended. The intent is twofold:

(1) Avoid the risk associated with immediate shutdown.
(2) Minimize the risk associated with this level of degradation by severely limiting its exposure time.

Licensees should make a concerted effort to restore at least one onsite ac power source during this restricted time period, and take systemwide actions to ensure that the offsite power system can accommodate the imminent shutdown.

The Available Onsite DC Power Sources Are One Less Than the LCO

This degradation level means that the available dc power sources do not have the required redundancy; however, the remaining train(s) of the dc power system has (have) full functional capability to effect a safe shutdown and mitigate the effects of an event. Since a subsequent degradation in an onsite ac or dc system could jeopardize plant safety (e.g., a subsequent single failure could render the entire power system ineffective on a generator trip), the time allowed for continued operation should be severely restricted. If the affected dc source is restored within this time period, unrestricted operation may resume. If not, the unit should promptly be brought to an orderly shutdown. The required functions of the dc system should be critically monitored during the shutdown period and corrective actions taken, if required, to ensure safety.

The regulatory positions in Section C of this regulatory guide are based on the grid operators' capabilities to ensure the adequacy of the offsite power system through contingency evaluations, as well as the plants' capabilities to manage risk-significant maintenance and outages.

C. REGULATORY POSITION

The intent of each of the following regulatory positions[1] is to ensure that a nuclear power plant is in an acceptably safe operating mode whenever the available electric power sources are less than the LCO. Accordingly, this section discusses the various levels of degradation of the electric power system, in order of increasing degradation; the TSs should incorporate the regulatory position for each degraded level. Whenever the TSs allow unrestricted operation to resume, such resumption should be contingent on verification of the integrity and capability of the restored sources. Similarly, whenever the TSs allow power operation to continue during a specific degradation level, such continued power operation should be contingent on (1) immediate verification of the availability, capability, and integrity of the remaining sources; (2) reevaluation of the availability of the remaining diesel generator(s) at time intervals not to exceed 24 hours; (3) verification that the required maintenance activities do not further degrade the power system or in any way jeopardize plant safety; and (4) compliance with the additional conditions stipulated for each specific degradation level.

The operating time limits delineated below are primarily for corrective maintenance activities only. The conduct of other maintenance or surveillance activities should be evaluated to determine their compliance with 10 CFR 50.65, "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants." Many plants are now attempting online testing.

1. The Available Offsite AC Power Sources Are One Less Than the LCO

If the available offsite ac power sources are one less than the LCO, power operation may continue for a period that should not exceed 72 hours if the electric grid system capability and reserves are such that a subsequent single failure (including a trip of the unit's generator, but excluding an unrelated failure of the remaining offsite circuit if this degraded state was caused by the loss of an offsite source) would not cause a total loss of offsite power.

If these conditions for continued power operation are met and the affected source is restored within 72 hours, unrestricted operation may resume. Conversely, if the conditions for continued power operation are met, but the source is not restored within 72 hours, the unit should be brought to hot shutdown (Mode 3) for boiling-water reactors (BWRs) in 6 hours, hot standby (Mode 3) for pressurized-water reactors (PWRs) in 6 hours, and cold shutdown for either within the next 36 hours.

2. The Available Onsite AC Power Sources Are One Less Than the LCO

If the available onsite ac power sources are one less than the LCO, power operation may continue for a period that should not exceed 72 hours, provided the redundant diesel generator is assessed within 24 hours to be free from common-cause failure.

3. The Available Offsite AC Power Sources Are Two Less Than the LCO

If the available offsite ac power sources are two less than the LCO, power operation may continue for 24 hours if it appears likely that at least one of the offsite sources can be restored within that time. If these conditions for continued power operation are met and both offsite sources are restored within 24 hours, unrestricted operation may resume. If only one offsite source is restored within 24 hours, power operation may continue for a total time that should not exceed 72 hours in accordance with the conditions described in Regulatory Position 1. Conversely, if no offsite source is restored within

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[1] See "Decision Flow Diagram for Availability of Electric Power Sources" (6 sheets) appended to this regulatory guide. These sheets graphically depict the regulatory position for each of the six levels of degradation covered by this guide.

the first 24-hour period of continued power operation, the plant should promptly be shut down in 6 hours to hot shutdown for BWRs (Mode 3) and hot standby for PWRs (Mode 3).

