U.S. ATOMIC ENERGY COMMISSION

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REGULATORY GUIDE

DIRECTORATE OF REGULATORY STANDARDS

REGULATORY GUIDE 1.93

AVAILABILITY OF ELECTRIC POWER SOURCES

A. INTRODUCTION

Section 50.36(c)(2), "Limiting Conditions for Operation," of 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires the Technical Specifications to include the limiting conditions for operation (LCO) and actions required to be taken by the licensee when the LCO is not met. Power operation may be initiated and continued without restriction only when the LCO is met.

This guide describes operating procedures and restrictions acceptable to the Regulatory staff which should be implemented if the available electric power sources are less than the LCO. This guide is applicable to single and multi-unit plants, including multi-unit plants that share the required electric power sources.

The LCO with respect to available electric power sources is an electric power system that satisfies General Design Criterion 17 (GDC-17), "Electric Power Systems," of Appendix A, "General Design Criteria for Nuclear Power Plants," of 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 a.c. power supplies, and (3) redundant onsite d.c. power supplies.

Nuclear power plants wherein only one of the two required offsite circuits can be made available within a few seconds following a LOCA are outside the scope of this guide. However, the restrictions imposed on such plants on the loss of required sources would generally be more stringent than those recommended in this guide.

B. DISCUSSION

Electric loads important to safety of nuclear power plants are served by an electric power system that conforms to GDC-17. Plants with more power sources than are required by GDC-17 can tolerate the loss of one or more sources and still meet the LCO. During the normal course of operation, however, any nuclear power plant may lose power sources to the extent that the LCO is not met. This guide addresses such cases.

GDC-17 specifies design requirements, not operating requirements; it therefore does not stipulate operational restrictions on the loss of power sources. Nevertheless, operational restrictions based on the intent of GDC-17 on the loss of power sources have been included in the Technical Specifications of recently licensed nuclear power plants. Such restrictions are based on the following assumptions:

- The LCO of nuclear power plants is met when all the electric power sources required by GDC-17 are available.
- Under certain conditions, it may be safer to continue operation at full or reduced power for a limited time than to effect an immediate shutdown on the loss of some of the 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 unit should be brought promptly to an orderly shutdown, and to a cold shutdown state as soon as possible. For example, the risks associated with an immediate shutdown on the loss of onsite a.c. power supply during a period of light system load would tend to be less than those during a peak load period because the stability of the offsite power system would be relatively higher. If, on balance, continued power operation is the safer course, the period of continued operation should be used to restore the lost source and to prepare for an orderly shutdown, provided, of course, that these activities do not risk further degradation of the electric power system or in any way jeopardize plant safety.
- If the LCO has not been achieved, the unit should be promptly brought to an orderly shutdown after the

allowed time for continued power operation has elapsed and to a cold shutdown state as soon as possible thereafter. The premise here 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 system-wide actions as increasing generation at other plants or dropping selected loads to ensure that the shutdown does not cause grid instability. In addition, if the loss of sources beyond the LCO were to occur during a peak load period, the allowed operating time could be used to defer the shutdown to an off-peak period when the stablility of the grid should be higher.

To develop bases for specific guidance, five levels of degradation of the power systems are described below in order of increasing severity:

1. The Available A.C. Power Sources Are One Less Than the LCO.

This degradation level means that one of the required offsite or onsite a.c. sources is not available. Thus, either the offsite or the onsite a.c. power system has no redundancy; however, each system retains full capability (one system with redundancy) to effect a safe shutdown and to mitigate the effects of a design basis accident. Operation could therefore safely continue if the availability of the remaining 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 of a typical offsite source is higher than that of a typical onsite a.c. supply. Thus, if risk is evaluated in terms of availability, the risk associated with the loss of an offsite power source (the source with the higher availability) would appear to be more severe than the risk associated with the loss of an onsite a.c. supply (the source with the 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 a.c. supply.

