Attachment 1

Interim Staff Guidance on the Review of Nuclear Power Plant Designs using a Gas Turbine Driven Standby Emergency Alternating Current Power System

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CONTENTS

ARTICLE 1: INTRODUCTION

Emergency diesel generators (EDGs) are widely used as the standby emergency power sources for the onsite alternating current (AC) power system. It is anticipated that new reactor designs will incorporate gas turbines to supply the standby emergency AC power system. This Interim Staff Guidance (ISG) document applies to applications for design certification or combined license applications for new reactors and provides guidance on the implementation of emergency gas turbine generators (EGTGs) used as AC power sources to supply power to safety-related equipment or equipment important to safety for all operational events and during accident conditions. Only EGTG systems that are air cooled and fueled by fuel oil are considered in this interim guidance ("fuel oil" refers to diesel fuel oil in accordance with ASTM D975).

This ISG is divided into a number of different articles. Article 1 of the ISG presents an overview of the differences and similarities of an EGTG and an EDG. This article also provides an introduction to this ISG document.

Article 2 presents a guide to the design and testing of an EGTG for emergency standby operation at a nuclear power plant (NPP). It endorses Institute of Electrical and Electronics Engineers (IEEE) 387-1995 (Reference 1), with a number of exceptions. Many of these exceptions are due to the fact that IEEE 387-1995 is written specifically for diesel standby power systems. Article 2 is formatted similarly to Regulatory Guide (RG) 1.9 (Reference 2), which was written to guide the testing of diesel engines.

The remaining articles are formatted similarly to the current U.S. Nuclear Regulatory Commission (NRC) standard review plan (SRP) sections that were written for EDGs and provide companion guidance applicable to plants adopting EGTGs. Article 3 is a review guide to the NRC staff (and NPP license applicants) on how to perform a thorough review of AC power systems. It is formatted similarly to SRP Section 8.3.1 (Reference 3), which was written for NPPs with an EDG. Much of Article 3 refers back to Article 2 of this report.

Articles 4 through 8 are a set of interim review guides to the NRC staff (and NPP applicants) on how to perform a thorough review of support systems for the EGTG. These are formatted similarly to SRP Sections 9.5.4 through 9.5.8 (References 4, 5, 6, 7, and 8), which were written for NPPs with an EDG. In general, these articles are virtually identical to the existing SRP sections since the support systems for an EGTG are very similar to the support systems for an EDG. However, some of these differences are significant and are highlighted in Articles 4 through 8.

NPPs are required to have redundant onsite emergency power sources of sufficient capacity and capability to power safety-related equipment. Within the current fleet of NPPs, EDGs are used to provide this power. It is anticipated that some new reactor designs will incorporate an EGTG for the onsite power system. This interim guidance document provides a collection of articles that address the review of EGTG system design to ensure that it is consistent with the intent of Title 10 of the *Code of Federal Regulations*, Part 50 and Part 52 (10 CFR Part 50 and

Part 52). The emergency power system should be reliable so that its operation can support the safety functions of the NPP during all normal and accident conditions.

There are many similarities between an EDG and an EGTG. First, the generators are quite similar. Possibly they are identical with the exception of a few parameters defining the control systems due to the increased rotational inertia with the gas turbine-driven system. The gas turbine can run on diesel fuel, and if this is the case the fuel supply systems are quite similar. The lubrication system would also be quite similar. The power capability of a gas turbine, like a diesel engine, is dependent upon the local pressure and temperature level. However, the functional relationship is somewhat different.

Differences between the design of gas turbines and diesel engines result in differences in their operation, design and maintenance. The most obvious difference is that the gas turbine is made up of different components. It is classically divided into a compressor, a combustor and a turbine. It does not include a turbocharger and a flywheel that are typical components of a diesel engine. It also typically will not include a jacket water system for cooling. Different components will result in different design considerations.

There is a conceptual difference that distinguishes a gas turbine from a diesel engine. The diesel engine is a cyclic device, while the gas turbine is essentially a steady state device. This allows for easier monitoring of gas turbine operations. More accurate instrumentation can be included in the gas turbine design, which permits more accurate determination of the operational state of the gas turbine. Direct measurements of temperature, pressure and vibration can be made, which in turn can determine the efficiency of the various processes. This then allows for better management of system operation and maintenance. Overhauls and anti-fouling operations can be scheduled based on operational measurements instead of calendar time. Measurability of operational parameters allows many more potential trip signals that can be used to stop gas turbine operations.

The starting sequence of a gas turbine is different than that of a diesel engine. Typically, a gas turbine is purged with air prior to the introduction of fuel to the combustor to prevent explosions. Also, a gas turbine has a significantly longer coast down time from rotational operations. Since it is typically started from rest (or near rest) restart operations can be locked out for a significant time period. And since the gas turbine operates at a much higher rotational speed it takes much longer to reach operating speed.

The high rotational speed results in a greater potential for missiles being generated from a gas turbine. Nearby safety-related equipment must be protected from the possibility of missiles. Also, a gas turbine requires a gear box to couple to a synchronous generator.

A gas turbine comes in many sizes. A typical size that might be considered for application as a standby emergency power source at a NPP will often use roller bearings. This is in contrast to the use of journal bearings in a diesel engine. A roller bearing still requires lubrication, but will not typically require pre-warming or pre-filling of the lubrication lines that are typical operations in a diesel engine designed for standby operation.

Due to the cyclic explosions in a diesel engine, the vibration level is much higher than in a gas turbine. This allows for using the vibration level as a diagnostic in a gas turbine system. In theory, the vibration level can indicate when the bearings are going bad. However, in practice this is not always accomplished due to the rapid nature of bearing failure. A gas turbine typically operates at a speed above the first resonance. Thus, the system must be designed to accelerate past the first resonance to obtain operational speeds.

Since the gas turbine includes more air than stoichiometrically required, the gas temperatures within the turbine are not as high as in the diesel engine. Thus, the cooling system is much simpler and less critical. Typically water cooling is not used.

A gas turbine generally has an air cooling system that passes air through the EGTG enclosure and an air cooler to provide cooling for the lubrication system.

A gas turbine may run on a variety of fuels. In fact a single machine will be capable of using more than one fuel. If diesel fuel is used in the gas turbine, it must be atomized, but the spray is a steady flow and need not be timed to the cylinder position as in a diesel.

The overhaul of a gas turbine is a significantly different process than what is typically done for a diesel engine. A gas turbine overhaul typically involves a replacement of the complete compressor/combustion/turbine assembly with a new or rebuilt cartridge. Hence, few operations are performed on site resulting in a much shorter down time for an overhaul.

References for Article 1

1) IEEE 387-1995, “IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations,” IEEE, Piscataway, NJ, 1995.

2) RG 1.9, “Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants,” Revision 4, March 2007, NRC, Washington, DC.

3) NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” Section 8.3.1, “AC Power Systems (Onsite),” March 2007.

4) NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” Section 9.5.4, “Emergency Diesel Engine Fuel Oil Storage and Transfer System,” March 2007.

5) NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” Section 9.5.5, “Emergency Diesel Engine Cooling Water System,” March 2007.

6) NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” Section 9.5.6, “Emergency Diesel Engine Starting System,” March 2007.

7) NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” Section 9.5.7, “Emergency Diesel Engine Lubrication System,” March 2007.

8) NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” Section 9.5.8, “Emergency Diesel Engine Combustion Air Intake and Exhaust System,” March 2007.

ARTICLE 2: APPLICATION AND TESTING OF SAFETY-RELATED GAS TURBINE GENERATORS IN NUCLEAR POWER PLANTS

EDGs are widely used as the standby emergency power sources for the onsite AC power system in NPPs, and their testing is covered in RG 1.9 (Reference 1). RG 1.9 endorses IEEE 387-1995 (Reference 4) with a number of exceptions. It is anticipated that new reactor designs will incorporate EGTGs to supply the emergency AC power system. This ISG document provides guidance on the testing of EGTGs used as AC power sources to supply power to safety-related equipment or equipment important to safety for all operational events and during accident conditions. This guide also endorses IEEE 387-1995, with a number of exceptions and is formatted as a companion document to RG 1.9 for NPPs with EGTGs. Only EGTG systems that are air cooled and fueled by fuel oil are considered in this ISG.

A. INTRODUCTION

General Design Criterion (GDC) 17, “Electric Power Systems,” of Appendix A, “General Design Criteria for Nuclear Power Plants,” to 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities” (Reference 2), requires that onsite electric power systems have sufficient independence, capacity, capability, redundancy, and testability to ensure that (1) specified acceptable nuclear fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences, and (2) the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents, assuming a single failure.

GDC 18, “Inspection and Testing of Electric Power Systems,” of Appendix A to 10 CFR Part 50 requires that electric power systems important to safety be designed to permit appropriate periodic inspection and testing to assess the continuity of the systems and the condition of their components.

Criterion III, “Design Control,” and Criterion XI, “Test Control,” of Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants,” to 10 CFR Part 50 require that (1) measures be provided for verifying or checking the adequacy of design through design reviews, the use of alternative or simplified calculational methods, or the performance of a suitable testing program and (2) a test program be established to ensure that systems and components perform satisfactorily and that the test program include operational tests during NPP operation.

10 CFR Section 50.63, “Loss of All Alternating Current Power,” requires that each light-water-cooled NPP must be able to withstand and recover from a station blackout (SBO) (i.e., loss of offsite and onsite emergency AC power systems) for a specified duration. The reliability of onsite AC power sources is one of the main factors contributing to the risk of core melt as a result of a SBO.

Currently, most onsite AC electric power systems use EDGs as the chosen standby onsite emergency AC power source. However, it is anticipated that EGTGs will be chosen for some of the new power reactors being considered. This ISG document provides guidance that the NRC staff considers acceptable to comply with the Commission's regulations for safety-related EGTGs intended for use as standby onsite emergency power sources in NPPs — specifically, that the EGTGs to be selected and installed at NPPs have sufficient capacity, and capability, be qualified, and have the necessary reliability and availability for operational and design-basis events (DBEs).

B. DISCUSSION

An EGTG selected for use as standby emergency power source for the onsite electric power system should have the capacity and capability to (1) start and accelerate a number of large motor loads in rapid succession, while maintaining voltage and frequency within acceptable limits, (2) provide power promptly to ESFs if a loss of offsite power (LOOP) and a DBE occur during the same time period, and (3) supply power continuously to the equipment needed to maintain the plant in a safe condition if an extended (e.g., 30-day period should be considered with refueling every 7 days) LOOP occurs.

IEEE 387-1995 (Reference 4) delineates principal design criteria and qualification and testing guidelines to ensure that selected EDGs meet performance requirements. Working Group SC 4.2 of Subcommittee 4 (Auxiliary Power) of the IEEE Nuclear Power Engineering Committee developed IEEE 387-1995, and the IEEE Standards Board approved the standard on December 2, 1995. RG 1.9 (Reference 1) issued by the NRC, incorporates much of IEEE 387-1995.

While RG 1.9 (and IEEE 387-1995) specifically addresses internal combustion diesel engine driven generators, many of the concepts are directly applicable to an EGTG. This ISG is designed as a companion document to RG 1.9, to be used by any NPP that incorporates an EGTG for standby emergency AC power applications. Differences between the design of an EGTG and an EDG result in some differences in how they are run, monitored, and maintained. A diesel engine operates as a four cycle piston engine. The state inside the piston is cyclic, and thus difficult to measure. Any location inside an EGTG is nearly constant and a steady thermodynamic state exists. This difference makes determination of the operating conditions of the EGTG easier since the diagnostic instrumentation need only record a steady value.

A knowledge of the characteristics of each load is essential to establish the bases for selection of an EGTG that is able to accept large loads in rapid succession. The majority of these emergency loads are large induction motors. At full voltage, this type of motor draws a starting current of five to eight times its rated full-load current. These sudden large increases in current drawn from the EGTG as a result of the startup of induction motors can result in substantial voltage reductions. This lower voltage could prevent a motor from starting (i.e., accelerating its load to rated speed in the required time), or could cause a running motor to coast down or stall. Other voltage-sensitive loads might also be lost because of low voltage or if their associated contactors drop out. Recovery from the transient caused by starting large motors, or from the loss of a large load, could cause EGTG overspeed that, if excessive, might result in a trip of the EGTG (i.e., loss of the safety-related power source). These same consequences can also result from the cumulative effect of a sequence of more moderate transients if the system is not permitted to recover sufficiently between successive steps in a loading sequence.

General industry practice is to specify a voltage reduction of 10–15 percent when starting large motors from large-capacity power systems, and a maximum voltage reduction of 25–30 percent when starting these motors from limited-capacity power sources such as EGTGs. Voltage reduction during load sequencing should be evaluated in light of the plant-specific equipment to prevent load interruption. Large induction motors can achieve rated speed in less than 5 seconds when powered from adequately sized EGTGs that are capable of restoring the bus voltage to 90 percent of nominal in about 1–2 second(s).

Protection of the EGTG from excessive overspeed, which can result from an improperly adjusted control system or governor failure, is provided by the immediate operation of an EGTG trip, which is usually set at 115 percent of nominal speed. Similarly, to prevent substantial damage to the generator, the generator differential current trip must operate immediately upon occurrence of an internal fault. Due to the ease in measuring the state of a gas turbine, an EGTG in industry typically has more trip channels than these two. These additional protective trips can also safeguard the EGTGs from possible damage. However, these trips could interfere with successful functioning of the EGTGs when they are most needed (i.e., during DBEs).

It is possible that these additional protective trips would needlessly shut down EGTGs because of spurious operation of a trip circuit. Consequently, it is important to take measures to ensure that spurious actuation of these other protective trips does not prevent the EGTGs from performing their safety function during the emergency mode of operation.

The uncertainties inherent in safety load estimates at an early stage of design or prior to the issuance of a combined license (COL) are sometimes of such magnitude that it is prudent to provide a large margin in selecting the load capabilities of the EGTGs. This margin can be provided by estimating the loads conservatively and by selecting the continuous rating of the EGTGs that exceeds the sum of the loads needed at any one time. The safety load calculation should be verified prior to reactor fuel load based on the as-purchased equipment and as-built facility, as well as on factory and preoperational testing of equipment powered by the EGTGs.

The reliability of EGTGs can be one of the main factors affecting the risk of core damage from an SBO event. Thus, both attaining and maintaining the high reliability of EGTGs at NPPs contribute greatly to reducing the probability of SBO. RG 1.155, “Station Blackout” (Reference 5), calls for the use of the reliability of the generator as one of the factors in determining the length of time a plant should be able to cope with an SBO. If all other factors (i.e., redundancy of EGTGs, frequency of LOOP, and probable time needed to restore offsite power) remain constant, a higher reliability of the EGTGs will result in a lower probability of a SBO, with a corresponding decrease in coping duration for certain plants.

The design of the EGTGs should also incorporate high operational reliability, and this high reliability should be maintained throughout their lifetime by initiating a reliability program that is designed to monitor, improve, and maintain reliability. Increased operational reliability can be achieved through appropriate testing and maintenance, as well as an effective root cause analysis of all EGTG failures. Like most complex systems, performance will degrade with time. However, due to the ease of diagnostic measurements in an EGTG, this degradation is more clearly evident. A trending analysis will help determine the condition of the EGTG components and allow scheduling of maintenance in a timely fashion.