4. The Available Offsite and Onsite AC Power Sources Are Each One Less Than the LCO

If the available offsite and onsite ac power sources are each one less than the LCO, power operation may continue for 12 hours if (1) the reserves and system stability are such that a subsequent single failure (including a trip of the unit's generator, but excluding an unrelated failure of the remaining offsite circuit) would not cause a total loss of offsite power, and (2) it appears likely that at least one of the affected sources can be restored within 12 hours.

If these conditions for continued power operation are met and both sources are restored within 12 hours, unrestricted operation may resume. If either an offsite or an onsite ac source is restored within 12 hours, power operation may continue for a total time that should not exceed 72 hours in accordance with the condition described in Regulatory Position 1 for the loss of one ac source. Conversely, if neither an offsite source nor an onsite source is restored within the first 12 hours of continued power operation, the plant should be brought to hot shutdown (Mode 3) for BWRs in 6 hours, hot standby (Mode 3) for PWRs in 6 hours, and cold shutdown for either within the next 36 hours.

5. The Available Onsite AC Power Sources Are Two Less Than the LCO

If the available onsite ac electric power sources are two less than the LCO, power operation may continue for a period that should not exceed 2 hours. If both onsite ac electric power sources are restored within these 2 hours, unrestricted operation may resume. If only one onsite ac power source is restored within these 2 hours, power operation may continue for a total time that should not exceed 72 hours, in accordance with the conditions described in Regulatory Position 1 for the loss of one ac source. Conversely, if no onsite ac source can be restored within the first 2 hours of continued power operation, the unit should be brought to cold shutdown within the next 36 hours.

6. The Available Onsite DC Power Sources Are One Less Than the LCO

If the available onsite dc power sources are one less than the LCO, power operation may continue for a period that should not exceed 2 hours. If the affected dc source is restored within these 2 hours, unrestricted operation may resume. If not, the plant should be brought to hot shutdown (Mode 3) for BWRs in 6 hours, hot standby (Mode 3) for PWRs in 6 hours, and cold shutdown within the next 36 hours. The required functions of the dc system should be critically monitored during the shutdown process, and necessary actions taken (such as cross-connecting a supply, or shedding optional loads) to ensure safe shutdown.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this draft regulatory guide. This regulatory guide reflects current regulatory practice; therefore, no backfitting is intended or approved in connection with its issuance.

The NRC has issued this draft guide to encourage public participation in its development. Except in those cases in which an applicant or licensee proposes or has previously established an acceptable alternative method for complying with specified portions of the NRC's regulations, the methods to be described in the active guide will reflect public comments and will be used in evaluating (1) submittals in connection with applications for construction permits, standard plant design certifications, operating licenses, early site permits, and combined licenses; and (2) submittals from operating reactor licensees who voluntarily propose to initiate system modifications following the issuance of this guide if there is a clear nexus between the proposed modifications and the subject for which guidance is provided herein.

REGULATORY ANALYSIS

1. Statement of the Problem

The U.S. Nuclear Regulatory Commission (NRC) issued Regulatory Guide 1.93 in December 1974 to ensure that nuclear power plants are in an acceptably safe operating mode whenever the available electric power sources are less than the limiting conditions for operation (LCO). This regulatory guide needs a general update to reflect the operating experience gained over the past 30 years, 10 CFR 50.63 (the Station Blackout Rule), 10 CFR 50.65 (the Maintenance Rule), issues related to grid reliability, and deregulation of the electrical industry.

2. Objective

The objective of this action is to provide current guidance for an acceptably safe operating mode whenever the available electric power sources are less than the LCO.

3. Technical Approach

This proposed Revision 1 of Regulatory Guide 1.93 was developed to achieve the objective outlined above. As such, this guide is consistent with current regulatory practice and the standardized technical specifications.