Based on these considerations, a general distinction does not appear to be warranted for operating restrictions associated with the loss of an offsite source and those restrictions associated with the loss of an onsite a.c. supply. However, the loss of an offsite source due to a cause associated with extensive consequences such as a severe ice storm or a forest fire would have implications more severe than the loss of an onsite a.c. supply. The risks associated with such an offsite loss would be compounded by three effects: (a) the maintainability advantage of the offsite sources would be lost, (b) the remaining offsite circuit could be susceptible to the same cause, and (c) the stability of the offsite power system might be affected. Thus, the loss of an offsite source by such a cause should be treated as equivalent to the loss of both required offsite sources.

2. The Available Offsite A.C. Power Sources Are Two Less Than the LCO.

This degradation level means that the offsite power system does not have the capability to effect a safe shutdown and to mitigate the effects of an accident; however, the onsite a.c. system has not been degraded. This degradation level generally corresponds to total loss of the immediately accessible offsite power sources.

Because of the normally high availability of the offsite sources, this level of degradation may appear to be more severe than the next two degradation levels listed. However, two factors tend to decrease the severity of this degradation level as compared to the next two degradation levels: (a) the configuration of the redundant a.c. power system that remains available for this degradation level is not susceptible to a single bus or switching failure, whereas the next degradation level listed (No. 3) may be so susceptible, and (b) 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 a.c. power source.

This degradation can be caused by any of several events, including the loss of two offsite circuits, an unstable offsite power system, or any condition that renders offsite power unavailable for safe shutdown and emergency purposes. Since the onsite power system has not been degraded and since simultaneous loss of offsite power and a LOCA were postulated as a design basis, a brief interval of continued operation is justified. (Note: Some nuclear power plants are designed to cause an automatic shutdown or to 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 reject load are considered to remain operating within the context of this guide.)

3. The Available Offsite and Onsite A.C. Power Sources Are Each One Less Than the LCO.

This degradation level results in the loss of individual redundancy in both the offsite power system and the onsite a.c. power system. However, since power system redundancy is provided by two diverse sources of power, the reliability, and hence the safety, of this degradation level appears to be higher than that of the previous degradation level. This apparent improvement could, however, be offset by the susceptibility of this power system configuration to a single bus or switching failure. 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 a.c. supply could render all emergency a.c. power ineffective.

Based on these considerations, the operating restrictions imposed on 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 a.c. power system has been degraded, and the simultaneous loss of the offsite power and a LOCA (or any event that causes generator trip) is a design basis event.

4. The Available Onsite A.C. Electric Power Supplies Are Two Less Than the LCO.

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

Since the offsite power system is the only source of a.c. power for this level of degradation, the risk associated with continued operation for a very short time could be less than that associated with immediate shutdown (the immediate shutdown could cause grid instability which could result in total loss of a.c. power). However, since any inadvertent generator trip could also result in total loss of a.c. power, the time allowed for continued operation should be severely restricted. The intent here is twofold: (a) to avoid the risk associated with immediate shutdown and (b) to subsequently minimize the risk associated with this level of degradation by severely limiting its exposure time.

A concerted effort should be made to restore at least one onsite a.c. supply during this restricted time period, and system-wide actions should be initiated to ensure that the offsite power system can accommodate the imminent shutdown.

5. The Available Onsite D.C. Supplies Are One Less Than the LCO.

This degradation level means that the available d.c. power supplies do not have the required redundancy; however, the d.c. power system has full functional capability to effect a safe shutdown and to mitigate the effects of an accident. Since a subsequent degradation 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 d.c. supply is restored within this time period, unrestricted operation may be resumed. If not, the unit should be brought promptly to an orderly shutdown and to a cold shutdown state as soon as possible. The required functions of the d.c. system should be critically monitored during the shutdown period and corrective actions taken, if required, to ensure the safety of the shutdown.

C. REGULATORY POSITION

The intent of each regulatory position[1] is to implement the safest operating mode whenever the available electric power sources are less than the LCO. Accordingly, various levels of degradation of the electric power system are listed below in order of increasing degradation; the regulatory position given for each degraded level should be incorporated in the Technical Specifications. Whenever the Technical Specifications allow unrestricted operation to be resumed, such resumption should be contingent on the verification of the integrity and capability of the restored sources. Whenever the Technical Specifications allow power operation to continue during a specific degradation level, such continued power operation should be contingent on (a) an immediate verification of the availability and integrity of the remaining sources, (b) reevaluation of the availability of the remaining diesel-generator(s) at time intervals not to exceed eight hours, (c) verification that the required maintenance activities do not further degrade the power system or in any way jeopardize plant safety, and (d) compliance with the additional conditions stipulated for each specific degradation level.

