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DRAFT REGULATORY GUIDE

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DRAFT REGULATORY GUIDE DG-1195

(Proposed Revision 1 to Regulatory Guide 1.93, dated December 1974)
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AVAILABILITY OF ELECTRIC POWER SOURCES

A. INTRODUCTION

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 limiting conditions for operation (LCO). This regulatory guide is applicable to single- and multi-unit plants.

In Title 10, Part 50, of the *Code of Federal Regulations* (10 CFR Part 50), "Domestic Licensing of Production and Utilization Facilities,"[1] Section 50.36(d)(2), (10 CFR 50.36(d)(2)) requires that the technical specifications include the LCO, which are defined as the lowest functional capability or performance levels of equipment required for safe operation of the facility. Furthermore, the same regulations require that, when an LCO of a nuclear reactor is not met, the licensee shall shut down the reactor or follow any remedial action the technical specifications permit until the condition can be met.

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] 10 CFR Part 50 is available electronically through the Electronic Reading Room on the NRC=s public Web site, at http://www.nrc.gov/reading rm/doc collections/cfr/. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415 3548; and e mail PDR@nrc.gov.

- 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)
- Redundant onsite alternating current (ac) power sources.
- Redundant onsite direct current (dc) power sources.

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 guide 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.

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 them is not required.

This regulatory guide contains information collection requirements covered by 10 CFR Part 50 approved by the Office of Management and Budget (OMB) 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

Background

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 required by GDC 17 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.

1. Loss of Offsite Power

The technical specifications of operating nuclear power plants include the operational restrictions resulting from the loss of power sources. In general, plant technical specifications 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 (which could potentially degrade the offsite power supplies) 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 technical specification provisions should be followed.

A licensee's ability to comply with technical specifications for offsite power may depend on grid conditions and plant status; in particular, maintenance on, and degraded conditions of, key elements of the plant switchyard and offsite power grid can affect the operability of the offsite power system, especially during times of high grid load and high grid stress. A communication interface with the plant's Transmission System Operator combined with training and other local means to maintain nuclear power plant operator awareness of changes in the plant switchyard and offsite power grid is important to enable the licensee to determine the effects of these changes on the operability of the offsite power system. Analysis tools give the transmission system operator the capability to determine the impact of the loss or unavailability of various transmission system elements (called contingencies) based on the condition of the transmission system. The transmission systems can generally cope with several contingencies without undue impairment of grid reliability, but it is important that the nuclear power plant operator know when the transmission system near the nuclear power plant can no longer sustain plant voltage based on the transmission system operator's analysis of a contingency. This knowledge helps the operator maintain awareness of the nuclear power plant's offsite power system. Additionally, the nuclear power plant operator should know the grid's condition before taking pertinent risk-significant equipment out-of-service, and should monitor it for as long as the equipment remains out-of-service.

For the passive plant designs that are exempted from providing the two offsite ac sources required by GDC 17 or for passive plant designs that fully meet the requirements of GDC 17 are not required to have any technical specification requirements for their offsite ac source(s) because passive plant designs rely on passive safety-related systems for core cooling and containment integrity. These passive safety-related systems only require electric power for valves and the related instrumentation. If no offsite power is available, it is expected that the non-safety-related onsite diesel generators would be available for important plant functions. These non-safety-related diesel generators do not require any technical specification requirements because they are treated under regulato0ry treatment of non-safety systems (RTNSS). The RTNSS basis applies to those non-safety systems that perform risk-significant functions, and therefore, are candidates for regulatory oversight. However, if an offsite power system or a diesel generator is found to be inoperable at these plants, it is expected that the licensees would make a concerted effort to restore inoperable offsite ac source or the diesel generator to operable status within a reasonable time period.

For evolutionary plant designs that have three or four safety trains and have excess redundancy in their onsite power systems, the restrictions imposed on such plants on the loss of required onsite power sources may differ from those recommended in this guide and should be evaluated on a case-by-case basis.

2. Operational Restrictions

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

2.1 Meeting the Limiting Condition for Operation

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.

2.2 Period of Continued Operation

Under certain conditions, it may be safer to continue operation at power for a limited time, rather than to implement 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 unit 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, with appropriate approvals, 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 unit's safety.

2.3 Orderly Shutdown

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 units 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.

3. Levels of Power System Degradation

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

3.1 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 remaining offsite power system retains full capability (voltage, frequency and capacity) to affect 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 availability and reliability are higher for typical offsite power sources. 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. 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, especially when the grid operator uses real-time contingency analysis.