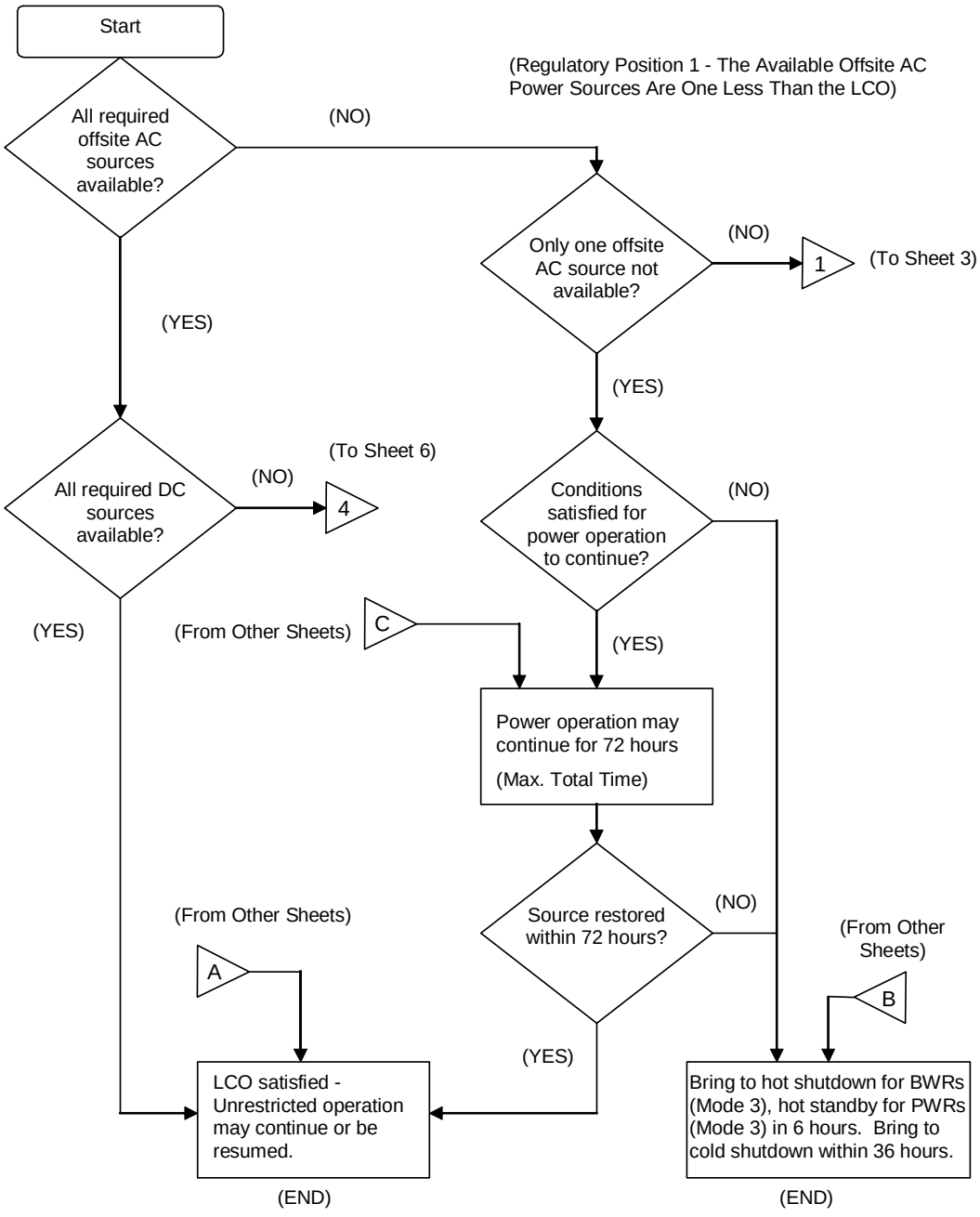
4. Conclusion

The NRC should issue this regulatory guide to enhance the licensing process. The staff has concluded that the proposed action will reduce unnecessary burden on both the NRC and its licensees, and will result in an improved and more uniform process for implementing the safest operating mode when the available power sources are not available. Moreover, the staff sees no adverse effects associated with issuing this regulatory guide.