1. If the available a.c. power sources are one less than the LCO, power operation may continue for a period that should not exceed 72 hours if the system stability 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 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. If the conditions for continued power operation are met but the source is not restored within 72 hours, the unit should be brought to a cold shutdown state within the next 36 hours.

If the conditions for continued power operation cannot be met, the unit should be ramped down immediately to the minimum power level required for stable operation (preferably that required to accommodate the unit's auxiliary loads only). The ramping rate should be at the maximum permitted by the Technical Specifications without resorting to blowdown. While the Unit is operating at this reduced power level, it should provide minimum real power to the grid (preferably zero); however, the generator may supply reactive power to the grid within its rating, as required to enhance grid stability. The unit may operate at this reduced power level for a period that should not exceed 48 hours. If the affected source is restored within 48 hours, unrestricted operation could be resumed. If not, the unit should be brought to a cold shutdown state within the next 36 hours.

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[1]See "Decision Flow Diagram for Availability of Electric Power Sources" (5 sheets) appended to this guide. These sheets depict graphically the regulatory position for each of the five levels of degradation covered by this guide.

2. If the available offsite a.c. 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 24 hours.

If these conditions for continued power operation are met and both offsite sources are restored within 24 hours, unrestricted operation may be resumed. 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 (loss of one a.c. source). If no offsite source is restored within the first 24-hour period of continued power operation, the unit should be promptly shut down and brought to a cold shutdown state, or the lowest attainable pressure-temperature state, within the next 36 hours.

If the conditions for continued power operation cannot be met, the unit should be ramped down to the minimum power level as described in Regulatory Position 1. The unit may operate at this reduced power level for a period that should not exceed 24 hours. If both offsite sources are restored within the 24-hour period, unrestricted operation could be resumed. If only one offsite source is restored within this 24-hour period, reduced power operation may continue for an additional 24 hours subsequent to the restoration of one source. If the other offsite source is restored within this additional time, unrestricted operation could be resumed; if not, the unit should be promptly shut down and brought to a cold shutdown state, or to the lowest attainable pressure-temperature state, within the next 36 hours. If no offsite source is restored within the first 24 hours of reduced power operation, the unit should be shut down as previously described.

3. If the available offsite and onsite a.c. power sources are each one less than the LCO, power operation may continue for 12 hours if (a) 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 total loss of offsite power and (b) 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 be resumed. If either an offsite or an onsite a.c. 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 a.c. source. If neither an offsite source nor an onsite source is restored within the first 12 hours of continued power operation, the unit should be brought to a cold shutdown state within the next 36 hours.

If the conditions for continued power operation cannot be met, the unit should be ramped down to the minimum power level as described in Regulatory Position 1. The unit may operate at this reduced power level for a period that should not exceed 12 hours. If both sources are restored within this 12-hour period, unrestricted operation may be resumed. If either an offsite or an onsite a.c. source is restored within this 12-hour period, reduced power operation may continue for an additional 12 hours subsequent to the restoration of one source. If the other source is restored within these additional 12 hours, unrestricted operation may resume; if not, the unit should be brought to a cold shutdown state within the next 36 hours. If neither an offsite nor an onsite a.c. source is restored within the first 12 hours of reduced power operation, the unit should be brought to a cold shutdown state within the next 36 hours.

4. If the available onsite a.c. electric supplies are two less than the LCO, power operation may continue for a period that should not exceed two hours. If both onsite a.c. electric power supplies are restored within these two hours, unrestricted operation may be resumed. If only one onsite a.c. supply is restored within these two 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 a.c. source. If no onsite a.c. supply is restored within the first two hours of continued power operation, the unit should be brought to a cold shutdown state within the next 36 hours.