This guide provides explicit guidance in the areas of preoperational testing, periodic testing, reporting and recordkeeping requirements, and valid demands and failures. The preoperational and periodic testing provisions set forth in this guide provide a basis for taking the corrective actions needed to maintain high inservice reliability of installed EGTGs. The database developed will assist ongoing performance monitoring for all EGTGs after installation and during service.

Clause 2 of IEEE 387-1995 references several industry codes and standards. If a referenced standard has been separately incorporated into the NRC's regulations, licensees and applicants must comply with that standard as set forth in the regulations. Similarly, if the NRC staff has endorsed a referenced standard in a RG, that standard constitutes an acceptable method of meeting a regulatory requirement as described in the given RG as applicable to EGTGs in standby service. Conversely, if a referenced standard has been neither incorporated into the NRC's regulations nor endorsed in a RG, licensees and applicants may consider and use the information in the referenced standard, if appropriately justified, consistent with regulatory practice.

Additional standards applicable to a gas turbine should be added to the IEEE 387 list. They are presented here:

1) International Standardization Organizational (ISO) 3977-3, "Gas Turbine Procurement Part 3 Design Requirements," August 18, 2004[1].

2) American Society of Mechanical Engineers (ASME) PTC 22-2005 "Performance Test Code on Gas Turbines," May 30, 2006[2].

C. REGULATORY POSITION

Conformance with the guidelines in IEEE 387-1995 (Reference 4), as they apply to EGTGs, constitutes an acceptable method for satisfying the Commission's regulations with respect to the design, qualification, and periodic testing of EGTGs used as standby emergency onsite electric power systems for NPPs, subject to the following exceptions and clarifications. Some of these exceptions and clarifications are a reiteration of the guidance contained in RG 1.9. This is because there are many similarities between an EDG and an EGTG. Others are introduced in order to address the design differences between the EDG and the EGTG.

1. Design Considerations

The following regulatory positions supplement the guidelines of IEEE 387-1995, as they relate to design considerations:

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[1] ISO publications are available from International Organization for Standardization, 1, ch. De la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland.

[2] ASME publications are available from the ASME, Three Park Ave., New York, NY 10016.

1.1 Clause 1.1.1, “Inclusions,” of IEEE 387-1995 should be supplemented to include EGTG auto controls, manual controls, and generator output breaker. It should also include the compressor, combustor and turbine. An EGTG typically would not include a flywheel, which is listed in IEEE 387-1995.

1.2 When the characteristics of the required EGTG loads are not accurately known, such as during an early stage of design (e.g., during design certification or combined license application), each EGTG selected for an onsite power supply system should have a continuous load rating (as defined in Section 3.2 of IEEE 387-1995) equal to the sum of the conservatively estimated connected loads (nameplate rating) that the EGTG would power at any one time, plus a 10- to 15-percent margin. In the absence of fully substantiated performance characteristics for mechanical equipment such as pumps, the electric motor drive ratings should be calculated using conservative estimates of these characteristics (e.g., pump runout conditions and motor efficiencies of 90 percent or less, and power factors of 85 percent or less).

1.3 The maximum design basis loads should be within the continuous rating (as defined in Section 3.2 of IEEE 387-1995) of the EGTG with sufficient margin (i.e., not less than 5 percent).

1.4 All design load calculations should take into account the site elevation and the worst case (typically hottest) atmospheric temperature conditions consistent with industry standards (i.e. Reference 6 or 10).

1.5 EGTG systems may include evaporative inlet air coolers and water injection. These subsystems may add to the maximum load that can be supported. However, they also add complexity to the system. All design load calculations should not take into account any additional power available due to the operation of these subsystems.

1.6 Clause 4.1.2 of IEEE 387-1995 pertains, in part, to the starting and load-accepting capabilities of the EGTG. In conformance with Clause 4.1.2, each EGTG should be capable of starting and accelerating to rated speed, in the required sequence, all the needed ESFs and emergency shutdown loads. The EGTG should be designed such that the frequency will not decrease, at any time during the loading sequence, to less than 95 percent of nominal and the voltage will not decrease to less than 75 percent of nominal (A larger decrease in voltage and frequency may be justified for an EGTG that carries only one large connected load.). Frequency should be restored to within 2 percent of nominal in less than 60 percent of each load-sequence interval for a stepload increase, and less than 80 percent of each load-sequence interval for disconnection of the single largest load. Voltage should be restored to within 10 percent of nominal within 60 percent of each load-sequence interval. The acceptance value of the frequency and voltage should be based on plant-specific analysis (where conservative values of voltage and frequency are measured) to prevent load interruption (A greater percentage of the load-sequence interval may be used if it can be justified by analysis. However, the load-sequence interval should include sufficient margin for the accuracy and repeatability of the load-sequence timer.). During recovery from transients caused by disconnection of the largest single load, the speed of the EGTG should not exceed the nominal speed plus 75 percent of the difference between nominal speed and the overspeed trip set point, or 115 percent of nominal (whichever is lower). Furthermore, the transient following a complete loss of load should not cause the EGTG speed to reach the overspeed trip set point.

1.7 EGTGs should be designed so that they can be tested as described in Regulatory Position 2. The design should allow testing of the EGTGs to simulate the parameters of operation (e.g., manual start, automatic start, load sequencing, load shedding, and operation time), normal standby conditions, and environments (e.g., temperature, humidity) that would be expected if actual demand were placed on the system. If pre-lubrication systems or pre-warming systems designed to maintain lube oil at certain temperatures (or both) are normally in operation, this would constitute normal standby conditions for the given plant.

1.8 Clause 4.2.2 of IEEE 387-1995 defines a number of precautions that limit the operations of EDGs. These are not directly applicable to operation of an EGTG system. During testing the plant operator should follow guidelines provided by the EGTG manufacturer to assure reliable long term operation.

1.9 Table 1 of IEEE 387-1995 defines a number of design and application considerations. Most of these are applicable to both EDGs and EGTGs. However, a few additional design considerations should be noted that apply directly to EGTG designs.

1.9.1 Missiles: The high rotational speeds of EGTGs may result in the creation of missiles upon failure of the rotational parts. Thus, all nearby safety-related equipment should be protected from the potential of missiles generated from an EGTG rotor. Protection of other nearby EGTG systems is required, but protection of subsystems associated with the same EGTG unit that incurs the failure is not required since failure of the rotor will make further use of these subsystems irrelevant (as long as these subsystems are not shared).

1.9.2 Turning motor: The turning motor should be used during all periods when the rotor is not driven by the working fluid and the rotor is hot as specified by the manufacturer. This includes periods after all operational modes.

1.9.3 Inlet freezing: Since the EGTG typically uses a larger volume of combustion air than an EDG; the pressure loss associated with the air intakes may be significant. The EGTG design should consider the local environment and the possibility of condensation of moisture from the ambient humidity. The design should also consider humid air and condensed moisture generated by wet cooling towers or other equipment onsite. During cold periods, ice may form on the inlet structures and impede the air flow. When there is a potential for low ambient temperatures an automatic de-icing system should be installed.

1.9.4 Safety: The system equipment should be designed to not fail due to overspeed resulting from the following:

i) instantaneous loss of maximum load with the fuel control valve failed in the full open position

ii) instantaneous loss of maximum load from the failure of the drive coupling (e.g. shear pin failure)

If the system trips due to the overspeed during startup, this will count as a start failure (as defined in Section 2.1).

1.9.5 Fire Protection: An automatic fire protection system should be installed inside of the enclosure consistent with the protection described in RG 1.189 (Reference 7) for EDGs.

1.9.6 The EGTG typically operates above the lowest natural frequency of the rotor. Thus, upon startup, the system must accelerate through the lowest natural frequency. The startup reliability should include the failures due to excessive vibration upon acceleration.

1.9.7 The system should permit rapid (as compared to the time demands of the NPP safety scheme) restarting from any condition without requiring a lengthy coast down period. This may be accomplished by including a mechanical or electrical braking system that can be manually activated by the operator in the Main Control Room (MCR) if necessary. Many EGTGs are not able to restart until the rotor is stopped or rotating very slowly.

1.9.8 The starting system should include an automatic gas purge of the turbine to prevent damage of the same and downstream components. The purge volume should be sized to replace three volumes of air.

1.9.9 Inlet air filter design should include a bypass door which opens automatically on high differential pressure across the filter.

1.10 Table 1 of IEEE 387-1995 defines a number of design and application considerations that are applicable to both EDGs and EGTGs. The list presented below is equally applicable to EDG and EGTG designs.

1.10.1 "Push to test" indicator lights should be used to ease verification of system status.

1.10.2 The initial design and maintenance schedule should reflect the extensive testing that will be required of the system. Rapid cold starts are especially damaging to system components (Reference 8).

1.10.3 The fuel stability should be considered for fuel storage. This is especially of concern when ultra-low-sulfur diesel fuel or biodiesel blends are used (References 9 and 11).

1.11 Design provisions should include the capability to test each EGTG independently of the redundant units. Test equipment should not cause a loss of independence between redundant EGTGs or between EGTG load groups. Testability should be considered in selecting and locating instrumentation sensors and critical components (e.g., governor, starting system components). Instrumentation sensors should be readily accessible and designed so that their inspection and calibration can be verified in place. The overall design should include status indication and alarm features.

1.12 Clause 4.5.3.1 of IEEE 387-1995 pertains to status indication of EDG unit conditions and should be applied to EGTG systems. The following paragraphs should supplement the guidance in this clause:

1.12.1 A surveillance system should be provided with a remote indication in the control room to display EGTG status (i.e., under test, ready-standby, lockout). A means of communication should also be provided between EGTG testing locations and the MCR to ensure that the operators know the status of the EGTG under test.

1.12.2 To facilitate the diagnosis of failure or malfunction, the surveillance system should indicate which of the EGTG protective trips has been activated first and which of multiple sensors caused/triggered the fault.

1.12.3 If a trip sensor detects a fault, but the coincident logic or trip bypass state does not yield a trip, an alarm should alert the operator of the potential fault condition.

1.13 Clause 4.5.3.3 of IEEE 387-1995 identifies the subsystems that require instrumentation for determination of the operating condition of an EDG. Due to the design differences between the EDG and the EGTG, additional subsystems should be monitored. In an EGTG, the compression, combustion and expansion processes should be monitored separately to allow a better understanding of the system state. Thus, the compressor system, combustion system and the turbine system should be added as items l, m and n on the list.

1.14 The following should supplement Clause 4.5.4 of IEEE 387-1995, which pertains to bypassing EGTG protective trips during emergency conditions:

The EGTG should be tripped automatically on turbine overspeed and generator-differential overcurrent. A trip should be implemented with two or more measurements for each trip parameter with coincident logic provisions for trip actuation. The design of the coincident logic trip circuitry should include the capability to indicate individual sensor trips. The design of the bypass circuitry should include the capability to (1) test the status and operability of the bypass circuits, (2) trigger alarms in the control room for abnormal values of all bypass parameters (common trouble alarms may be used), and (3) manually reset the trip bypass function. The capability to automatically reset the bypass function is not acceptable because the cause of any trip should be adequately assessed and corrected prior to any reset of the trip bypass. Clause 4.5.4(b) of IEEE 387-1995 which pertains to retaining all protective devices during emergency generator testing, does not apply to periodic tests [safety injection actuation system (SIAS), combined with SIAS and LOOP, and protective trip bypass] that demonstrate generator system response under simulated DBEs.

1.15 Clause 4.5.2.2 of IEEE 387-1995 should be modified to read as follows:

Upon receipt of an emergency start-EGTG signal, the automatic control system should provide automatic startup and automatic adjustment of speed and voltage to a ready-to-load condition in the emergency mode.

1.16 Annex C of IEEE 387-1995 provides further insight and guidance into creating a trending analysis. This is acceptable to the NRC staff. However, many of the parameters defined to monitor in Table C.1 (of IEEE 387-1995) are not applicable to EGTGs. For example all of the references to a cooling water system may not be applicable to most EGTG designs. Since an EGTG is much more amenable to parameter monitoring, many more measurements are typically made to determine the state of the EGTG. Table 4 (of IEEE 387-1995), as modified in Section 2.2.1 of this document below, should be used to identify a recommended set of parameters to monitor. The following items observed under a standard load indicate the need for an overhaul:

a. increasing exhaust gas temperature
b. increasing vibration
c. decreasing run out time after shutdown
d. fouling of compressor blades (as inferred from comparison to ideal model results)
e. deposits or deterioration of turbine blades or vanes (as inferred from ideal model results)

2. Gas Turbine Generator Testing

Table 1 identifies those safety-related components and systems that should be considered to be within the EGTG boundary when evaluating failures. Systems that support the EGTG and perform other plant functions are depicted as being outside this boundary. IEEE 387-1995 provides similar definitions of components and system boundaries and may also be used as guidance; however, generator breakers should be considered as within the EGTG boundary.

Table 1: EGTG System Components

EGTG System Safety-Related Components
Compressor air intake system
Compressor
Combustor
Turbine
Governor
Cooling system
Lubrication system
Fuel system
Turbine exhaust system
Starting system
Instruments and alarms
Trips and controls
Generator Safety-Related Components
Generator
Exciter and voltage regulator
Local control and protective systems
GTG output breaker

Clauses 3, 5, 6, and 7 of IEEE 387-1995 should be supplemented as discussed below.

2.1 Definitions

The following definitions apply to the regulatory positions within this document that address testing, recordkeeping, and reporting of EGTG performance:

Load-run demands: To be valid, the load-run attempt should follow a successful start and meet one of the following criteria (see the exceptions below):

- A load-run of any duration that results from a real (i.e., not a test) automatic or manual signal.

- A load-run test to satisfy the plant's load and duration test specifications.

- Other operations (e.g., special tests) in which the EGTG is planned to run for at least 1 hour with at least 50 percent of design loads.

Load-run failures: A load-run failure should be counted when the EGTG starts but does not pick up the load and run successfully. Any failure during a valid load-run demand should count (see the exceptions below). (For monthly surveillance tests, the EGTG can be loaded at the rate recommended by the manufacturer to minimize stress and wear.) Any condition identified during maintenance inspections (with the EGTG in the standby mode) that definitely would have resulted in a load-run failure if a demand had occurred should count as a valid load-run demand and failure.

Split Shaft: Some EGTG designs incorporate two shafts. One supports the low pressure portion of the turbine and is connected to the generator. The second supports the compressor and the high pressure portion of the turbine (which drives the compressor). Each shaft is allowed to rotate at a different speed. This is done to better accommodate variable load conditions.

Start demands: All valid and inadvertent start demands, including all start-only demands and all start demands that are followed by load-run demands, whether by automatic or manual initiation, are start demands. In a start-only demand, the EGTG is started, but no attempt is made to load the EGTG (see the exceptions below).