BACKFIT ANALYSIS

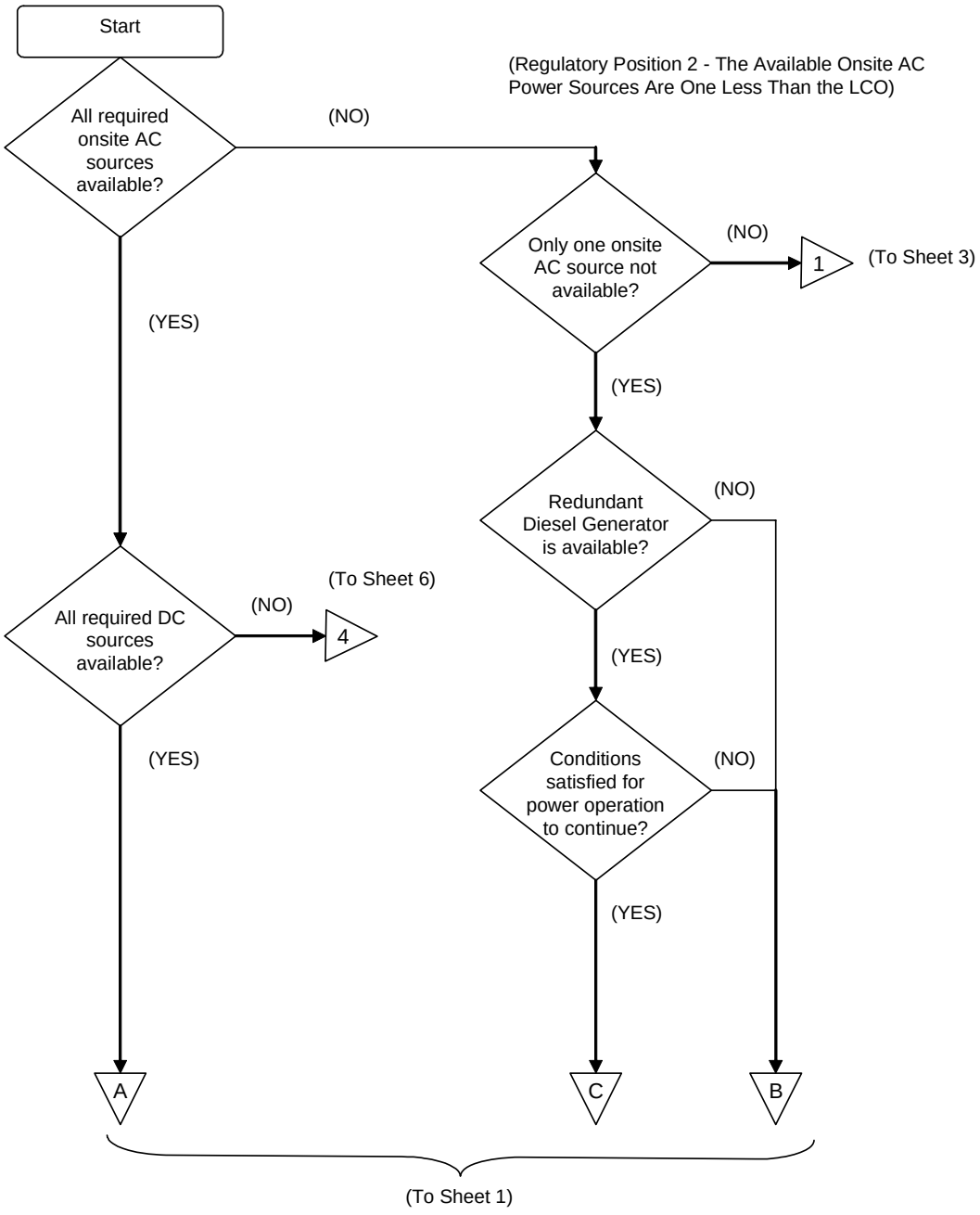
Because this proposed Revision 1 of Regulatory Guide 1.93 reflects current regulatory practice, it does not require a backfit analysis as described in 10 CFR 50.109(c).