5. If the available onsite d.c. supplies are one less than the LCO, power operation may continue for a period that should not exceed two hours. If the affected d.c. supply is restored within these two hours, unrestricted operation may be resumed. If not, the unit should be brought promptly to a controlled shutdown and to a cold shutdown state within the next 36 hours. The required functions of the d.c. system should be critically monitored during the shutdown process and necessary actions taken, such as cross-connecting a supply to a load, if required, to ensure a safe shutdown.

The operating time limits delineated above are explicitly for corrective maintenance activities only. The operating time limits should not be construed to include preventive maintenance activities which require the incapacitation of any required electric power source. Such activities should be scheduled for performance during cold shutdown and/or refueling periods.

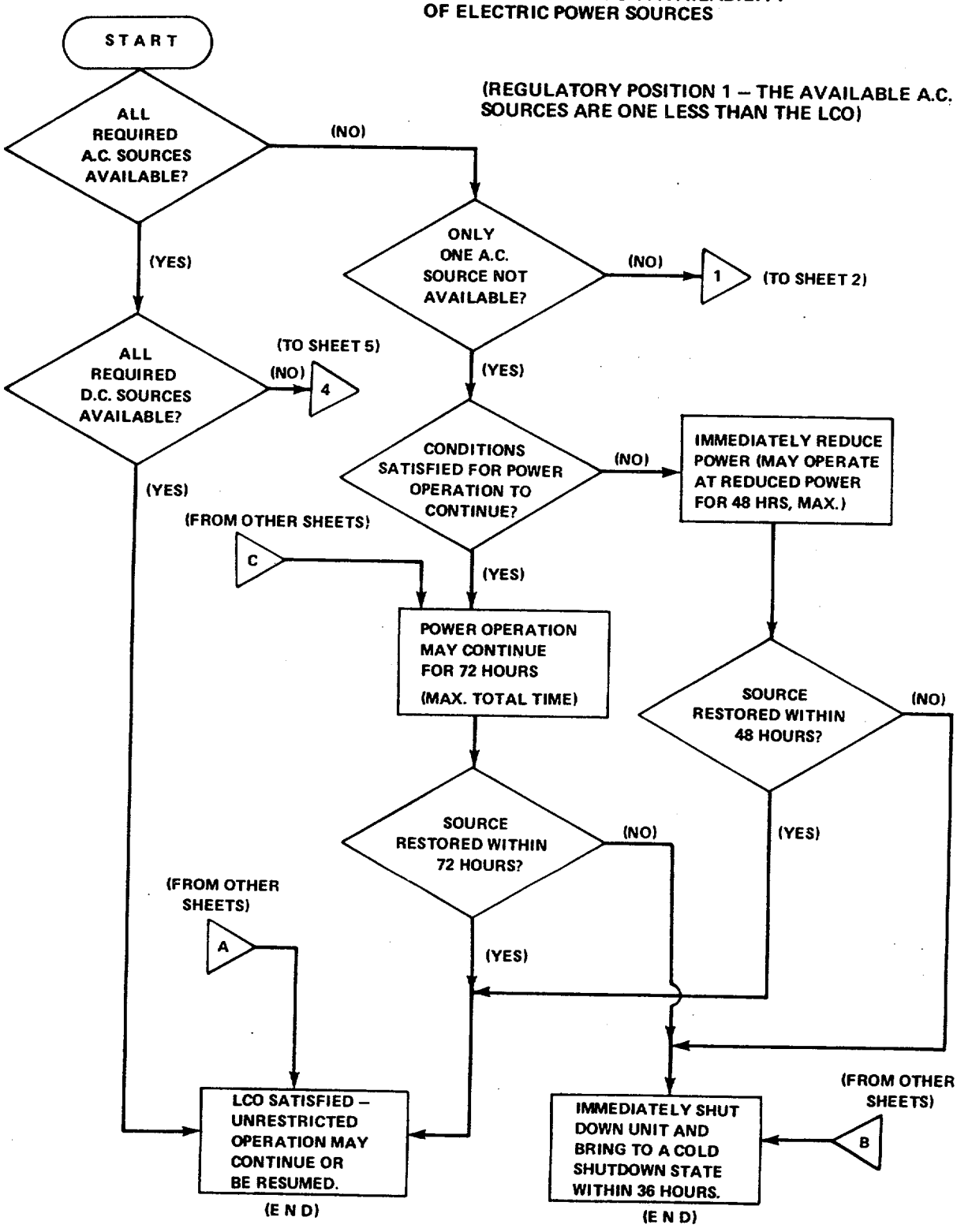
D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the Regulatory staff's plans for utilizing this regulatory guide.