Start failures: Any failure within the EGTG system that prevents the generator from achieving a specified frequency (or speed) and voltage within specified time allowance is classified as a valid start failure. (For monthly surveillance tests, the EGTG can be brought to rated speed and voltage in the time recommended by the manufacturer to minimize stress and wear.) Any condition identified during maintenance inspections (with the EGTG in the standby mode) that would definitely have resulted in a start failure if a demand had occurred should count as a valid start demand and failure.
Turning motor: A motor designed to slowly rotate the EGTG rotor, typically only used during cooldown. This will allow the rotor to cool down from its operational temperature to the ambient temperature without sagging between its bearings.

Voting: The situation where more than one sensor measures the state of the EGTG. When availability is the concern, multiple coincident fault signals are required to trip the EGTG. When equipment preservation is the primary concern (as during EGTG testing programs), one fault signal may be allowed to trip the EGTG.

Exceptions: Unsuccessful attempts to start or load-run should not count as valid demands or failures when they can definitely be attributed to any of the following:

- Any operation of a trip that would be bypassed in the emergency operation mode (e.g., high lubricant temperature trip).

- Any trip that would have not met the coincident requirements during emergency operating mode and determined to be due to a faulty sensor.

- Malfunction of equipment that is not required to operate during the emergency operating mode (e.g., synchronizing circuitry).

- Unintentional termination of the test because of alarmed or observed abnormal conditions (e.g., small water or oil leaks) that would not have ultimately resulted in significant damage or failure of the EGTG.

- Component malfunctions or operating errors that did not prevent the EGTG from being restarted and brought to load within 5 minutes (i.e., without corrective maintenance or significant problem diagnosis).

- A failure to start because a portion of the starting system was disabled for test purposes, if followed by a successful start with the starting system in its normal alignment.

Each EGTG valid failure that results in declaration of the EGTG as being inoperable should count as one demand and one failure. Exploratory tests during corrective or preventive maintenance should not count as demands or failures. However, the successful test that is performed to declare the EGTG operable should count as a demand.

2.2 Test Descriptions

Table 2 defines the site testing requirements for the EGTG. This is a modified version of Table 3 of IEEE 387-1995. In this section supplementary guidance on the test descriptions which should be used in conjunction with the factory testing, qualification requirements and site testing described in IEEE 387-1995 is presented. The applicant or licensee should have detailed procedures for each test described herein. The procedures should identify special arrangements or changes in normal system configuration that must be made to put the EGTG under test. Jumpers and other nonstandard configurations or arrangements should not be used after initial equipment startup testing.

Table 2: EGTG System Tests

Reference IEEE 387 Clause:	Tests	Site Acceptance Tests (7.2)*	Pre-Operational Tests (7.3)*	Availability Tests 7.4.2.1 (Surveillance)		System Operation Tests: Shutdown/ Refueling (7.4.2.2)*	Independence Tests 10 years (7.4.2.3)*
				Monthly	6 Month		
7.2.1.1	Starting	X		X			
7.2.1.2	Load Acceptance	X		X			
7.2.1.3	Rated Load	X		X			
7.2.1.4	Load Rejection	X					
7.2.1.5	Electrical	X					
7.2.1.6	Subsystem	X					
7.3.3	Reliability		X				
7.5.1	Start		X	X			
7.5.2	Load Run		X	X			
7.5.3	Fast Start		X		X	X	
7.5.4	LOOP		X			X	
7.5.5	SIAS		X				
7.5.6	Combined SIAS & LOOP		X			X	
7.5.7	Largest load Rejection		X			X	
7.5.8	Design load Rejection		X			X	
7.5.9	Endurance and load margin		X†			X	
7.5.10	Hot restart		X			X	
7.5.11	Synchronizing		X			X	
7.5.12	Protective trip Bypass		X			X	
7.5.13	Test mode override		X			X	
7.5.14	Independence		X				X

† use 2 hr. and 22 hr. * IEEE 387-1995

2.2.1 Clause 5.2.1(b.2) of IEEE 387-1995 identifies the data that should be recorded and retained from factory testing of an EDG. Due to the differences in the design and operation of EDGs and EGTGs, this list requires modification as follows:

2.2.1.1 The following items should be deleted since they typically do not apply to an EGTG:

a. item vi) Individual cylinder exhaust temperature
b. item vii) turbocharger exhaust temperature
c. item viii) jacket water temperature inlet and outlet
d. item ix) jacket water pressure at inlet

2.2.1.2 The following items are inserted to enable determination of the EGTG state. The list below is provided as a minimum. Optionally more parameters could be measured as prescribed by the EGTG manufacturer. For example, depending upon the sophistication of the model used to simulate the turbine performance, a specific humidity measurement might be required.

a. compressor rotational speed (for a split shaft design)
b. compressor inlet pressure (downstream of filters)
c. compressor exit temperature
d. compressor exit pressure
e. gas flow rates through compressor
f. turbine inlet temperature
g. turbine exhaust temperature
h. turbine exhaust pressure
i. fuel flow rate and caloric value
j. fuel consumption
k. load (or power)
l. bearing temperatures
m. air cooling inlet and outlet temperature
n. vibration levels near each major bearing
o. acceleration time to operational speed
p. run out (coast down) time

2.2.2 Clause 6.2.2 describes a series of 100 consecutive successful valid start and load tests on a prototype as necessary to establish a sufficient level of reliability for new designs. This is acceptable for diesel generators as any new design will not fundamentally differ from previously qualified designs. However, this level of rigorous testing does not demonstrate 95% reliability with 95% confidence and this is the very minimum acceptable level for truly new designs such as EGTGs. Therefore, the first sentence of the second paragraph of this clause should be replaced with the following: A total number of valid start and load tests shall be performed with no failures allowed in order that a minimum reliability of 95% with a confidence level of at least 95% can be demonstrated. The actual number of tests selected must be justified by the applicant and shown to meet or exceed these acceptance criteria.

Clause 6.2.2(c) describes test conditions of an EDG assuming that a keep warm system is provided. Since a keep warm system is typically not supplied with an EGTG, this clause is modified. It should read: At least 90% of these tests should be performed with the EGTG unit at cold standby. Cold standby is defined as the rotor and lube oil being within 55°C (100°F) of ambient. After the load is applied, the EGTG unit should continue to operate at full speed until the lube oil temperatures are within 5.5°C (10°F) and the exhaust gas temperature is within 55°C (100°F) of the normal EGTG operating temperatures for the corresponding load. If a safety-rated keep warm system is supplied, the initial condition of the EGTG system can initiate at or below the keep warm temperature recommended by the manufacturer.

2.2.3 Clause 7.4 identifies the data that should be recorded and retained from periodic testing of a diesel engine in Table 4 of IEEE 387-1995. Due to the differences in the design and operation of EDGs and EGTGs, this list requires modification as follows:

2.2.3.1 First, the following items are deleted from Table 4 of IEEE 387-1995 when they do not apply to an EGTG:

a. Crankcase pressure
b. Jacket water inlet and outlet temperature
c. Cylinder exhaust temperature
d. Turbocharger exhaust temperature
e. Exhaust manifold temperature
f. Water coolant level (inventory)

2.2.3.2 Second, the items listed above in clause 2.2.1.2 of this document should also be inserted into Table 4 of IEEE 387-1995 to enable determination of the EGTG state (all should be recorded during the test; others may be added to facilitate a better trending analysis).

2.2.4 Starting Test

Clause 7.2.1.1 of IEEE 387-1995 should be supplemented as follows:

The acceptance criteria for frequency and voltage should be equal to or higher than the minimum required voltage and frequency within specified time allowance for the safety-related loads.

2.2.5 Slow-Start Test

Clause 7.5.1 of IEEE 387-1995 should be supplemented as follows:

This test involves demonstrating proper startup from standby conditions, and verifying that the required design voltage and frequency are attained. For this test, the EGTG can be slow-started and reach rated speed on a prescribed schedule to minimize stress and wear.

2.2.6 Load Run (Load Acceptance) Test

Clause 7.5.2 of IEEE 387-1995 should be supplemented as follows:

This test involves demonstrating 90–100 percent of the continuous rating of the EGTG, for an interval of not less than 1 hour and until attainment of temperature equilibrium. This test may be accomplished by synchronizing the generator with offsite power. The loading and unloading of an EGTG during this test should be gradual and based on a prescribed schedule that is selected to minimize stress and wear on the EGTG.

2.2.7 Rated Load Test

Clause 7.2.1.3 (a) of IEEE 387-1995 should be supplemented as follows:

If the DBE or SBO loads are higher than the continuous rating of the EGTG, the test should be conducted at the worst case DBE loads including a margin to account for future load growth.

2.2.8 LOOP Test

Clause 7.5.4 of IEEE 387-1995 should be supplemented as follows:

This test involves simulating a LOOP to demonstrate that (1) the emergency buses are de-energized and the loads are shed from the emergency buses, and (2) the EGTG starts on the autostart signal from its standby conditions; attains the required voltage and frequency, and energizes permanently connected loads within acceptable limits and time; energizes all auto-connected shutdown loads through the load sequencer; and operates for greater than or equal to 5 minutes. If the required safety loads are not available, one or more equivalent load(s) may be used.

2.2.9 Combined SIAS and LOOP Test

Clause 7.5.6 of IEEE 387-1995 should be modified to read as follows:

This test involves demonstrating that the EGTG can satisfactorily respond to a LOOP in conjunction with an SIAS in whatever sequence they might occur [e.g., loss-of-coolant accident (LOCA) followed by delayed LOOP or LOOP followed by LOCA]. A simultaneous LOOP/LOCA event would be demonstrated by verifying that the EGTG starts on the auto-start signal from its standby conditions attains the frequency and voltage within acceptable limits and time, energizes the auto-connected shutdown loads through the load sequencer within the acceptable limits of pump start time, and operates for a minimum of 5 minutes.

2.2.10 Largest Load Rejection Test

Clause 7.5.7 of IEEE 1995 should be supplemented as follows:

This test involves demonstrating the EGTG's capability to reject a load equal to loss of the largest single load while operating at its design load power factor and verifying that the frequency and voltage requirements are met and the unit will not trip on overspeed.

2.2.11 Design-Load Rejection Test

Clause 7.5.8 of IEEE 1995 should be supplemented as follows:

This test involves demonstrating the EGTG's capability to reject a load equal to 90–100 percent of the continuous rating while operating at its design load power factor and verifying that the voltage requirements are met and that the unit will not trip on overspeed.

2.2.12 Endurance and Load Margin Test

Clause 7.5.9 of IEEE Std 387-1995 should be supplemented as follows:

This test involves demonstrating the capability of the EGTG at continuous rating and worst case power factor for an interval of not less than 24 hours. Of this period, 2 hours are at a load equal to 105–110 percent of the EGTG's continuous rating, and 22 hours are at a load equal to 90-100 percent of the EGTG's continuous rating. The test process should verify that frequency and voltage requirements are maintained. The endurance and load tests should be performed at the nameplate rating of power factor or the load power factor, whichever is more limiting.

2.2.13 Hot Restart Test

Clause 7.5.10 of IEEE 387-1995 should be supplemented as follows:

This test involves demonstrating the hot restart functional capability at full load-temperature conditions (after the EGTG has operated for 2 hours at continuous rating) by verifying that the EGTG starts on a manual or auto-start signal, attains the required frequency and voltage within acceptable limits and time, and operates for longer than 5 minutes. This test may be performed following the endurance and margin test described above.

2.2.14 Periodic-Trip Bypass Test

Clause 7.5.12 of IEEE 387-1995 should be supplemented as follows:

This test involves demonstrating that automatic EGTG unit trips are automatically bypassed as designed. Typically, engine overspeed, generator differential current trip and those trips retained with coincident logic are not bypassed. This test should also verify that the critical protective trips that are not automatically bypassed perform their intended function.

2.3 Preoperational and Surveillance Testing

Table 2 relates preoperational and surveillance tests to the anticipated schedule for performance (e.g., preoperational, monthly surveillance, 6-month testing, scheduled refueling period, and 10-year testing). A pre-lube period should precede all planned tests described in this RG if such a system is supplied by the manufacturer. The tests should be in general accordance with the manufacturer's recommendations for reducing EGTG wear, including cooldown operation at reduced power followed by post-operation turning and lubrication.

2.3.1 Preoperational Testing

A pre-operational test program should be implemented for all EGTG systems following assembly and installation at the site. This program should include the tests identified in Table 2. If the test program is not adequately described in the COL or DCD, the creation of the detailed program should be a license condition.

In addition, through a minimum of 25 valid start and load demands without failure on each installed EGTG, this test should demonstrate that the new EGTG has attained a level of reliability acceptable for entering into an operational category.

2.3.2 Surveillance Testing

After plants are licensed (after fuel load), periodic surveillance testing of each EGTG should demonstrate the continued capability and reliability of the EGTG unit to perform its intended function. When the EGTG is declared operational in accordance with the plant's TSs, the following periodic test program should be implemented.

2.3.2.1 Monthly Testing

After completion of the reliability demonstration during preoperational testing, the EGTGs should be periodically tested during normal plant operation. Each EGTG should be started as described in Regulatory Position 2.2.5 and loaded as described in Regulatory Position 2.2.6 at least once every 31 days (with the maximum allowable extension not to exceed 25 percent of the surveillance interval).

2.3.2.2 6 Month (or 184-Day) Testing

This test may substitute for a monthly test. To demonstrate the capability of the EGTG to start from standby conditions and provide the necessary power to mitigate a LOCA coincident with a LOOP, each EGTG should be started from standby conditions once every 6 months as described in Clause 7.5.3 of IEEE 387-1995. This will verify that the EGTG reaches the required voltage and frequency within acceptable limits and time as specified in the plant TSs. Following this test, the EGTG should be loaded as described in Clause 7.5.2 of IEEE 387-1995 (see also Table 2).

2.3.2.3 Refueling Outage Testing

The capability of the overall EGTG design should be demonstrated during every refueling outage (or at a frequency of not more than every 24 months) by performing the tests identified in Table 2. Certain tests may be conducted during the operating mode with NRC approval if the tests can be safely performed without increasing the probability of plant trip, loss of power to the safety buses, or LOOP.

2.3.2.4 10-Year Testing

This testing involves demonstrating that the trains of standby electric power are independent at a frequency of once every 10 years (during a plant shutdown) or after any modifications that could affect EGTG independence (whichever is shorter) by starting all redundant units simultaneously to identify certain common-failure modes undetected in single EGTG unit tests (see also Table 2).

3. Reporting Criteria

Licensees must conform to the reporting requirements of 10 CFR Part 21, "Reporting of Defects and Noncompliance" (Reference 3); 10 CFR 50.72, "Immediate Notification Requirements for Operating Nuclear Power Reactors"; and 10 CFR 50.73, "License Event Reporting System."

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this ISG. No backfitting is intended or approved in connection with the issuance of this guide.

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 described in this guide will be used in evaluating (1) submittals in connection with applications for construction permits (CPs), standard plant DCs , OLs, early site permits (ESPs), and COLs; and (2) submittals from operating reactor licensees who voluntarily propose to initiate system modifications involving EGTGs used as onsite emergency electric power systems.