Decision Flow Diagram For Availability
Of Electric Power Sources



Sheet 1 of 6

Decision Flow Diagram For Availability
Of Electric Power Sources



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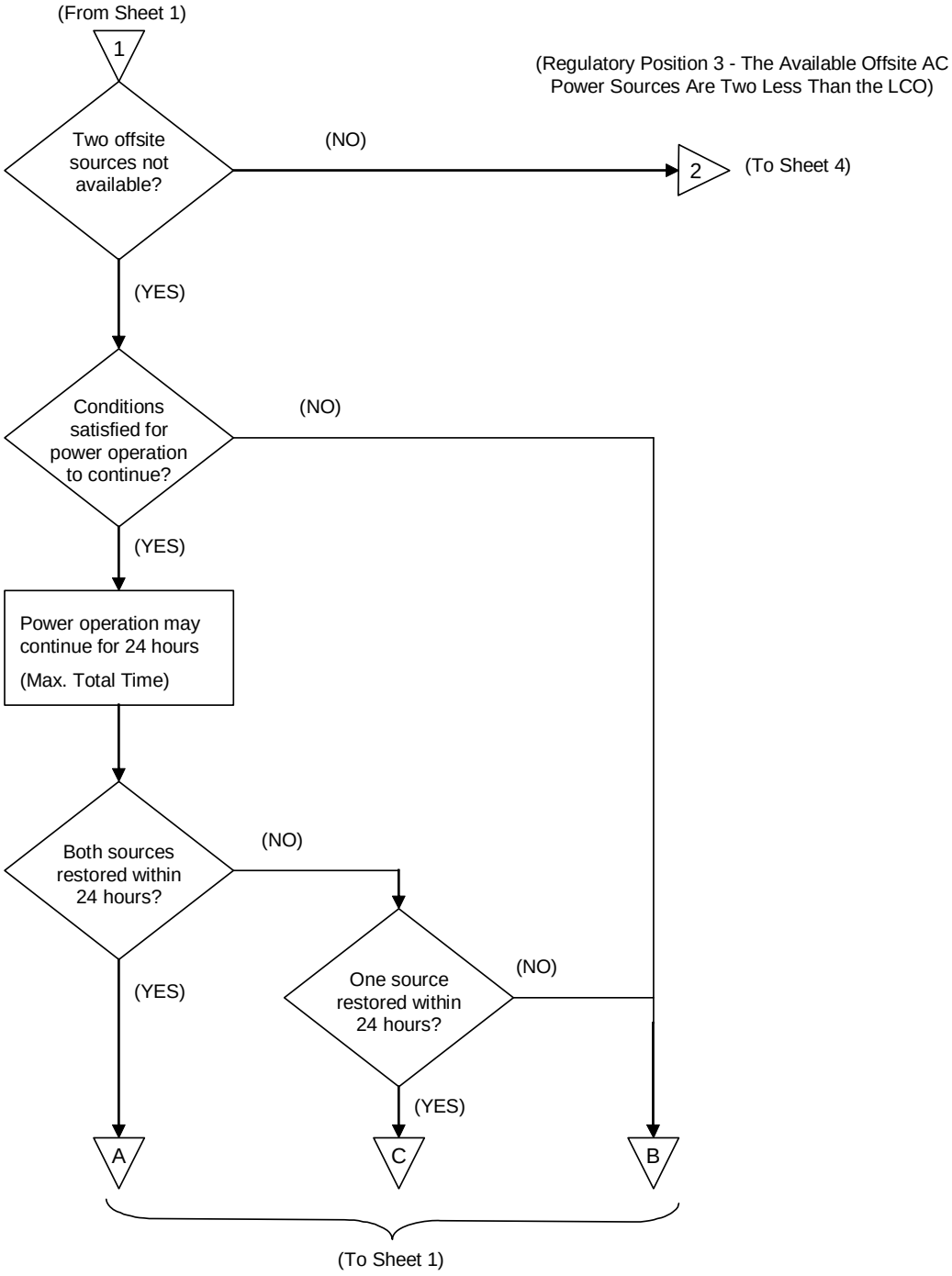