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. The risks associated with such an offsite loss would be compounded because:

- the maintainability advantage of the offsite sources would be lost;
- the remaining offsite circuit could be susceptible to the same cause;
- the consequential trip probability of a number of units would be higher because of the potential loss of loads; and
- 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.

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

3.2 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 typically 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:

- Avoid the risk associated with immediate shutdown.
- 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.

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

This degradation level means that the offsite power system cannot affect 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 (inadequate capacity, voltage, or frequency) 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 below. However, two factors tend to decrease the severity of this degradation level as compared to the next two degradation levels listed. 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 may be justified if an onsite 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 units are designed to cause an automatic shutdown or initiate load rejection at this level of degradation. Units designed to undergo 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.

3.4 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.

3.5 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 the event of a loss of offsite power. In a single unit, this usually means that two diesel generators are inoperable. In multiple units that share onsite ac supplies, this degradation level usually 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:

- Avoid the risk associated with immediate shutdown.
- 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.

3.6 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 unit 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 passive designs that depend heavily on dc power systems for core cooling and containment integrity have batteries that last for 72 hours. The design of batteries to meet the long duration constant current demands that is required of passive designs may have different monitoring requirements (recommended by their manufacturers) than those required in current designs. Therefore, the required functions of these batteries should also be critically monitored during the shutdown period and corrective actions taken, if required, to assure that these batteries will perform their functions for the long duration as designed.

3.7 The Available Inverters Are One Less Than the LCO

This degradation level means that the available inverters do not have the required redundancy; however, the remaining trains of the inverter power system have full functional capability to prevent a reactor trip. Since a subsequent single failure of another inverter could cause a reactor trip, the time allowed for continued operation should be severely restricted. If the affected inverter is restored within this time period, unrestricted operation may resume. If not, the unit should promptly be brought to an orderly shutdown.

The outage times provided in Section C of this regulatory guide reflect an acceptable regulatory practice for designs with two or more onsite ac sources, two or more dc power sources, inverters, and two offsite power sources. Specific outage times are expected to be specified in the technical specifications. Further, the regulatory positions in Section C are based on the grid operators' capabilities to ensure the adequacy of the offsite power system through contingency evaluations, as well as the unit's capabilities to manage risk-significant maintenance and outages.

C. REGULATORY POSITION

The intent of each of the following regulatory positions 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 technical specifications should incorporate the regulatory position for each degraded level. Whenever the technical specifications allow unrestricted operation to resume, such resumption should be contingent on verification of the capability of the restored sources. Similarly, whenever the technical specifications allow power operation to continue during a specific degradation level, such continued power operation should be contingent upon:

a. immediate verification of the availability and capability of the remaining sources;
b. verification that the required maintenance activities do not further degrade the power system or in any way jeopardize plant safety; and
c. compliance with the additional conditions stipulated for each specific degradation level specified in the plant specific technical specifications.

The conduct of 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."

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 the time period allowed for continued operation as specified in the plant specific technical specifications.

If the affected source is restored within the time period specified in the plant specific Technical Specifications, unrestricted operation may resume. Conversely, if the conditions for continued power operation are met, but the source is not restored within the time period specified in the plant specific technical specifications, the unit should be brought to shutdown.

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 time period that should not exceed the time period allowed for continued operation as specified in the plant specific technical specifications, provided the redundant diesel generator is assessed within 24 hours to be free from common-cause failure.

If the affected source is restored within time period specified in the plant technical specifications, unrestricted operation may resume. Conversely, if the conditions for continued power operation are met, but the source is not restored within the time period specified in the plant specific technical specifications, the unit should be brought to shutdown.

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 the time period specified in the plant specific technical specifications 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 the time period specified in the plant technical specifications, unrestricted operation may resume. If only one offsite source is restored within the time period specified in the plant specific technical specifications, power operation may continue for a total time that should not exceed the specified time in accordance with the conditions described in Regulatory Position 1. Conversely, if no offsite source is restored within the first period of continued power operation, the unit should promptly brought to shutdown based on plant specific technical specifications.

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 a short time period as specified in the plant technical specifications.

If these conditions for continued power operation are met and both sources are restored within 12 hours, operation may resume. If either an offsite or an onsite ac source is restored within the time period specified in the plant specific technical specifications, power operation may continue for a total time that should not exceed the time period specified 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 time period of continued power operation, the unit should be brought to shutdown based on plant specific technical specifications.