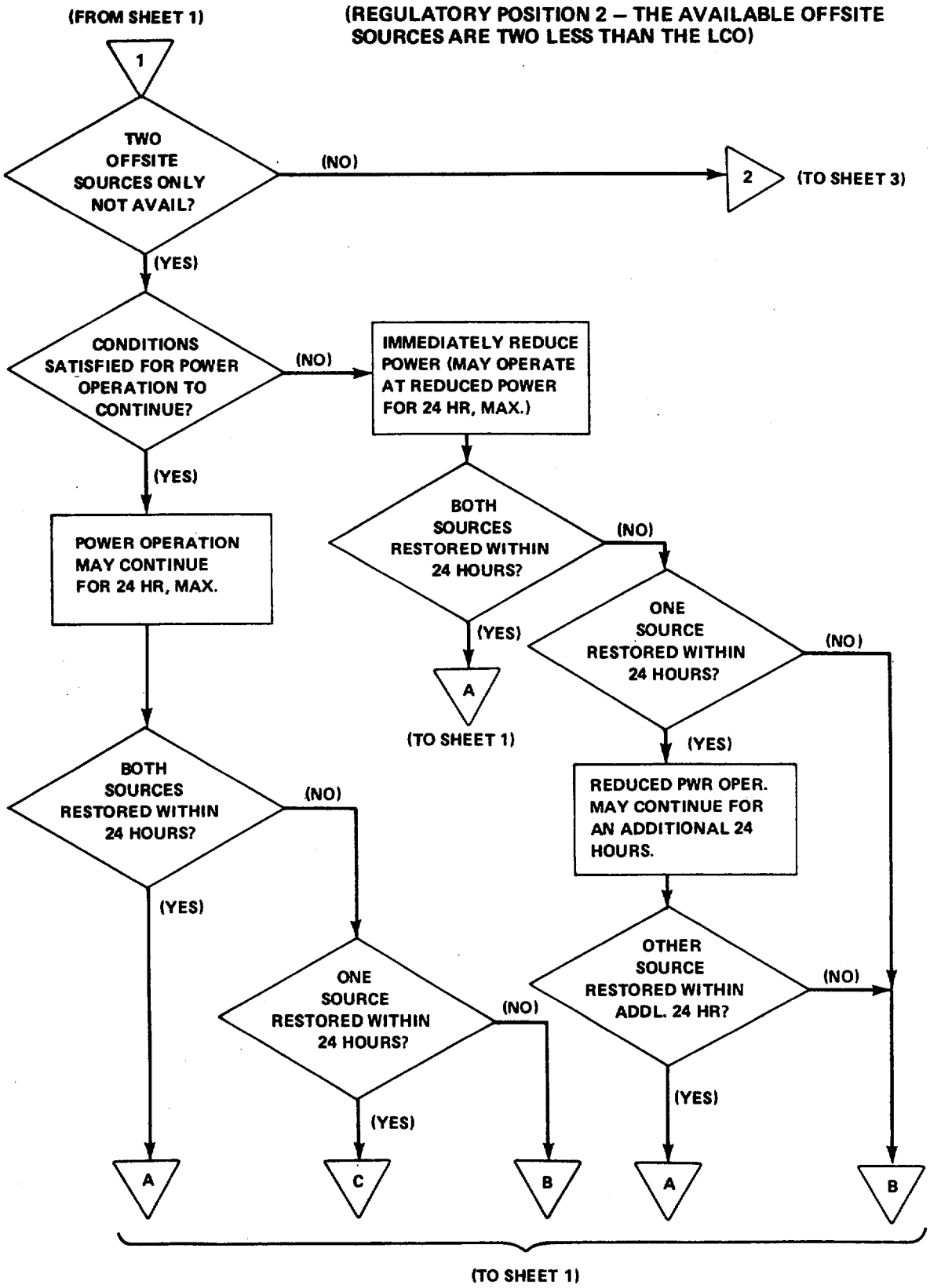
This guide reflects current regulatory practice. Therefore, except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, this guide will be used by the Regulatory staff in evaluating all construction permit applications for which the issue date of the Safety Evaluation Report (SER) is July 1, 1974, or after.