REGULATORY ANALYSIS/BACKFIT ANALYSIS

As described in 10 CFR 50.109(c), this draft interim guidance does not require a backfit analysis because the use of this guidance by licensees of currently operating NPPs is voluntary.

REFERENCES

1) RG 1.9, "Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants," NRC, Washington, DC.

2) 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," NRC, Washington, DC.

3) 10 CFR Part 21, "Reporting of Defects and Noncompliance," NRC, Washington, DC.

4) IEEE Std. 387-1995, "IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations," IEEE, Piscataway, NJ, 1995.

5) RG 1.155, "Station Blackout," NRC, Washington, DC, March 2007, Revision 4.

6) ISO 3977-3, "Gas Turbine Procurement Part 3 Design Requirements," August 18, 2004.

7) RG 1.189, "Fire Protection for Nuclear Power Plants," March 2007.

8) Generic Letter (GL) 84-15, "Proposed Staff Actions to Improve and Maintain Diesel Generator Reliability," July 2, 1984.

9) Information Notice (IN) 2006-22, “New Ultra-Low-Sulfur Diesel Fuel Oil Could Adversely Impact Diesel Engine Performance,” October 12, 2006.

10) ASME PTC-22-2005 “Performance Test Code on Gas Turbines,” May 30, 2006.

11) IN 2009-02, “Biodiesel in Fuel Oil Could Adversely Impact Diesel Engine Performance,” February 23, 2009.

ARTICLE 3: MODIFIED SRP SECTION 8.3.1(I): AC POWER SYSTEMS (ONSITE) WITH EMERGENCY GAS TURBINE GENERATORS

REVIEW RESPONSIBILITIES

Primary – The organization responsible for electrical engineering review.

Secondary – None

I. AREAS OF REVIEW

EDGs are widely used as the standby power source for the onsite AC power system and are covered in SRP Section 8.3.1. It is anticipated that some new reactor designs will incorporate EGTGs to power the emergency AC power system. This ISG document provides guidance on the review of AC power systems using an EGTG to ensure reliable AC power to safety-related equipment or equipment important to safety for all normal operating and accident conditions. This guidance document is formatted as a companion document to SRP Section 8.3.1 for reviewing NPPs with EGTGs as standby emergency power sources.

The descriptive information, analyses, and referenced documents, including functional logic diagrams, electrical single-line diagrams, tables, physical arrangement drawings, and electrical control and schematics, for the onsite AC power system presented in the applicant's safety analysis report (SAR) are reviewed. The intent of the review is to determine that the onsite AC power system satisfies the requirements of GDCs 2, 4, 5, 17, 18, and 50 and will perform its intended functions during all plant operating and accident conditions.

The onsite AC power system includes those standby power sources, distribution systems, and auxiliary supporting systems provided to supply power to safety-related equipment or equipment important to safety for all normal operating and accident conditions. EGTGs used as the standby power source for the onsite AC power system will be covered in this section. Emphasis is placed on those portions of the systems that are safety-related. Those portions that are not related to safety are reviewed to determine potential interactions with safety-related portions. Other standby power sources such as nearby hydroelectric, nuclear, or fossil units will not be addressed herein. These sources, when proposed, will be evaluated on a case-by-case basis. In addition, those interface areas between the onsite and offsite power systems at the station distribution system level are within the scope of review of this ISG section insofar as they relate to the independence of the onsite power system.

This ISG incorporates considerations for the review of the electric power system design brought about by the new advanced light-water reactor (ALWR) designs, including evolutionary plant designs, such as the advanced boiling-water reactor (ABWR) and the System 80+, and passive plant designs, such as the AP1000. The passive light-water reactor (LWR) design applications provide passive safety systems that do not need Class 1E AC electric power, other than that provided by the Class 1E direct current batteries and their inverters, to accomplish the plant's safety-related functions for 72 hours. References are provided in the individual SRP sections identifying regulatory documentation, such as SECY-94-084 and RG 1.206 that specifically address the unique design requirements and review considerations applicable to the ALWR plant designs.

The specific areas of review are as follows:

1. System Redundancy Requirements

   The onsite power system is reviewed to determine that the required redundancy of safety-related components and systems is provided such that a system safety function can be accomplished assuming a single failure. This includes an examination of the AC power system configuration, including the power supplies, power supply feeders, and switchgear arrangement, loads supplied from each bus, and power connections to the I&C devices of the power system.

2. Conformance with the Single Failure Criterion

   In establishing the adequacy of this system to meet the single failure criterion, both electrical and physical separation of redundant power sources and associated distribution systems are examined to assess the independence of redundant portions of the system. This will include a review of interconnections of redundant buses, buses and loads, and buses and power supplies; physical arrangement of redundant switchgear and power supplies; criteria and bases governing the installation of electrical cables for redundant power systems; and proposed sharing of the AC power system between units at the same site.

3. Onsite and Offsite Power System Independence

   In evaluating the independence of the onsite power system with respect to the offsite power system, the scope of review extends to the station distribution load centers that are powered from the unit auxiliary transformers and the startup transformers (considered for the purposes of this guidance as the offsite or preferred power sources). It includes the supply breakers connecting the "low" side of these transformers to the distribution buses. This evaluation includes a review of the electrical protective relaying circuits and power supplies to ensure that, in the event of a LOOP, the independence of the onsite power system is established through prompt opening of isolation-feeder breakers.

4. Standby Power Supplies

   Design information and analyses demonstrating the suitability of the EGTGs as standby power supplies are reviewed to ensure that the EGTGs have sufficient capacity, capability, and reliability to perform their intended function. This will include an examination of the characteristics of each load and the length of time each load is needed, the combined load demand connected to each EGTG during the "worst" operating condition, automatic and manual loading and unloading of each EGTG, voltage and frequency recovery characteristics of the EGTGs, continuous and short-term ratings for the EGTGs, acceptance criteria with regard to the number of successful EGTG tests and allowable failures to demonstrate acceptability, and starting and load shedding circuits. In addition, where the proposed design provides for the connection of nonsafety loads to the EGTGs or sharing of EGTGs between nuclear units at the same site, particular review emphasis is given to the possibility of marginal capacity and degradation of reliability that may result from such design provisions [For new plants, sharing of EGTGs between units is not recommended.]

5. Identification of Cables, Raceways, and Terminal Equipment

The basis proposed for identifying the onsite AC power system components including cables, raceways, and terminal equipment as safety-related equipment in the plant is reviewed. Also, the identification scheme used to distinguish between redundant Class 1E systems, associated circuits assigned to redundant Class 1E divisions, non-Class 1E systems and their associated cables, raceways, and terminal equipment of the power system is reviewed.

6. Auxiliary Supporting Systems/Features

The instrumentation, control circuits, and power connections of auxiliary supporting systems and features are reviewed to determine that they are designed to the same criteria as those for the safety-related loads and power systems that they support. This will include an examination of the auxiliary supporting system component redundancy; power feed assignment to instrumentation, controls, and loads; initiating circuits; load characteristics; equipment identification scheme; and design criteria and bases for the installation of redundant cables.

7. System Testing and Surveillance

Onsite testing capabilities are reviewed. The means proposed for automatically monitoring the status of system operability are reviewed.

8. Reliability Program for Emergency Onsite AC Power Sources

A reliability program for emergency onsite power sources should be implemented to maintain onsite emergency source reliability at an acceptable level. The program designed to attain and maintain the long-term reliability of each source at or above specified reliability targets is reviewed to verify its adequacy.

9. Specific EGTG Design and Operational Features

The EGTG should be designed and built to appropriate standards such as ISO 3977 Part 3, 2004 (Reference 67).

10. Other Review Areas

The AC power system is reviewed to determine that:

A. The system and its components have the appropriate seismic design classification.

B. The system and its components are housed in a structure with seismic category I classification.

C. The system and its components are designed to withstand environmental conditions associated with normal operation, natural phenomena (including lightning discharges), and postulated accidents.

D. The system and its components have a "Class 1E" quality assurance classification.

E. Variations in voltage, frequency and waveform (harmonic distortion) in the onsite power system and its components during any mode of plant operation do not degrade the performance of any safety system load below an acceptable level.

11. Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). For DC and COL reviews, the staff reviews the applicant's proposed ITAAC associated with the structures, systems, and components (SSCs) related to this ISG in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." Since the proposed ITAAC are based on the design of the SSCs, the review of ITAAC should be performed subsequent to the review of the associated system design against the acceptance criteria contained in the appropriate ISG section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

12. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action or information items and requirements and restrictions (e.g., interface requirements and site parameters).

    For a COL application referencing a DC, a COL applicant must address COL action or information items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other SRP sections interface with this section as follows:

1. Review of the adequacy of the offsite power system, including preferred power circuits to the onsite power system, and the independence of the preferred power system and any alternate AC (AAC) power sources provided for SBO, as part of its primary review responsibility for SRP Section 8.2.

2. Review of the adequacy of the onsite direct current power systems, including: safety-related direct current distribution systems; station batteries, battery chargers, and associated direct current systems; inverters and associated direct current systems; and direct current instrumentation and control (I&C) power systems, as part of its primary review responsibility for SRP Section 8.3.2.

3. Review of the overall compliance with 10 CFR 50.63 requirements, as part of its primary review responsibility for SRP Section 8.4, including the adequacy of the SBO analysis, the adequacy of reliability targets for onsite AC sources (EGTGs), the duration for which the plant will be able to withstand or cope with, and recover from, an SBO event, and the adequacy of direct current system power supplies (e.g., batteries and chargers) that are not

a part of the onsite direct current power system reviewed under SRP Section 8.3.2 with respect to the specified SBO event/duration.

4. Review of the adequacy of the environmental qualification of safety-related electrical equipment as part of its primary review responsibility for SRP Section 3.11. In particular, the reviewer determines the capability of safety-related electrical equipment to perform its intended safety functions when subjected to the effects of (1) accident environments such as LOCAs and/or steam line breaks, (2) abnormal environments that may temporarily exceed equipment continuous duty design parameters such as temperature and humidity, (3) abnormal environments caused by degradation or loss of heating, ventilation, and/or air conditioning systems, (4) seismic shaking, and (5) normal design environments on redundant safety-related electrical equipment that does not include design diversity (e.g., redundant components manufactured and designed by the same supplier).

In the review of other areas associated with the onsite power system, the reviewer will coordinate other branches' evaluations that interface with the overall review of the system.

The listed SRP sections interface with this section as follows:

1. The organization responsible for the review of plant systems evaluates the adequacy of those auxiliary supporting systems that are vital to the proper operation and/or protection of the AC power system as part of its primary review responsibility for SRP Sections 9.4.1 through 9.4.5. This includes such systems as the heating, ventilation, and air conditioning systems provided to maintain a controlled environment for safety-related instrumentation and electric equipment. In particular, the organization responsible for the review of plant systems determines that the piping, ducting, and dampers for these heating and ventilation systems are adequate.

2. The organization responsible for the review of plant systems examines the physical arrangement of components and structures for Class 1E systems and their supporting auxiliary systems to determine that single events and accidents will not disable redundant features as part of its primary review responsibility for SRP Sections 3.4.1, 3.5.1.1, 3.5.2, and 3.6.1. Each EGTG need not be protected from the missiles generated from its components. However, it must be protected from missiles generated from other nearby EDGs.

3. The organization responsible for the review of plant systems determines those system components needing electric power as a function of time for each mode of reactor operation and accident condition as part of its primary review responsibility for SRP Sections 6.5.1, 6.7, 9.1.3, 9.1.4, 9.2.1, 9.2.2, 9.2.4, 9.2.5, 9.2.6, 9.3.1, 9.3.3, 10.4.5, 10.4.7, and 10.4.9.

4. The organization responsible for the review of plant systems examines fire detection and fire protection systems protecting the AC power system and its auxiliary supporting systems to ensure that the adverse effects of fire are minimized as part of its primary review responsibility for SRP Section 9.5.1. This review includes examining the adequacy of protection provided for redundant safe shutdown circuits to determine that a single design basis fire will not disable both redundant circuits.

5. The organization responsible for the review of materials and chemical engineering determines those system components needing electric power as a function of time for each mode of reactor operation and accident condition as part of its primary review responsibility for SRP Sections 5.4.8, 9.2.3, 9.3.2, and 9.3.4.

6. The organization responsible for the review of containment systems and severe accidents evaluates the adequacy of those containment ventilation systems provided for maintaining a controlled environment for safety-related electrical equipment located inside the containment as part of its primary review responsibility for SRP Section 6.2.2. The organization responsible for the review of containment systems and severe accidents determines those system components needing electric power as a function of time for each mode of reactor operation and accident condition as part of its primary review responsibility for SRP Sections 6.2.2, 6.2.3, 6.2.4, and 6.2.5.

7. The organization responsible for the review of reactor systems determines those system components needing electric power as a function of time for each mode of reactor operation and accident condition as part of its primary review responsibility for SRP Sections 4.6, 5.4.6, 5.4.7, 5.4.12, 6.3, and 9.3.5.

8. The organization responsible for the review of I&Cs determines those system components needing electric power as a function of time for each mode of reactor operation and accident condition as part of its primary review responsibility for SRP Sections 7.2 through 7.7. In addition, the organization responsible for the review of I&Cs verifies the adequacy of safety-related display instrumentation and other instrumentation systems needed for safety as part of its primary review responsibility for SRP Sections 7.5 and 7.6.

9. The organization responsible for quality assurance and maintenance review determines the acceptability of the preoperational and initial startup tests and programs as part of its primary review responsibility for SRP Section 14.2.

10. The reviews of design, construction, and operations phase quality assurance programs, including the general methods for addressing periodic testing, maintenance, and reliability assurance, are performed by the organization responsible for the review of quality assurance as part of its primary review responsibility for SRP Chapter 17.

11. The organization responsible for mechanical engineering review, as part of its primary review responsibility for SRP Section 3.10, reviews the criteria for seismic qualification and the test and analysis procedures and methods to ensure the mechanical survivability of Category I instrumentation and electrical equipment (including raceways, switchgear, control room boards, and instrument racks and panels) in the event of a seismic occurrence.

12. The organization responsible for the review of TSs coordinates and performs reviews of TSs as part of its primary review responsibility for SRP Section 16.0.

13. The organization responsible for human factors assessment, as part of its primary review responsibility for SRP Sections 13.5.1.1 and 13.5.2.1, reviews the adequacy of administrative, maintenance, testing, and operating procedure programs.

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

Requirements

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. GDC 2, as it relates to SSCs of the AC power system being capable of withstanding the effects of natural phenomena without the loss of the capability to perform their safety functions.

2. GDC 4, as it relates to SSCs of the AC power system being capable of withstanding the effects of missiles and environmental conditions associated with normal operation, maintenance, testing, and postulated accidents.

3. GDC 5, as it relates to sharing of SSCs of the AC power systems.

4. GDC 17, as it relates to the onsite AC power system's (a) capacity and capability to permit functioning of SSCs important to safety; (b) independence, redundancy, and testability to perform its safety function assuming a single failure; and (c) provisions to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit or the loss of power from the transmission network.

5. GDC 18, as it relates to inspection and testing of the onsite power systems.

6. GDCs 33, 34, 35, 38, 41, and 44, as they relate to the operation of the onsite electric power system, encompassed in GDC 17, to ensure that the safety functions of the systems described in GDCs 33, 34, 35, 38, 41, and 44 are accomplished.