Decision Flow Diagram For Availability
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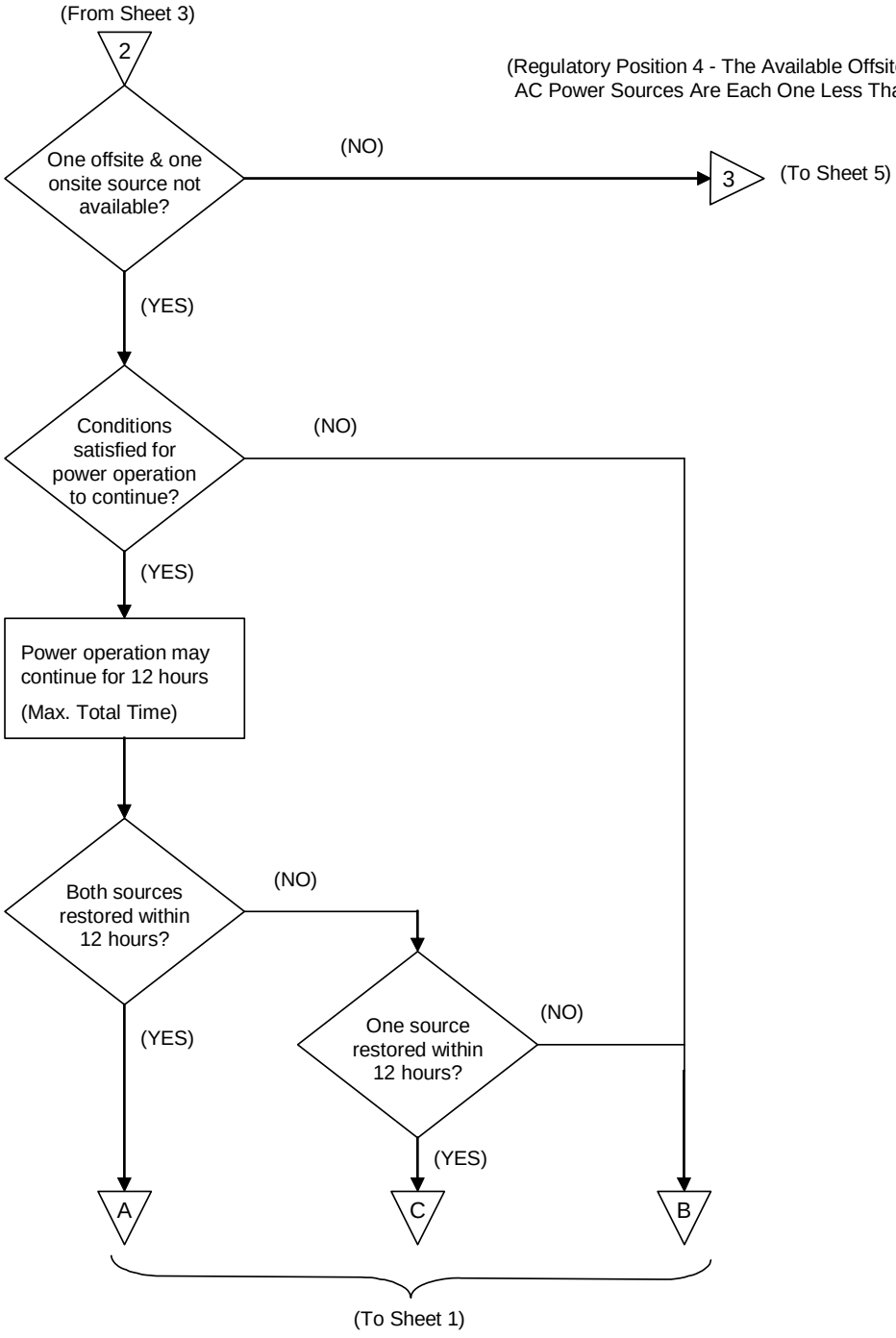