DECISION FLOW DIAGRAM FOR AVAILABILITY OF ELECTRIC POWER SOURCES

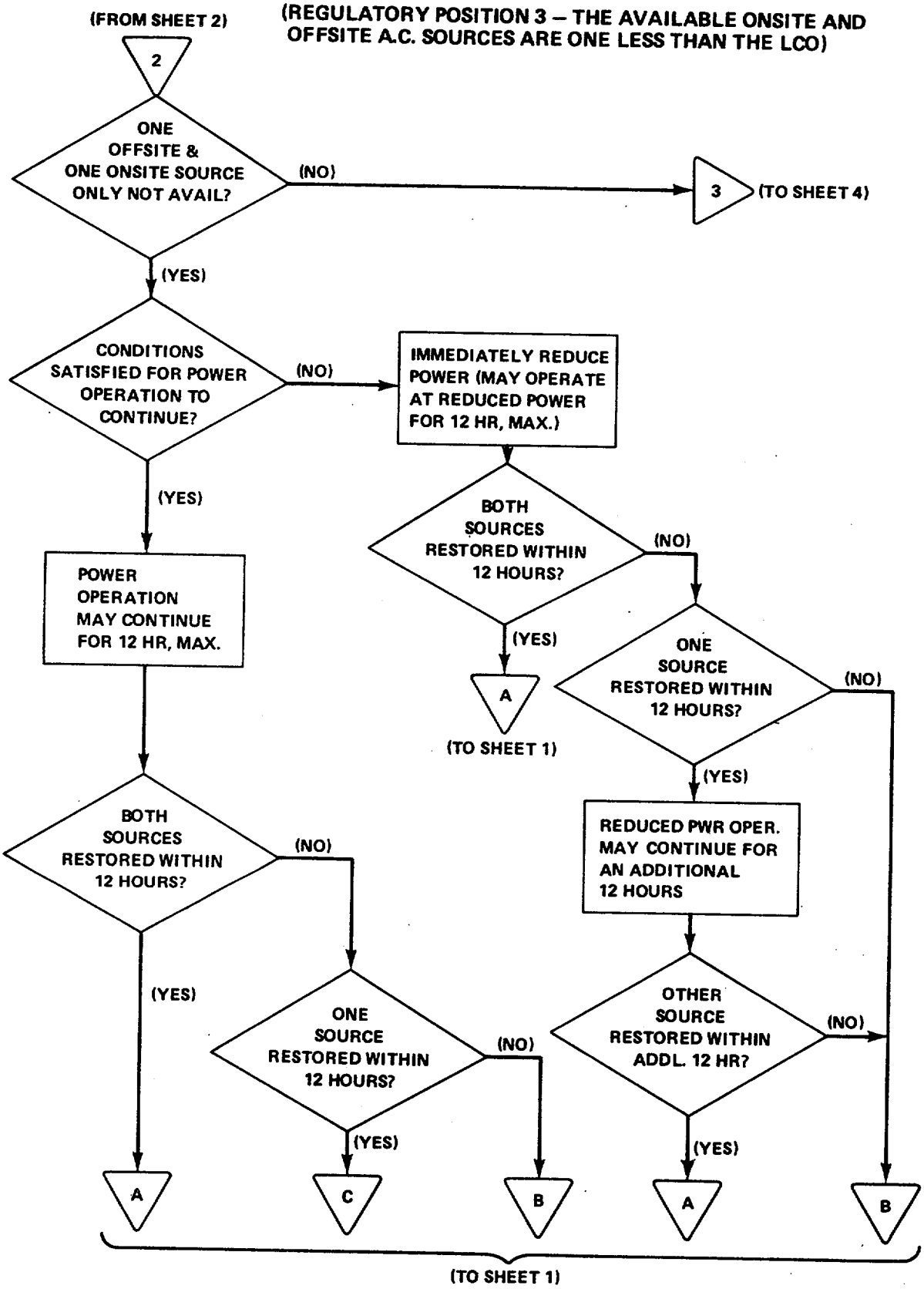
(REGULATORY POSITION 1 – THE AVAILABLE A.C. SOURCES ARE ONE LESS THAN THE LCO)