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 time period specified in the plant specific technical specifications. If both onsite ac electric power sources are restored within this time period unrestricted operation may resume. If only one onsite ac power source is restored within this time period power operation may continue but power operation should not exceed the specified time period, in accordance with the conditions described in Regulatory Position 2 for the loss of one onsite ac source. Conversely, if no onsite ac source can be restored within the first time period of continued power operation, the unit should be brought to cold shutdown based on plant specific technical specifications.

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 the time period specified in the plant specific technical specifications. If the affected dc source is restored within this time period, unrestricted operation may resume. If not, the unit should be brought to hot shutdown based on plant specific technical specifications.

7. The Availability of Inverters Are One Less Than the LCO

If the available inverters are one less than the LCO, power operation may continue for a period that should not exceed the time period specified in the plant specific technical specifications. If the affected inverter is restored within this time period, unrestricted operation may resume. If not, the unit should be brought to hot shutdown based on the time period specified in the plant specific technical specifications.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC's plans for using this draft regulatory guide. The NRC does not intend or approve any imposition or backfit in connection with its issuance.

The NRC has issued this draft guide to encourage public participation in its development. The NRC will consider all public comments received in development of the final guidance document. In some cases, applicants or licensees may propose an alternative or use a previously established acceptable alternative method for complying with specified portions of the NRC's regulations. Otherwise, the methods described in this guide will be used in evaluating compliance with the applicable regulations for license applications, license amendment applications, and amendment requests.

REGULATORY ANALYSIS

1. Statement of the Problem

The NRC published Regulatory Guide 1.93 in December 1974 to provide licensees with guidance for complying with the regulations for the availability of electric power sources in the then current version of 10 CFR Part 50. The implementation of a risk-informed and performance based approach as well as multiple revisions and additions to 10 CFR Part 50 make the current regulatory guide obsolete.

An earlier draft guide [2] (DG-1153) was issued in October 2006 but later withdrawn to resolve multiple comments. The NRC has made major modifications to the earlier draft guide to address these comments and concerns and is issuing this new draft guide to promulgate the NRC's viewpoint. Therefore, revision of this regulatory guidance is issued to provide licensees with more modern guidance that incorporates the risk-informed and performance-based approach currently favored by the NRC.

2. Objective

The objective of this regulatory action is to provide a more useful and up-to-date version of the guidance acceptable to the NRC when the availability of electric power sources is less than the limiting conditions for operation for the facility.

3. Alternative Approaches

The NRC staff considered the following alternative approaches:

- Do not revise Regulatory Guide 1.93.
- Update Regulatory Guide 1.93.

3.1 Alternative 1: Do Not Revise Regulatory Guide 1.93

Under this alternative, the NRC would not revise this guidance, and the original version of this regulatory guide would continue to be used. This alternative is considered the baseline or "no action" alternative and, as such, involves no value/impact considerations.

3.2 Alternative 2: Update the Regulatory Guide 1.93

Under this alternative, the NRC would update Regulatory Guide 1.93, taking into consideration the need to address current regulations and prepare for multiple new license applications. This action would address an important aspect of safe nuclear power plant operation in the event of a loss of power onsite and offsite power sources that result in a failure to meet the LCO. This revised regulatory guide will replace old, outdated, and inapplicable guidance with updated guidance that focuses on a regulatory framework that has changed since Regulatory Guide 1.93 was first written.

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[2] Draft Regulatory Guide DG-1153 is available electronically under Accession Number ML062840370 in the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html. Copies of this draft regulatory guide are available through the NRC's interactive rulemaking Web page (see above); the NRC's public Web site under Draft Regulatory Guides in the Regulatory Guides document collection of the NRC's Electronic Reading Room at http://www.nrc.gov/reading-rm/doc-collections/; and the NRC's Accession No. ML080220459.

The costs to the NRC would be the one time cost of issuing the revised regulatory guide (which is expected to be relatively small) and applicants would incur little or no cost.

4. Conclusion

Based on this regulatory analysis, the staff recommends revision of Regulatory Guide 1.93. The staff concludes that the proposed action will enhance reactor safety by providing a more risk-informed and performance-based approach to the loss of onsite and offsite electrical power sources that result in a failure to meet the LCO. It could also lead to cost savings for the industry, especially with regard to applications for standard plant design certifications and combined licenses.