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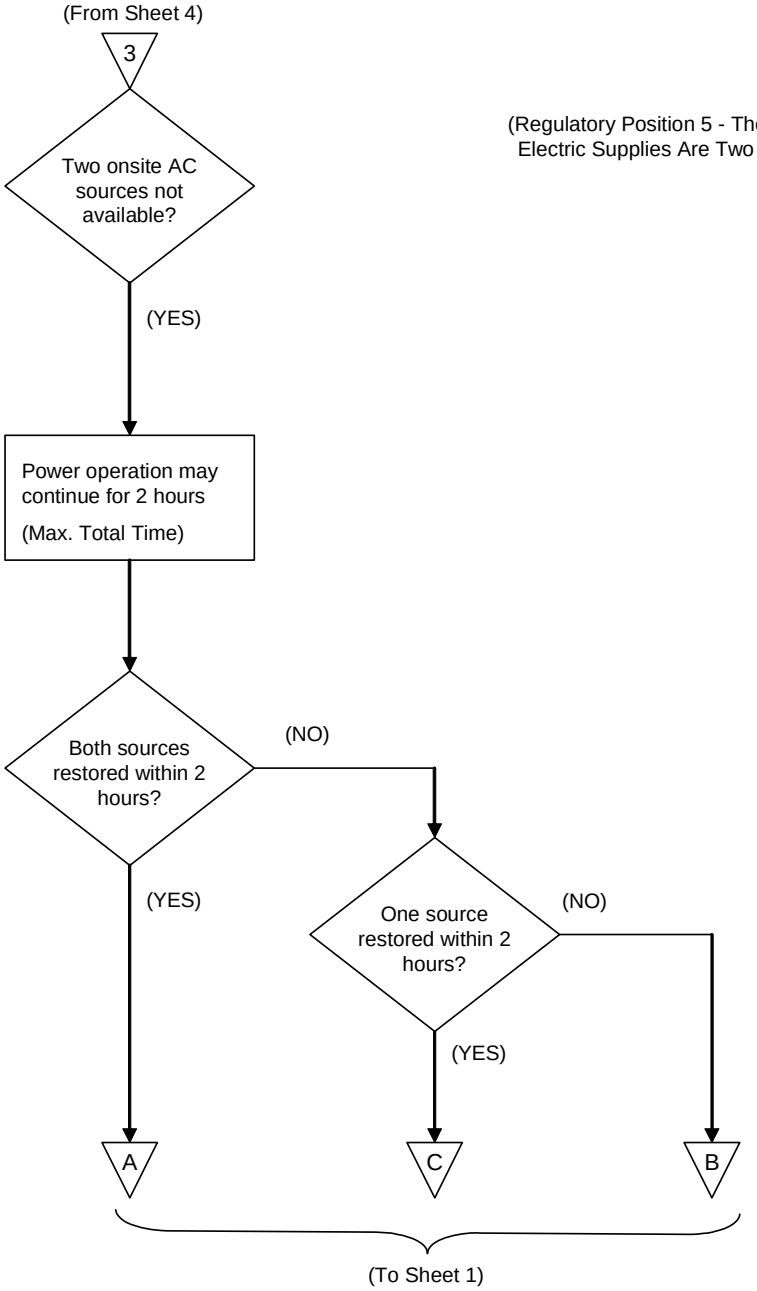

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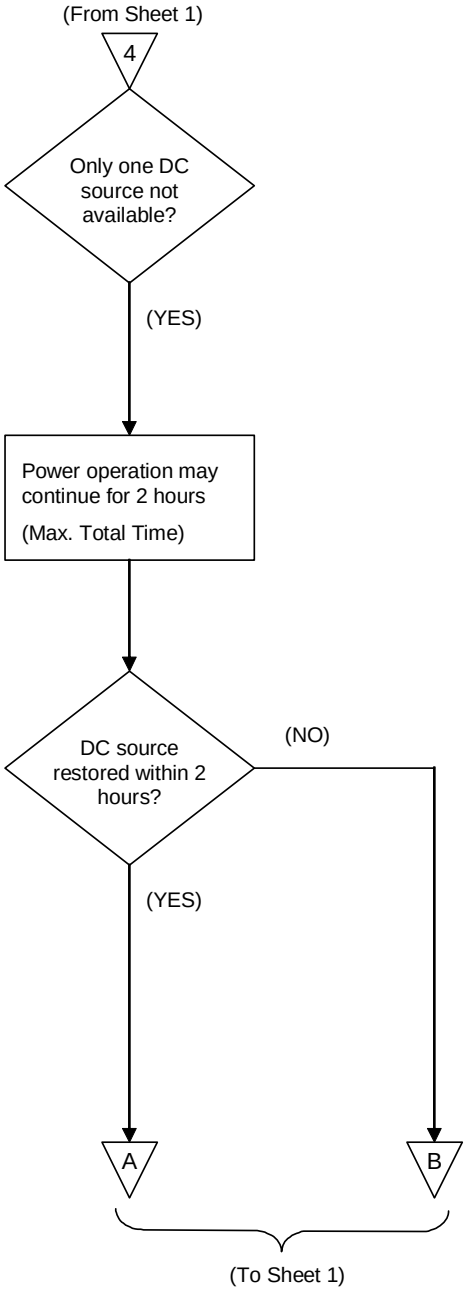

(Regulatory Position 6 - The Available Onsite DC Supplies Are One Less Than the LCO)