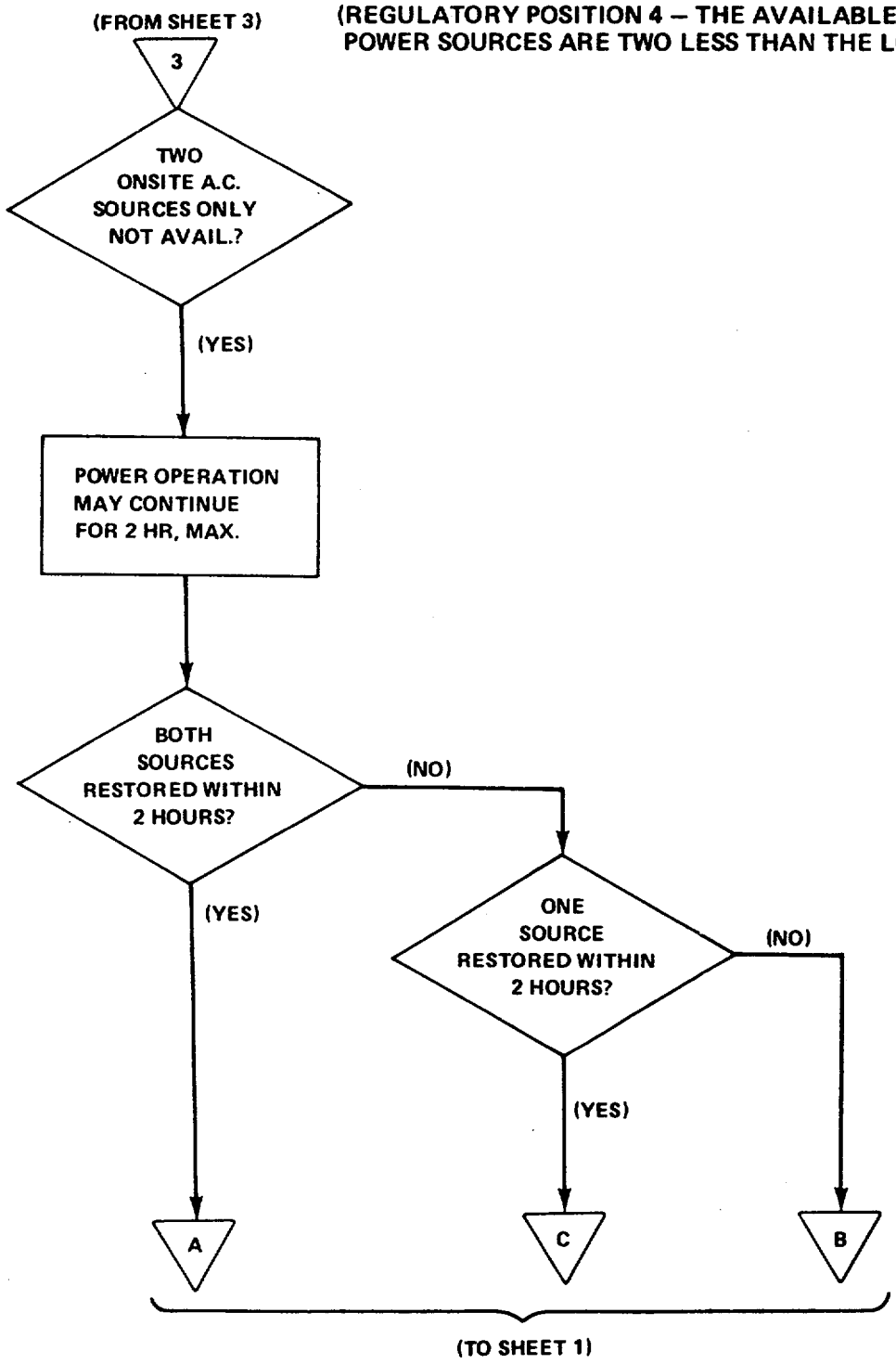
SHEET 1 OF 5


(FROM SHEET 1)
(REGULATORY POSITION 2 – THE AVAILABLE OFFSITE SOURCES ARE TWO LESS THAN THE LCO)
1
TWO OFFSITE SOURCES ONLY NOT AVAIL?
(NO)
2
(TO SHEET 3)
(YES)
CONDITIONS SATISFIED FOR POWER OPERATION TO CONTINUE?
(NO)
IMMEDIATELY REDUCE POWER (MAY OPERATE AT REDUCED POWER FOR 24 HR, MAX.)
(YES)
POWER OPERATION MAY CONTINUE FOR 24 HR, MAX.
BOTH SOURCES RESTORED WITHIN 24 HOURS?
(NO)
(YES)
A
(TO SHEET 1)
ONE SOURCE RESTORED WITHIN 24 HOURS?
(NO)
(YES)
REDUCED PWR OPER. MAY CONTINUE FOR AN ADDITIONAL 24 HOURS.
BOTH SOURCES RESTORED WITHIN 24 HOURS?
(NO)
(YES)
ONE SOURCE RESTORED WITHIN 24 HOURS?
(NO)
(YES)
OTHER SOURCE RESTORED WITHIN ADDL. 24 HR?
(NO)
(YES)
A
C
B
A
B
(TO SHEET 1)

SHEET 2 OF 5


(FROM SHEET 2)
(REGULATORY POSITION 3 – THE AVAILABLE ONSITE AND OFFSITE A.C. SOURCES ARE ONE LESS THAN THE LCO)
2
ONE OFFSITE & ONE ONSITE SOURCE ONLY NOT AVAIL?
(NO)
3
(TO SHEET 4)
(YES)