7. GDC 50, as it relates to the design of containment electrical penetrations containing circuits of the AC power system and the capability of electric penetration assemblies in containment structures to withstand a LOCA without loss of mechanical integrity and the external circuit protection for such penetrations.

8. 10 CFR 50.63, as it relates to the establishment of a reliability program for emergency onsite AC power sources and the use of the redundancy and reliability of EGTG units as a factor in limiting the potential for SBO events.

9. 10 CFR 50.65 (a)(4), as it relates to the assessment and management of the increase in risk that may result from proposed maintenance activities before performing the maintenance activities. These activities include, but are not limited to, surveillances, post-maintenance testing, and corrective and preventive maintenance. Compliance with the maintenance rule, including verification that appropriate maintenance activities are covered therein, is reviewed

under SRP Chapter 17. Programs for incorporation of requirements into appropriate procedures are reviewed under SRP Chapter 13.

10. 10 CFR 50.55a(h), as it relates to the incorporation of IEEE 603-1991 (including the correction sheet dated January 30, 1995), and IEEE 279 for protection and safety systems.

11. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the DC is built and will operate in accordance with the DC, the provisions of the Atomic Energy Act (AEA), and the NRC's regulations.

12. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee should perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the COL, the provisions of the AEA, and the NRC's regulations.

ISG Acceptance Criteria

Specific ISG acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in this ISG section. The ISG is not a substitute for the NRC's regulations, and compliance with it is not required. However, in accordance with 10 CFR 52.47, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the ISG acceptance criteria and evaluate how the proposed alternatives to the ISG acceptance criteria provide acceptable methods of compliance with the NRC regulations.

In general, the onsite AC power system is acceptable when it can be concluded that this system has the required redundancy, meets the single failure criterion, is protected from the effects of postulated accidents, is testable, and has the capacity, capability, and reliability to supply power to all safety loads and other required equipment in accordance with GDCs 2, 4, 5, 17, 18, and 50. Table 8-1 of SRP 8.1 lists GDCs, regulations, RGs and branch technical positions (BTPs) used as the bases for arriving at this conclusion.

1. GDC 2 is satisfied, as it relates to SSCs of the onsite AC power system being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods, as established in Chapter 3 of the SAR, and reviewed by the organizations with primary responsibility for the reviews of plant systems, civil engineering and geosciences, and mechanical engineering.

2. GDC 4 is satisfied, as it relates to SSCs of the AC power system being capable of withstanding the effects of missiles and environmental conditions associated with normal operation and postulated accidents, as established in Chapter 3 of the SAR and reviewed by the organizations with primary responsibility for the reviews of plant systems, materials, and chemical engineering.

3. GDC 5 is satisfied, as it relates to the sharing of SSCs of the AC power system and the following guidelines:

   A. RG 1.32, as it relates to the sharing of SSCs of the Class 1E power system at multi-unit stations.

   B. RG 1.81, as it relates to the sharing of SSCs of the AC power system, positions C.2 and C.3.

4. GDC 17 is satisfied, as it relates to the onsite AC power system's: (a) capacity and capability to permit functioning of SSCs important to safety; (b) independence, redundancy, and testability to perform its safety function assuming a single failure; and (c) provisions to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit or the loss of power from the transmission network. Acceptance is based on meeting the following specific guidelines:

   A. RG 1.6, as it relates to the independence of the onsite AC power system, positions D.1, D.2, D.4, and D.5.

   B. Article 2 of this ISG (see also IEEE 387).

   C. RG 1.32 (see also IEEE 308), as it relates to design criteria for onsite AC power systems.

   D. RG 1.53 (see also IEEE 279 and IEEE 603), as it relates to the application of the single-failure criterion to safety systems.

   E. RG 1.75 (see also IEEE 384), as it relates to the onsite AC power system.

   F. RG 1.153 (see also IEEE 603), as it relates to criteria for electrical portions of safety-related systems.

   G. RG 1.155, as it relates to the use of onsite emergency AC power sources for SBO.

   H. RG 1.204 (see also IEEE 665, 666, 1050, and C62.23), as it relates to the lightning and surge protection for the onsite AC power system.

   I. NUREG/CR-0660 was written specifically for EDGs; however, it is referenced as it relates to the following recommendations[3]:

      i) The EGTGs should be capable of operation at less than full load for extended periods of time without degradation of performance or reliability. With offsite power available, no-load operation of the EGTGs will occur following a safety injection signal.

[3] NOTE: If EGTGs are used as the standby ac power supply then the review criteria for those units are provided in Interim Guidance document 8.3.1(I).

ii. A complete formal training program should be provided for all personnel who will be responsible for the maintenance and availability of the EGTGs. The depth and quality of training should be at least equivalent to that provided by major EGTG manufacturers' training programs.

iii. A preventive maintenance program should be provided which encompasses investigative testing of components which have a history of repeated malfunctioning and a plan for the replacement of those components that require constant attention and repair with other products of proven reliability.

iv. Repair and maintenance procedures should provide for a final equipment check prior to an actual start-run-load test to ensure that all electrical circuits are functional (i.e., fuses in place, no loose wires, test leads removed, etc.) and all valves are in the proper position. The test procedure(s) should explicitly state that upon satisfactory test completion, the EGTG unit should be returned to a ready automatic standby service under the control of the control room operator.

v. Except for sensors and other equipment that need to be directly mounted on the turbine or associated piping, the controls and monitoring instruments should be installed on a free-standing, floor-mounted panel located on a vibration-free floor area.

   [NOTE: If the floor is not vibration free, the panel should be equipped with vibration mounts.]

J. Interim Guide "Application and Testing of Safety-Related Gas Turbine Generators in Nuclear Power Plants," as it describes design and operational features of a gas turbine generator system required for reliable operation (Article 2 of this ISG).

   i. Turning motors will slowly rotate the turbine rotor after each start that results in a heated rotor until the rotor has cooled to manufacturer's specification.

   ii. Coincident trip logic is required for all safety trips retained during emergency operation.

   iii. Trips on turbine overspeed and generator differential overcurrent should be retained during emergency operation.

   iv. A trending analysis should be instituted to determine the need for overhaul and maintenance.

   v. The applicant should identify the time constraints that are due to the coast down of the rotor, and how this will delay a restart attempt of an EGTG that is rotating due to a prior start attempt or a recent trip. This should be accounted for in the availability analysis of the EGTG. A mechanical or electrical braking system may be used to minimize this down time.

K. Acceptance criteria for the interface between the onsite AC power system and the offsite power system to satisfy the requirements of GDC 17 are documented in SECY-91-078, which states that the design should include at least one offsite circuit to each redundant safety division supplied directly from one of the offsite power sources with no intervening nonsafety buses in such a manner that the offsite source can power the safety buses upon the failure of any nonsafety bus. The evolutionary LWR design should also include an alternate power source to nonsafety loads, unless it can be demonstrated that existing design margins will ensure that transients for loss of nonsafety power events are no more severe than those associated with the turbine-trip-only event specified in current plant designs.

Passive LWR design applications provide passive safety systems that do not need Class 1E AC electric power, other than that provided by the Class 1E DC batteries and their inverters, to accomplish the plant's safety-related functions for 72 hours. However, in accordance with SECY-94-084, SECY-95-132, and RG 1.206, Section C.IV.10, AC power system features will be evaluated using the process for regulatory treatment of nonsafety systems (RTNSS) for electrical distribution issues on passive designs. The AP1000 passive plant DC, for example, includes an exemption to the requirement of GDC 17 for two physically independent offsite circuits, by providing safety-related passive safety systems for core cooling and containment integrity. However, even for this design, one offsite power source with sufficient capacity and capability from the transmission network should be provided to power the safety-related systems and all other auxiliary systems under normal, abnormal, and accident conditions. The offsite power source should be designed to minimize to the extent practical the likelihood of its failure under normal, abnormal, and accident conditions.

Detailed reviews of the offsite AC power system and its interface with the onsite power system for ALWR design applications are covered in Section 8.2, "Offsite Power System."

5. GDC 18 is satisfied, as it relates to the testability of the onsite AC power system, and the following guidelines:

   A. RG 1.32 (see also IEEE 308), as it relates to capability for testing of the onsite AC power system.

   B. RG 1.47, with respect to indicating the bypass or inoperable status of portions of the protection system, systems actuated or controlled by the protection system, and auxiliary or supporting systems that must be operable for the protection system and the system it actuates to perform their safety-related functions.

   C. RG 1.118 (see also IEEE 338), as it relates to the capability for testing the onsite AC power system.

   D. RG 1.153 (see also IEEE 603), as it relates to the onsite AC power system.

6. The design requirements for an onsite AC power supply for systems covered by GDCs 33, 34, 35, 38, 41, and 44 are encompassed in GDC 17.

7. GDC 50 is satisfied, as it relates to the design of containment electrical penetrations containing circuits of the AC power system, and the guidelines of RG 1.63 are followed (see

also IEEEs 242, 317, and 741), as related to the capability of electric penetration assemblies in containment structures to withstand a LOCA without loss of mechanical integrity and the external circuit protection for such penetrations, as well as to ensure that electrical penetrations will withstand the full range of fault current (minimum to maximum) available at the penetration.

8. 10 CFR 50.63, as it relates to use of the redundancy and reliability of EGTG units as a factor in limiting the potential for SBO events. Acceptance is based on meeting the following specific guidelines:

   A. Article 2 of this ISG, as it relates to the adequacy of the generator surveillance criteria provided to attain and maintain the target reliability levels of generator units.

   B. RG 1.155, as it relates to use of the reliability of emergency onsite AC power sources as a factor in determining the coping duration for SBO and the establishment of a reliability program for attaining and maintaining source target reliability levels. Determination of SBO coping time is reviewed in detail in SRP Section 8.4.

      Except for passive reactor designs described in the acceptance criteria of Subsection II.4.J above, new applications should provide an adequate AAC source of diverse design (with respect to onsite AC emergency sources) that is consistent with the guidance in RG 1.155 and capable of powering at least one complete set of normal safe shutdown loads. These issues are reviewed in detail under SRP Section 8.4.

9. 10 CFR 50.65, Section 50.65(a)(4), as it relates to the requirements to assess and manage the increase in risk that may result from proposed maintenance activities before performing the maintenance activities. Acceptance is based on meeting the following specific guidelines:

   A. RG 1.160, as it relates to the effectiveness of maintenance activities for onsite emergency AC power sources including grid-risk-sensitive maintenance activities (i.e., activities that tend to increase the likelihood of a plant trip, increase LOOP frequency, or reduce the capability to cope with a LOOP or SBO).

   B. RG 1.182, as it relates to implementing the provisions of 10 CFR 50.65 (a)(4) by endorsing Section 11 to NUMARC 93-01, “Nuclear Energy Institute Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,” February 22, 2000.

10. 10 CFR 50.55a(h), as it relates to protection systems for plants with CPs issued after January 1, 1971, but before May 13, 1999, which must meet the requirements stated in either IEEE 279, "Criteria for Protection Systems for Nuclear Power Generating Stations," or IEEE 603-1991, "Criteria for Safety Systems for Nuclear Power Generating Stations,” and the correction sheet dated January 30, 1995. For NPPs with CPs issued before January 1, 1971, protection systems must be consistent with their licensing basis or may meet the requirements of IEEE 279-1971. NPPs with applications filed on or after May 13, 1999 for preliminary and final design approvals (10 CFR Part 52, Appendix O), DC, CPs, OLs, and COLs that do not reference a final design approval or DC, must meet the requirements for safety systems in IEEE 603-1991 and the correction sheet dated January 30, 1995.

BTPs and industry standards that are acceptable to the staff for implementing the requirements of GDCs 2, 4, 5, 17, 18, and 50 are identified in SRP Section 8.1, and Table 8.1. In addition, 10 CFR 50.34(f)(2)(v), (xiii), and (xx), related to Task Action Plan items I.D.3, II.E.3.1 and II.G.1 of NUREG-0718 and NUREG-0737, provide additional guidance for the reviewer.

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this ISG section is discussed in the following paragraphs:

1. Compliance with GDC 2 requires that NPP SSCs important to safety be designed to withstand the effects of natural phenomena such as earthquake, tornado, hurricane, flood, tsunami, or seiche without loss of capability to perform their intended safety function.

   With regard to the AC power system, this criterion requires that the onsite AC power system be designed to withstand the effects of natural phenomena without loss of capability to perform its safety functions with appropriate consideration of the most severe natural phenomena that have been historically reported for the site and surrounding area. Therefore, the AC power system and its components should normally be located in seismic Category I structures that provide protection from the effects of tornadoes, tornado missiles, and floods. Equipment and components comprising the onsite AC power system should also generally be seismically designed and/or qualified to perform their functions in the event of an earthquake.

   Meeting this requirement will provide assurance that equipment and structures will be designed to withstand the effects associated with natural phenomena, thus decreasing the probability that seismically- and/or climatology-related natural phenomena could initiate accidents or prevent equipment from performing its safety function during an accident.

2. Compliance with GDC 4 requires that SSCs important to safety (a) be designed to accommodate the effects of, and be compatible with, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents and (b) be appropriately protected against dynamic effects, including the effects of missiles, that may result from equipment failures.

   The AC power system is necessary to provide power to systems important to safety during normal, abnormal, accident, and post-accident conditions.

   Meeting these requirements will provide assurance that the AC power system will supply electric power necessary for operation of systems important to safety even if/when subject to adverse environmental conditions and/or dynamic effects.

3. Compliance with GDC 5 requires that SSCs important to safety not be shared among nuclear power units, unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units.

Accordingly, component parts of the AC power system should not be shared among units without sufficient justification, thereby ensuring that an accident in one unit of a multiple unit facility can be mitigated using an available compliment of mitigative features, including necessary AC power, irrespective of conditions in the other units and without giving rise to conditions unduly adverse to safety in another unit. This ISG cites RG 1.32 and 1.81 to establish acceptable guidance related to the sharing of SSCs of the preferred offsite and onsite power systems. [Sharing of onsite AC electric power systems and components is no longer recommended per RG 1.81. (For new plants, sharing of EGTGs between units is not recommended.)]

Meeting the requirements of GDC 5 provides assurance that an accident within any one unit of a multiple-unit plant may be mitigated irrespective of conditions in other units without affecting the overall operability of the offsite and onsite power systems.

4. Compliance with GDC 17 requires that onsite and offsite electrical power be provided to facilitate the functioning of SSCs important to safety. Each electric power system, assuming the other system is not functioning, must provide sufficient capacity and capability to assure that specified acceptable fuel design limits and the design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences and that the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents.

   GDC 17 further requires that electric power from the transmission network to the onsite electric distribution system be supplied by two physically independent circuits designed and located so as to minimize the likelihood of their simultaneous failure under operating, postulated accident, and postulated environmental conditions. Each of these circuits is required to be designed to be available in sufficient time following a loss of all onsite AC power supplies and the other offsite electric power circuit, to assure that specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded. One of these circuits is also required to be designed to be available within a few seconds following a LOCA to assure that core cooling, containment integrity, and other vital safety functions are maintained.