CONDITIONS SATISFIED FOR POWER OPERATION TO CONTINUE?
(NO)
IMMEDIATELY REDUCE POWER (MAY OPERATE AT REDUCED POWER FOR 12 HR, MAX.)
(YES)
POWER OPERATION MAY CONTINUE FOR 12 HR, MAX.
BOTH SOURCES RESTORED WITHIN 12 HOURS?
(NO)
(YES)
A
(TO SHEET 1)
ONE SOURCE RESTORED WITHIN 12 HOURS?
(NO)
(YES)
REDUCED PWR OPER. MAY CONTINUE FOR AN ADDITIONAL 12 HOURS
BOTH SOURCES RESTORED WITHIN 12 HOURS?
(NO)
(YES)
ONE SOURCE RESTORED WITHIN 12 HOURS?
(NO)
(YES)
OTHER SOURCE RESTORED WITHIN ADDL. 12 HR?
(NO)
(YES)
A
C
B
A
B
(TO SHEET 1)

SHEET 3 OF 5


(FROM SHEET 3)
3
(REGULATORY POSITION 4 – THE AVAILABLE ONSITE A.C. POWER SOURCES ARE TWO LESS THAN THE LCO)
TWO ONSITE A.C. SOURCES ONLY NOT AVAIL.?
(YES)
POWER OPERATION MAY CONTINUE FOR 2 HR, MAX.
BOTH SOURCES RESTORED WITHIN 2 HOURS?
(NO)
(YES)
ONE SOURCE RESTORED WITHIN 2 HOURS?
(NO)
(YES)
A
C
B
(TO SHEET 1)

(REGULATORY POSITION 5 – THE AVAILABLE ONSITE D.C. SUPPLIES ARE ONE LESS THAN THE LCO)