   GDC 17 requirements for the interface between the onsite AC power system and the offsite power system in evolutionary LWR design applications are documented in SECY-91-078, which states that the design should include at least one offsite circuit to each redundant safety division that is supplied directly from an offsite power source with no intervening nonsafety buses, thereby permitting the offsite source to supply power for safety buses in the event the nonsafety bus(es) fails. The design should also include an alternate offsite power source to nonsafety loads, unless it can be demonstrated that existing design margins will ensure that transients for loss of nonsafety power events are no more severe than those associated with the turbine-trip-only event specified in current plant designs.

   As documented in SECY-94-084 and SECY-95-132, the staff addressed technical issues associated with the RTNSS process in passive plant designs. Risk-important, non-safety-related, active systems in passive LWRs may have a significant role in accident and consequence mitigation by providing defense-in-depth (DID) functions to supplement the capability of the safety-related passive systems. Certified passive designs should demonstrate how the RTNSS evaluation process addresses the resolution of design issues, in accordance with SECY-94-084, SECY-95-132, and RG 1.206 Section C.IV.10. Subsequent COL applications could then reference the RTNSS evaluation in the applicable existing certified design control documents (DCDs) to demonstrate compliance with design requirements for passive design power systems as described in Section C.III.1 of RG 1.206. Further detailed information and guidance on electrical design for passive COL applications is provided in Section C.III.1.8.3.1 of RG 1.206, SECY-94-084, and SECY-95-132.

The COL applicant should submit a reliability assurance program describing the reliability assurance activities it will perform before the initial fuel load. The program should maintain the reliability objectives consistent with the PRA assumptions designed into the plant. Reliability assurance activities for the operating stage are integrated into existing programs (e.g., maintenance rule, surveillance testing, inservice inspection, inservice testing, and quality assurance). Further detailed information and guidance on reliability assurance programs for passive COL applications are provided in Section C.III.17.4 of RG 1.206, SECY-94-084, and SECY-95-132.

Provisions should also be included to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit, the loss of power from the transmission network, or the loss of power from the onsite electric power supplies. The trip of the nuclear power unit is an anticipated operational occurrence that can result in reduced switchyard voltage, potentially actuating the plant's degraded voltage protection and separating the plant's safety buses from offsite power. It can also result in grid instability, potential grid collapse, inadequate switchyard voltages, and a subsequent LOOP due to loss of the real and/or reactive power support supplied to the grid from the nuclear unit. Plant technical specifications (TSs) limiting conditions for operation (LCO) require the offsite power system to be operable. However, since the capability of the offsite power system cannot be tested except when challenged during an actual event, the design bases for the offsite power system can only be assured through analysis of the grid and plant conditions. Plant operators should therefore be aware of: (1) the capability of the offsite power system to supply power, as required by TS, during operation and (2) situations that can result in a LOOP following a trip of the plant. Additional information on the adequacy of grid voltage, grid stability and grid reliability challenges due to deregulation of the utility industry, and the effect of grid events on NPP performance, is provided in References 7, 13, and 38.

GDC 17 also requires that the onsite power supplies and the onsite electrical distribution system have sufficient independence, redundancy, and testability to perform their safety functions assuming a single failure. Therefore, no single failure will prevent the onsite power system from supplying electric power, thereby permitting safety functions and other vital functions needing electric power to be performed in the event of any single failure in the power system. Guidance on the application of the single-failure criterion is provided in RG 1.53, with applicability as established in 10 CFR 50.55a(h).

This ISG cites RGs 1.6, 1.32, 1.75, 1.153, and 1.155, and NUREG/CR-0660 as establishing acceptable guidance for meeting the requirements of GDC 17.

Meeting the requirements of GDC 17 provides assurance that a reliable electric power supply will be provided for all facility operating modes, including anticipated operational occurrences and design-basis accidents (DBAs) to permit safety functions and other vital functions to be performed, even in the event of a single failure.

5. Compliance with GDC 18 requires that electric power systems important to safety be designed to permit appropriate periodic inspection and testing of important areas and features to assess the continuity of the systems and the condition of their components. These systems should be designed with a capability to test periodically: (1) the operability and functional performance of the components of the systems, such as onsite power sources, relays, switches, and buses, and (2) the operability of the systems as a whole and, under conditions as close to design as practical, the full operational sequence that brings the systems into operation, including operation of applicable portions of the protection system, and the transfer of power among the nuclear power unit, the offsite power system, and the onsite power system.

   Accordingly, the AC power system should provide the capability to perform integral testing of Class 1E systems on a periodic basis. RGs 1.32, 1.47, 1.118, and 1.153, and BTP 8-5 are cited as establishing acceptable guidance for meeting the requirements of this criterion.

   Meeting the requirements of GDC 18 provides assurance that, when necessary, offsite power systems can be appropriately and unobtrusively accessed for required periodic inspection and testing, enabling verification of important system parameters, performance characteristics, and features and detection of degradation and/or impending failure under controlled conditions.

6. GDCs 33, 34, 35, 38, 41, and 44 set forth requirements for the safety systems for which the access to both offsite and onsite power sources must be provided. Accordingly, capability should be provided for reactor coolant makeup during small breaks, residual heat removal, emergency core cooling, containment heat removal, containment atmosphere cleanup, and cooling water for SSCs important to safety. These systems should be available during normal and accident conditions, as necessary for the specific system.

   GDCs 33, 34, 35, 38, 41, and 44 require safety system redundancy such that, for onsite power system operation (assuming offsite power is unavailable), the system safety function can be accomplished, assuming a single failure. Redundancy must be reflected in the standby power system with regard to both power sources and associated distribution systems. Also, redundant safety loads should be distributed between redundant distribution systems, and the I&C devices for the Class 1E loads and power system should be supplied from associated redundant distribution systems. For the AC power system, these requirements are met if the minimum design required by GDC 17 is provided.

   Meeting these criteria as encompassed by GDC 17 provides assurance that necessary electric power will be provided for all facility operating modes, including transients and DBAs so that the safety functions required by these criteria may be performed, even in the event of any single failure.

7. Compliance with GDC 50 requires that the reactor containment structure, including access openings, penetrations, and containment heat removal systems, be designed so that the containment structure and its internal compartments can accommodate, without exceeding the design leakage rate and with sufficient margin, the calculated pressure and temperature

conditions resulting from any LOCA. Accordingly, containment electric penetrations should be designed to accommodate, without exceeding their design leakage rate, the calculated pressure and temperature conditions resulting from a LOCA. In addition, the penetration conductors should be able to withstand all ranges of over load and short circuit currents up to the maximum fault current versus time conditions that could occur given single random failures of circuit protective devices.

This criterion, as it applies to this ISG section, relates specifically to ensuring the integrity of containment electrical penetrations in the event of design basis LOCA conditions. This ISG cites RG 1.63 and the industry standards, IEEE 317 and IEEE 741, for electric penetration design and protection, respectively, as guidance acceptable to the staff for meeting the requirements of this criterion.

Meeting the requirements of GDC 50 provides assurance that a LOCA will not cause a containment structure, including its electrical penetrations, to exceed the design leakage rate, thus limiting the consequences of a LOCA.

8. Compliance with 10 CFR 50.63 requires that each light-water-cooled NPP be able to withstand for a specified duration and recover from an SBO. As required by 10 CFR 50.63, electrical systems that are necessary support systems for SBO provide sufficient capacity and capability to ensure that core cooling and appropriate containment integrity are maintained in the event of an SBO. One acceptable means of complying with 10 CFR 50.63 requirements involves the provision of an AAC source (as defined in 10 CFR 50.2) of sufficient capacity, capability, and reliability for operation of all systems necessary for coping with SBO and for the time necessary to bring and maintain the plant in safe shutdown that will be available on a sufficiently timely basis.

   Also pursuant to 10 CFR 50.63, through citation of the definition of AAC source in 10 CFR 50.2, there should be minimum potential for common mode failure (i.e., acceptable independence) between any AAC power source used for SBO and the offsite power system or onsite power sources. Electrical ties between these systems, as well as the physical arrangement of their interface equipment, should not prevent the use of any AAC power source during loss of the offsite power system and/or onsite power sources. It is also important that provisions for an AAC source not adversely affect performance of offsite or onsite power system functions. AAC power sources located at or near the plant should conform to guidance provided in RG 1.155 concerning their capacity, capability, and physical independence from onsite safety-related systems and the preferred power system. See SRP Section 8.4 for details of the review of AAC power sources for SBO.

   As specified in 10 CFR 50.63, the reliability and redundancy of emergency onsite AC power sources must be used as a factor in determining the duration for which the plant must be capable of coping with an SBO event. A reliability program should also be provided to attain and maintain the target reliability levels of emergency onsite AC sources with respect to SBO considerations. RG 1.155, Article 2 of this ISG, and SRP Section 8.4 describe guidance acceptable to the staff for meeting the requirements of 10 CFR 50.63 related to addressing emergency onsite AC source reliability for SBO. Determination of SBO coping time is reviewed in detail in SRP Section 8.4.

As documented in SECY-94-084, the electrical distribution system for evolutionary LWR design plants should include: 1) an alternate offsite power source available for non-safety-related loads, unless the design margins for loss of non-safety-related loads are no more severe than turbine-trip-only events in current plants, and 2) at least one offsite circuit to each redundant safety division supplied directly from offsite power sources, with no intervening non-safety-related buses.

For passive reactor design applications, such as the AP1000, the potential risk contribution of an SBO is minimized by not needing AC power sources for DBEs. The safety-related passive systems in these plants do not need any AC power sources to perform safety-related functions. They are designed to automatically establish and maintain safe shutdown conditions after DBEs for 72 hours, without operator action, following a loss of both onsite and offsite AC power sources. Consequently, a passive reactor design meets the requirements of 10 CFR 50.63 if it can establish and maintain safe shutdown conditions for the specified duration of the SBO event, without operator action, following a loss of both onsite and offsite AC power sources.

Detailed reviews to verify that the evolutionary and passive ALWR design applications satisfy the requirements of 10 CFR 50.63 are covered in SRP Section 8.4, "Station Blackout."

Meeting the requirements of 10 CFR 50.63 provides assurance that the NPP will be able to withstand or cope with, and recover from, an SBO and will ensure that core cooling and appropriate containment integrity are maintained.

9. 10 CFR 50.65 (a)(4) requires that licensees assess and manage the increase in risk that may result from proposed maintenance activities before performing the maintenance activities. Grid stability and offsite power availability are examples of emergent conditions that may result in the need for action prior to the conduct of the assessment or that could change the conditions of a previously performed assessment. Accordingly, licensees should perform grid reliability evaluations as part of the maintenance risk assessment before performing “grid-risk-sensitive” maintenance activities (such as surveillances, post-maintenance testing, and preventive and corrective maintenance). Such activities are those which could increase risk under existing or imminent degraded grid reliability conditions, including (1) conditions that could increase the likelihood of a plant trip, (2) conditions that could increase the likelihood of a LOOP or a SBO, and (3) conditions that could have an impact on the plant’s ability to cope with a LOOP or SBO, such as out-of-service risk-significant equipment (for example, an EGTG, a battery, a steam-driven pump, or an AAC power source).

III. <u>REVIEW PROCEDURES</u>

The primary objective in the review of the AC power system is to determine that this system satisfies the acceptance criteria stated in Subsection II and will perform its design functions during plant normal operation, anticipated operational occurrences, accident conditions, and post-accident conditions. To ensure that acceptance criteria stated in Subsection II are satisfied, the review is performed as detailed below.

The primary reviewer will coordinate this review with the other branch areas of review as stated in Subsection I. The primary reviewer obtains and uses such input as necessary to ensure that this review procedure is complete.

The reviewer will select material from the procedures described below, as may be appropriate for a particular case.

These review procedures are based on the identified acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

1. <u>System Redundancy Requirements</u>

   GDCs 33, 34, 35, 38, 41, and 44 set forth requirements with regard to the safety systems that must be supplied by the onsite AC power system. Also, these criteria state that safety system redundancy should be such that, for onsite power system operation (assuming offsite power is not available); the system safety function can be accomplished assuming a single failure. The acceptability of the onsite power system with regard to redundancy is based on conformance to the same degree of redundancy of safety-related components and systems required by these GDCs. As endorsed by RG 1.153, IEEE 603 provides criteria used to evaluate all aspects of the electrical portions of safety-related systems and the onsite power system, including criteria addressing redundancy, and IEEE 279 provides criteria for protection systems, with applicability determined by the date of issuance of the CP as described in 10 CFR 50.55a(h). The descriptive information, including electrical single-line diagrams, physical arrangement drawings, and electrical control and schematics, is reviewed to verify that this redundancy is reflected in the standby power system with regard to both power sources and associated distribution systems. Also, it is verified in coordination with other branches that redundant safety loads are distributed between redundant distribution systems and that the I&C devices for the Class 1E loads and power system are supplied from the related redundant distribution systems.

2. <u>Conformance with the Single Failure Criterion</u>

   As required by GDC 17, the onsite AC power system must be capable of performing its safety function assuming a single failure.

   In evaluating the adequacy of this system in meeting the single failure criterion, both electrical and physical separation of redundant power sources and distribution systems, including their connected loads, are reviewed to assess the independence of redundant portions of the system.

   To ensure electrical independence, the design criteria, analyses, description, and implementation as depicted on functional logic diagrams, electrical single-line diagrams, and electrical control and schematics are reviewed to determine that the design meets the recommendations set forth in IEEE 308 and satisfies the positions of RG 1.6. As endorsed by RG 1.153, IEEE 603 provides criteria used to evaluate all aspects of the electrical portions of safety-related systems and the onsite power system, including basic criteria for addressing single failures, and IEEE 279 provides criteria for protection systems with applicability determined by the date of issuance of the CP as described in 10 CFR 50.55a(h). Additional guidance in evaluating this aspect of the design is derived from IEEE 379, "Guide for the Application of the Single-Failure Criterion to Nuclear Power Generating Station Protection Systems," as augmented by RG 1.53, "Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems." Other aspects of the design where special review attention is given to ascertain that the electrical independence and physical separation has not been compromised are as follows:

A. Should the proposed design provide for sharing of the onsite AC power system between units at the same site, the criteria of IEEE 308 governing the sharing of this system between units are not specific enough to be used as the basis for assessing the adequacy of the design in meeting the requirements of GDC 5 and satisfying the single failure criterion. Therefore, the acceptability of such a design is determined by reviewing the proposed system design criteria and electrical schematics as well as analyses substantiating the adequacy of the design to withstand the consequences of electrical faults and failures in one unit with respect to the others. Generally, the reviewer is guided by Position C.2 of RG 1.81, "Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants," for CP applications docketed before June 1, 1973. Position C.3 of this RG does not recommend the sharing of onsite power systems between nuclear units for CP applications docketed after June 1, 1973. Further details of the review with regard to Position C.2 on sharing of the onsite power system between units are covered in item 4, below. [For new plants, sharing of EGTGs between units is not recommended.]

B. The interconnections between redundant load centers through bus tie breakers and multi-feeder breakers used to connect extra redundant loads to either of the redundant distribution systems are examined to ensure that no single failure in the interconnections will cause the paralleling of the standby power supplies. To ensure this, the control circuits of the bus tie breakers or multi-feeder breakers should preclude automatic transferring of load centers or loads from the designated supply to the redundant counterpart upon loss of the designated supply (Position D.4 of RG 1.6). Regarding the interconnections through bus tie breakers, an acceptable design should provide for two tie breakers connected in series and physically separated from each other in accordance with the acceptance criteria for separation of the onsite power system, which is discussed below. Further, the interconnection of redundant load centers should be accomplished only manually. With respect to the interconnections through the multi-feeder breakers supplying power to extra redundant loads, the review relates to the use of the extra redundant unit as one of the necessary operating units (if the substituted-for-normal unit is inoperable). If this is the selected mode of operation prior to an accident concurrent with the LOOP, it is verified by reviewing the breaker arrangement and associated control circuits to ensure that no single failure in the feeder breaker that is not connected to the extra redundant unit could cause the closing of this breaker, resulting in the paralleling of the power supplies. To ensure against compromising the independence of the redundant power systems in this situation, an acceptable design for connecting extra redundant loads to either distribution system should provide for at least dual means for connecting and isolating each load from each redundant bus. Such a design should also meet the acceptance criteria for electrical and physical separation of the onsite power system.

In addition, the provisions of the design to automatically break all the interconnections (e.g., open tie and multi-feeder breakers) of redundant load centers immediately following an accident condition concurrent with the LOOP are reviewed to ascertain that the independence of the redundant portions of this system is established given a single failure.

Operating experience has shown that potential single failure and fire vulnerabilities may exist whereby a circuit failure could result in safety bus lockouts and prevent re-energization of the redundant safety bus (see Reference 12). Certain safety bus protection schemes involving three current transformers for individual phase overcurrent relays and a ground overcurrent relay connected in a basic residual scheme were identified, which also included connection to a single common watt-hour meter summing the power for redundant safety buses. A fire-induced fault or watt-hour meter failure resulting in an open circuit could be interpreted by the bus differential protection system as an electrical fault on both safety buses causing in multiple bus lockouts. The reviewer should examine the electrical protection and metering schemes to verify that no such interconnections exist between protection and metering circuits that would constitute a common-mode failure vulnerability.

C. To ensure physical independence, the criteria governing the physical separation of redundant equipment, including cables and raceways and their implementation as depicted on preliminary or final physical arrangement drawings, are reviewed to determine that the design arrangements satisfy the recommendations set forth in IEEE 384 as augmented by RG 1.75. This standard and RG set forth acceptance criteria for the separation of circuits and electrical equipment contained in or associated with the Class 1E power system. To determine that the independence of the redundant cable installation is consistent with satisfying the recommendations set forth in IEEE 384 as augmented by RG 1.75, the proposed design criteria governing the separation of Class 1E cables and raceways are reviewed, including such criteria as those for cable derating; raceway filling; cable routing in containment, penetration areas, cable spreading rooms, control rooms, and other congested areas; sharing of raceways with non-safety-related cables or with cables of the same system or other systems; prohibiting cable splices in raceways; control wiring and components associated with Class 1E electric systems in control boards, panels, and relay racks; and fire barriers and separation between redundant raceways.

Operating experience, as documented in GL 2007-01, has shown that undetected degradation of electric cables due to protracted exposure to wetted environments or submergence in water or resulting from pre-existing manufacturing defects could result in multiple equipment failures. The reviewer should verify that underground or inaccessible power and control cable runs that are susceptible to protracted exposure to wetted environments or submergence as a result of tidal, seasonal, or weather event water intrusion are adequately identified, that they are monitored, or that corrective actions are implemented. Underground or inaccessible power cables connecting offsite power to safety buses or power cables to equipment with accident mitigating functions should be considered in the review. Examples of submerged and wetted underground cable failures from the operating experience are provided in IN 2002-12 and GL 2007-01.

3. Onsite and Offsite Power System Independence

In ascertaining the independence of the onsite power system with respect to the offsite power system, the electrical ties between these two systems as well as the physical arrangement of the interface equipment are reviewed to ensure that no single failure will prevent the separation of the redundant portions of the onsite power system from the offsite power system when necessary. The scope of the review for independence extends from the supply breakers connected to the low side of the unit auxiliary transformers and startup transformers (referred to as the offsite or preferred power supplies) to the station safety-related distribution system. The number and capability of electrical circuits from the offsite power system to the safety buses should be consistent with satisfying the requirements of GDC 17. Then, downstream of the offsite power breakers at the safety buses, the design must satisfy the requirements for redundancy and independence of GDCs 34, 35, 38, 41, and 44; that is, for onsite power system operation (assuming offsite power is not available), the system safety function can be accomplished assuming a single failure.

To determine that the physical independence of the preferred power circuits to the Class 1E buses is consistent with satisfying the requirements of GDC 17 and the recommendations of IEEE 308, the physical arrangement drawings are examined to verify that each circuit is physically separate and independent from its redundant counterparts. In addition, the final feeder-isolation breaker in each circuit through which preferred power is supplied to the safety buses should be designed and physically separated in accordance with the criteria for the onsite power system. Following the loss of preferred power, the safety buses are powered solely from the standby power supplies. Under this situation, the design of the feeder-isolation breaker in each preferred power circuit should preclude the automatic connection of preferred power to the respective safety bus upon the loss of standby power. In this regard, an acceptable design should include the capability for restoring preferred power to the respective safety bus by manual actuation only.

Supplying power to the Class 1E buses from offsite power sources through non-Class 1E buses, or from a common transformer winding to that supplying non-Class 1E loads, makes it more difficult to obtain suitable voltage regulation at the Class 1E buses. It also subjects the Class 1E loads to transients caused by non-Class 1E loads (e.g., the tripping of a reactor coolant pump). Such configurations also provide the potential for additional failure points between the offsite power source and the Class 1E buses/loads. Therefore, it is preferable that the design include at least one offsite circuit supplied directly to each redundant safety division from one of the offsite power sources with no intervening nonsafety buses in such a manner that the offsite source can power the safety buses in the event of failure of any nonsafety bus.

In plants where there is no alternate source to supply power to nonsafety components such as Reactor Coolant Pumps, Reactor Recirculation Pumps, Feedwater Pumps, etc.; the loss of power to these loads due to a plant trip or a 100% load rejection caused by the opening of the main generator high-side circuit breaker will result in a loss of forced circulation in the reactor coolant system and reduced feedwater flow. Therefore, the electrical drawings should also be examined to ensure that the design includes an alternate power source for nonsafety loads, unless it has been demonstrated that the design margins will result in transients for loss-of nonsafety-power events that are no more severe than those associated with the turbine-trip-only event in existing plant designs.

As documented in SECY-91-078, evolutionary LWR design applications should satisfy the requirements of GDC 17 with an electrical distribution system design that includes at least one offsite circuit to each redundant safety division supplied directly from one of the offsite power sources with no intervening nonsafety buses in such a manner that the offsite source can power the safety buses upon the failure of any nonsafety bus. Aside from this configuration variation, the review to ascertain the independence of the onsite with respect to the offsite power systems is similar to that for existing plant designs.

Passive LWR design applications provide passive safety systems that do not need Class 1E AC electric power, other than that provided by the Class 1E DC batteries and their inverters, to accomplish the plant's safety-related functions for 72 hours. However, as documented in SECY 94-084, SECY-95-132, and RG 1.206 of Section C.IV.10, the staff addressed technical issues associated with the RTNSS process in passive plant designs for risk-important, non-safety-related, active systems, such as the AC power system. These systems may have a significant role in accident and consequence mitigation by providing DID functions to supplement the capability of the safety-related passive systems. Passive reactor plant designs should; therefore, include one offsite power source with sufficient capacity and capability from the transmission network to power the safety-related systems and all other auxiliary systems under normal, abnormal, and accident conditions. The offsite power source should be designed to minimize to the extent practical the likelihood of its failure under normal, abnormal, and accident conditions. The design review should; therefore, address the independence of the offsite power system with regard to the onsite AC power criteria to support those risk-important, non-safety-related, active systems identified through the RTNSS process.

Certified passive designs should demonstrate how the RTNSS evaluation process addresses the resolution of design issues, in accordance with SECY-94-084 and SECY-95-132. Subsequent COL applications could then reference the RTNSS evaluation in the applicable existing certified DCDs to demonstrate their compliance with design requirements for passive design power systems as described in Section C.III.1 of RG 1.206. Further detailed information and guidance on electrical design for passive COL applications are provided in Section C.III.1.8.3.1 of RG 1.206, SECY-94-084, and SECY-95-132.

The COL applicant should submit a reliability assurance program describing the reliability assurance activities it will perform before the initial fuel load. This program should maintain the reliability objectives consistent with the PRA assumptions designed into the plant. Reliability assurance activities for the operating stage are integrated into existing programs (e.g., maintenance rule, surveillance testing, inservice inspection, inservice testing, and quality assurance). Further detailed information and guidance on reliability assurance programs for passive COL applications are provided in Section C.I.17.4 of RG 1.206, SECY-94-084, and SECY-95-132. The reviewer verifies that adequate provisions are made in the design of the onsite power systems for grounding, surge protection, and lightning protection. The reviewer evaluates onsite power system grounding, ground fault current limiting features, lightning/transient surge protection features, and measures for isolation of instrumentation grounding systems. RG 1.204 and IEEE Stds 665, 666, 1050, and C62.23, which the RG endorses, provide acceptable guidelines for the design, installation, and performance of lightning protection systems. Guidance with respect to grounding system design and analysis criteria for COL applications that are not based on certified ALWR designs is provided in RG 1.206 of Section C.I.8.3.1, and for those COL applications based on certified designs, in RG 1.206 of Section C.III.1, Chapter 8. Detailed review of grounding and lightning protection for the generating station and offsite power system is provided in SRP Section 8.2.

Variations in voltage, frequency and waveform (harmonic distortion) in the onsite power system and its components during any mode of plant operation should not degrade the performance of any safety system load below an acceptable level. IEEE 308 and other industry standards (Reference 60), and RG 1.206 of Section C.I.8.3.1, for COL applications that are not based on certified ALWR designs, provide guidance on system power quality limits and the effects of degraded voltage on instrumentation and protection systems. RG 1.206 of Section C.III.1, Chapter 8, provides similar guidance for COL applications that are based on certified ALWR designs.

In assessing the adequacy of the electrical ties between the onsite and offsite power systems, and the capability of the preferred power circuits to deliver power to the safety-related buses, both primary and secondary backup protective relaying schemes and their coordination, relay settings, and assigned control power supplies are reviewed. The reviewer should ensure that, in the event of an electrical fault, between the preferred power transformer supply breakers and the safety buses, no single failure will result in reducing the number of preferred power circuits to less than the minimum necessary for safety or prevent the separation of the affected circuit from the respective redundant portion of the onsite power system. In addition, it is verified that no single protective relay or interlock failure will prevent separation of the necessary redundant portions of the onsite power system from the preferred power system upon loss of the latter. Industry standards (References 47, 48, and 56) for COL applications that are not based on certified ALWR designs, RG 1.206 of Section C.I.8.3.1.2, provide further information for the reviewer regarding power system analysis studies - including load flow with voltage regulation, short circuit analysis, equipment sizing studies, protective relay setting and coordination, motor starting, grounding system design and insulation coordination - to verify the capability of the onsite AC power system and the interface with the offsite power system. RG 1.206 of Section C.III.1, Chapter 8, provides similar guidance for COL applications that are based on certified ALWR designs.

The analysis of the onsite AC power system should consider the effects of the offsite power system, particularly the grid voltage, on the capability of the onsite system and the response of the undervoltage relaying. The review should ensure that the grid stability analysis considers the effect of grid events on the adequacy of offsite grid voltage available at the plant switchyard. Operating experience has shown that a variety of factors, such as power flow through the transmission grid, reactive power capacity, the plant voltage and frequency protective schemes and setpoints, and weather or temperature conditions in the region, can all affect grid voltage levels and overall stability. BTP 8-6 and References 7 and 13 provide information for the reviewer regarding degraded transmission grid voltage and the effects of grid events on grid voltage at the plant switchyard. Detailed review regarding the analysis of grid operating conditions and stability and their potential interactions with the onsite power system is covered in SRP Section 8.2, "Offsite Power System."

In reviewing the mode of operation where both power systems are being operated in parallel (such is the case during full-load testing of standby power supply EGTGs), the interlock scheme, including electrical protective relay coordination and settings, is closely examined to verify that the independence of the necessary redundant portions of the onsite power system is established upon a failure in the offsite power system. The event of concern under this mode of operation is an accident concurrent with a LOOP and a single failure preventing the opening of the feeder-isolation breaker through which the paralleling of the power systems was being accomplished. Because the signal to start the EGTGs is normally derived from undervoltage relays, and under this situation the voltage is maintained above the trip relay settings by the EGTG under test, the remaining redundant EGTGs will not be commanded to start running. Consequently, the added capacity resulting from the connection of non-safety-related loads to the EGTG under test will cause the tripping of this EGTG due to overload or underfrequency. The end result could be the total loss of power to the safety buses. However, this power interruption could be of momentary duration if the remaining redundant EGTGs are commanded automatically to start by undervoltage relay action immediately after total power is lost. The EGTG under test will be inoperable due to the self-locking feature preventing restarting after an overload or under frequency trip condition. The reviewer ascertains that the time delay introduced in making power available to the safety buses as a result of this event is within the response time limits assumed in the accident analyses. This should include verification that subsequent failures such as those resulting from improper electrical relaying coordination and self-locking features will not impair the automatic starting of the remaining redundant EGTGs required to meet minimum safety criteria. If the time delay introduced in making power available to the safety buses is not tolerable, it either must be demonstrated that the probability of occurrence of this event is low when compared with the frequency and duration of testing each EGTG, or the design must provide diverse automatic signals, other than undervoltage, to ensure the availability of standby power to the safety buses.

Parallel operation of the offsite and onsite power systems, other than for testing of the standby power supply EGTGs, should not be allowed. Frequent interconnection of the offsite and standby power supplies, for example, to supply power to the electrical grid system during peak load demand periods, violates a requirement of GDC 17. GDC 17 states, in part, that provisions shall be included to minimize the probability of losing electric power from any of the remaining supplies, as a result of, or coincident with, the loss of power generated by the nuclear power unit, the loss of power from the transmission network, or the loss of power from the onsite electric power supplies. Parallel operation of these two systems does not minimize the probability of their coincident loss but rather increases the probability by compromising their independence. In addition, the overall power system is thereby subject to common cause failure which is prohibited by IEEE Std. 308, Section 5.2.1(5). Further discussion on this topic is can be found in BTP 8-2.

Operating experience has provided insights into aging-, operation-, and design-related problems associated with medium-and low-voltage switchgear equipment, electrical buses, and circuit breakers used in the onsite AC power system. These include, but are not limited to:

- bus failures, involving the integrity of bus bar splice joints, torque relaxation, cyclical bus loading, and incipient damage resulting from a high fault current transient/arcing fault explosion, that can lead to a LOOP (Reference 8);

- failures of safety-related circuit breakers due to problems with preventive maintenance programs, circuit breaker lubrication, licensee/vendor interface, control voltage criteria, and review of circuit breaker operating experience (References 5 and 6);

- metal-clad switchgear circuit breaker failure involving an energetic arcing fault fire/explosion that propagated damage to adjacent circuit breaker cubicles and resulted in a LOOP (Reference 9); and

- potential for degradation of switchgear control and protection wiring at the circuit breaker cubicle door hinges that could affect safety equipment function (Reference 10).

The review should verify that medium and low-voltage switchgear, metal-enclosed bus preventive maintenance and performance and condition monitoring activities are evaluated periodically in accordance with the Maintenance Rule and that they incorporate, where practical, the insights of internal and industry-wide operating experience.

4. Standby Power Supplies

The reviewer should ensure that the requirements of GDC 17 and the recommendations of IEEE Std 308 have been met with regard to the standby power supply (EGTGs) having sufficient capacity and capability to supply the distribution system loads. In addition, the reviewer should verify that the standby power supply meets the design bases and design criteria, and should have analyses to support the design. Further, the reviewer should verify that the standby power supply has been described and implemented as depicted on electrical drawings and physical arrangement drawings. The EGTGs are reviewed to verify that the bases for their selection satisfy the positions of Article 2 of this ISG. Specifically, the reviewer first becomes familiar with the purpose and operation of each safety system, including system component arrangement as depicted on physical arrangement drawings, expected system performance as established in the accident analyses, modes of system operation and their interactions during normal and accident conditions, and interactions between systems. Following this, it is verified that the tabulation of all safety-related loads to be connected to each EGTG is consistent with the information establishing the safety-related systems and loads and their redundancy. The characteristics of each load (such as motor horsepower, volt-amp rating, in-rush current, starting volt-amps, and torque), the length of time each load is required, and the basis used to establish the power necessary for each safety load (such as motor nameplate rating, pump run-out condition, or estimated load under expected flow and pressure) are used to verify the calculations establishing the combined load demand to be connected to each EGTG during the "worst" operating condition. In applying this combined load demand to the selection of each EGTG capacity, an acceptable design should satisfy Positions C.1.2 through C1.5 of Article 2 in this ISG. Further guidance on the review of capacity, capability and reliability criteria of standby power supplies and onsite power system design analysis studies is provided in industry standards (References 47, 48 and 56) and, for COL applications that are not based on certified ALWR designs, in RG 1.206 of Section C.I.8.3.1. RG 1.206 of Section C.III.1, Chapter 8, provides similar guidance for COL applications that are based on certified ALWR designs. It is noted that the load capability of a gas turbine is a strong function of the environmental temperature and altitude and this is discussed in industry standards (Reference 67).

To ensure that each EGTG is capable of starting and accelerating to rated speed all the connected loads in the necessary sequence and within the minimum time intervals established by the accident analyses, the reviewer examines for each EGTG the loading profile curves, voltage and frequency recovering characteristic curves, and the response time of the excitation system to load variations. This examination should verify that the capability of each EGTG to respond to voltage and frequency variations satisfies Position C.1.6 of Article 2 of this ISG. In addition, the adequacy of the circuit design for starting and disconnecting and connecting safety loads from and to each EGTG is checked. This includes a review of the starting initiating circuits; manual and automatic sequential loading and unloading circuits; interrupting capacity of switchgear, load centers, control centers, and distribution panels; grounding criteria; and electrical protective relaying circuits, including their coordination, relay settings, and assigned control power supplies for each load and each EGTG. In reviewing the criteria governing the design of the thermal overload protection for motors of motor-operated safety-related valves, the reviewer is guided by RG 1.106. Motor starting studies, load flow studies, demand load (bus loading) studies, and short circuit studies should be reviewed in accordance with the guidance provided in industry standards (References 47, 48, and 56) and, for COL applications that are not based on certified ALWR designs, RG 1.206 of Section C.I.8.3.1. RG 1.206 of Section C.III.1, Chapter 8, provides similar guidance for COL applications that are based on certified ALWR designs.

Regarding the review of the electrical protective trip circuits of the EGTGs, Positions C.1.12 and C.1.14 of Article 2 of this ISG are used as an evaluation guide. The capability of the automatic sequential loading circuits to reset during a sustained low voltage condition on the EGTGs is reviewed to ensure that upon restoration of normal voltage, the safety-related loads can be connected in the prescribed sequence. Otherwise, the reconnection of all the loads at the same time could result in an overload condition causing the trip of the respective EGTG. In ensuring that those safety-related loads being powered through latched-type breakers are capable of being reconnected to their respective buses after restoration of power, the design should provide for resetting the breaker anticycle feature when there is an undervoltage condition. The normal function of this feature is to prevent immediate reclosure of a breaker following a trip.

Where the proposed design provides for the sharing of EGTGs between units at the same site, and connection and disconnection of non-Class 1E loads to and from the Class 1E distribution buses, particular attention is given in the review to ensure that the implementation of such design provisions does not compromise the capacity or capability of the standby power supplies.

Pursuant to GDC 5, EGTGs may not be shared unless it can be shown that the EGTGs are capable of performing all necessary safety functions in the event of an accident in one unit and an orderly shutdown and cooldown of the remaining units. In ensuring that the proposed design for sharing EGTGs between units meets the requirements of GDCs 5 and 17 as supplemented by GDCs 34, 35, 38, 41, and 44 and satisfies the positions of Article 2 of this ISG, the reviewer is guided by RG 1.81. This guide sets forth two principal positions. Position C.3 applies to those CP applications docketed after June 1, 1973, and does not recommend the sharing of onsite power systems between units. Conformance of the design with Position C.3 is verified by reviewing the descriptive information, including electrical drawings, to ensure that the onsite power system of each unit is electrically independent with respect to the onsite power system of other units.

Position C.2 of RG 1.81 establishes acceptable bases under which sharing of onsite power systems between units is permitted. Conformance with Position C.2 with regard to the adequacy of EGTG capacity and capability under the sharing mode of operation is verified by following the procedure discussed above for tabulating and summing all loads. In particular, the load tabulation and calculations establishing the EGTG capacity are examined to ensure that the selected capacity is sufficient to power the minimum engineered safety feature (ESF) loads in any unit and safely shut down the remaining units in the event of an accident in one unit and a single failure or spurious or false accident signal from another unit and loss of preferred power to all the units. In addition, the physical arrangement of I&C devices on control room panels and consoles in one unit with respect to the other units is examined to ensure that the design minimizes the coordination needed between unit operators to accomplish sharing of the standby power systems.

In the absence of specific criteria in IEEE 308 governing the connection and disconnection of non-Class 1E loads to and from the Class 1E distribution buses, the review of the interconnections will consider isolation devices as defined in IEEE 384 and augmented by RG 1.75 to determine the adequacy of the design. In ensuring that the interconnections of non-Class 1E loads and Class 1E buses will not result in the degradation of the Class 1E system, the isolation device through which standby power is supplied to the non-Class 1E load, including control circuits and connections to the Class 1E bus, should be designed to meet Class 1E criteria. Should the standby power supplies not have been sized to accommodate the added non-Class 1E loads during emergency conditions, the design should provide for the automatic disconnection of those non-Class 1E loads upon the detection of the emergency condition. This action should be accomplished whether or not the load was already connected to the power supply. Further, the design must also prevent the automatic or manual connection of these loads during the transient stabilization period subsequent to this event.

The description of the qualification test program and the results of such tests for demonstrating the suitability of the EGTGs as standby power supplies are judged to be acceptable if they satisfy the acceptance criteria stated in Subsection II. In the event that EGTGs have not been selected for a particular plant, a commitment from the applicant to perform qualification tests on EGTGs of the same design in accordance with the acceptance criteria, is considered acceptable. The required qualification tests are described in Article 2 of this ISG.

Guidance for the review of the EGTG auxiliary systems is provided in Articles 4 through 8 of this report.

To ensure that EGTG reliability and operation will not be degraded, the reviewer evaluates the EGTG descriptive information and the results of failure modes and effects analyses in the SAR and, using engineering judgment, verifies the following items:

A. Provisions have been made in the facility design and in the design and installation of electrical equipment associated with the starting of the EGTGs to minimize failure to start on demand due to accumulation of dust and other deleterious material ingested via the ventilation system or generated in the EGTG room during normal plant operation on the electrical starting equipment (e.g., auxiliary relay contacts, control switches, etc.) panel or individually mounted.

B. The EGTGs are capable of operation at less than full load without degradation of performance or reliability.

C. A complete formal training program is provided for all mechanical and electrical maintenance, quality control, and operating personnel, including supervisors who are responsible for the maintenance and availability of the EGTGs.

D. A preventive maintenance program is provided that encompasses investigative testing of components and a replacement plan as specified in Subsection II.

E. The repair and maintenance procedures provide for a final equipment check, and test procedures provide for returning the EGTG to automatic standby service and under the control of the control room operator.

F. Except for sensors and other equipment that needs to be mounted directly on the EGTG or associated piping, the controls and monitoring instruments are installed on a free-standing, floor-mounted panel located on a vibration-free floor area. If the floor is not vibration free, the panel should be equipped with vibration mounts. In the event that the instruments and controls cannot be removed from the engine skid, due to plant design, the controls and instrumentation should be environmentally qualified for vibration service. Until the environmental qualification of the components is completed, the applicant has implemented an augmented inspection, test, and calibration program. Verify that this program has been adequately described in the SAR.

5. Identification of Cables, Raceways, and Terminal Equipment

The identification scheme used for safety-related cables, raceways, and terminal equipment in the plant and internal wiring in the control boards is reviewed to see that it is consistent with IEEE 384 as augmented by RG 1.75. This includes the criteria for differentiating between (a) safety-related cables, raceways, and terminal equipment of different channels or divisions; (b) non-safety-related cable which is run in safety raceways; (c) non-safety-related cable that is not associated physically with any safety division; and (d) safety-related cables, raceways, and terminal equipment of one unit with respect to the other units at a multi-unit site.

6. Auxiliary Supporting Systems/Features

The reviewer will verify the design adequacy of those auxiliary supporting systems identified as being vital to the operation of safety-related loads and systems. IEEE 603, as endorsed by RG 1.153, provides criteria used to evaluate all aspects of the instrumentation, control, and electrical portions of auxiliary supporting systems and features, including basic criteria that call for auxiliary supporting systems and features to satisfy the same criteria as the supported safety systems. The reviewer will verify the design adequacy of the instrumentation, control, and electrical aspects of the auxiliary supporting systems and features to ensure that their design conforms to the same criteria as those for the systems that they support.

Hence, the review procedure to be followed for ascertaining the adequacy of these systems and features is the same as that discussed herein for the onsite systems. In essence, the reviewer first becomes familiar with the purpose and operation of each auxiliary supporting system and feature, including its components arrangement as depicted on functional piping and instrumentation diagrams (P&IDs). Subsequently, the design criteria, analyses, and description and implementation of the instrumentation, control, and electrical equipment, as depicted on electrical drawings, are reviewed to verify that the design is consistent with satisfying the acceptance criteria for Class 1E systems. In addition, it is verified that the auxiliary supporting system redundant instrumentation, control devices, and loads are examined to verify that they are powered from the same redundant distribution system as the system that they support. The reviewer will also verify that the auxiliary supporting systems that are associated with the emergency EGTG - such as the fuel oil storage and transfer system, cooling system, starting air system, and lubrication system - are in accordance with the acceptance criteria.

The organization responsible for plant systems reviews the other aspects of the auxiliary supporting systems to verify that the design, capacities, and physical independence of these systems are adequate for their intended functions. Included is a review of the heating, and ventilation, and air conditioning (HVAC) systems identified as necessary to Class 1E systems, such as the HVAC systems for the electrical switchgear and EGTG rooms. The organization responsible for the review of plant systems will verify the adequacy of the HVAC system design to maintain the temperature and relative humidity in the room necessary for proper operation of the safety equipment during both normal and accident conditions. It will also verify that redundant HVAC systems are located in the same enclosure as the redundant unit they serve or are separated in accordance with the same criteria as those for the systems they support.

7. System Testing and Surveillance

In ensuring that the proposed periodic onsite testing capabilities of the onsite AC power system satisfies the requirements of GDC 18 and the positions of RG 1.118 and Article 2 of this ISG, the descriptive information, functional logic diagrams, and electrical schematics are reviewed to verify that the design has the built-in capability to permit integral testing of Class 1E systems on a periodic basis when the reactor is in operation. Basic criteria relevant to the review of the surveillance and testability of safety-related aspects of the AC power system are also described in IEEE 603 as endorsed by RG 1.153.

Operating experience (Reference 4) has revealed numerous instances of inadequacies in the logic functional surveillance testing of safety-related circuits in which the testing procedures did not provide sufficient overlap to completely test multiple logic pathways as required by TSs. The reviewer should verify that licensees have compared electrical schematic drawings and logic diagrams for the reactor protection system, EGTG load shedding and sequencing, actuation logic for the onsite power system and the EGTG, and actuation logic for ESF systems against surveillance test procedures to ensure that all portions of the logic circuitry, including the parallel logic, interlocks, bypasses and inhibit circuits, are adequately covered to fulfill the TS requirements. The licensee's review should have included relay contacts, control switches, and other relevant electrical components within these systems, utilized in the logic circuits performing a safety function.

The Maintenance Rule Section 50.65(a)(4) requires that licensees assess and manage the increase in risk that may result from proposed maintenance activities before performing the maintenance activities. RG 1.182, used as a companion guide to RG 1.160, provides guidance for assessing and managing the increase in risk that may result from maintenance activities and for implementing the optional reduction in scope of SSCs considered in the assessment. The review should verify that grid reliability evaluations are performed, as part of the maintenance risk assessment required by 10 CFR 50.65 before performing "grid-risk-sensitive" maintenance activities, including, but not limited to, surveillances, post-maintenance testing, and corrective and preventive maintenance. Such activities are those which could increase risk under existing or imminent degraded grid reliability conditions, including: (1) conditions that could increase the likelihood of a plant trip, (2) conditions that could increase the likelihood of LOOP or SBO, and (3) conditions that have an impact on the plant's ability to cope with a LOOP or SBO, such as out-of-service risk-significant equipment (e.g., an EGTG, a battery, a steam-driven pump, and alternate AC power source).

The descriptive information and the design implementation (as depicted on electrical drawings) of the means proposed for automatically indicating at the system level a bypassed or deliberately inoperative status of a redundant portion of a safety-related system are reviewed to ascertain that the design is consistent with RG1.47 and BTP 8-5. This position establishes the basis to be considered in arriving at an acceptable design for the inoperable status indication system.

8. Reliability Program for Emergency Onsite AC Power Sources

RG 1.155 provides guidance for setting minimum reliability goals for emergency onsite AC power sources. Review is conducted in accordance with SRP Section 8.4 to verify that the target reliability for such sources satisfy the positions of RG 1.155. RG 1.155 also recommends that the reliable operation of emergency onsite AC power sources be ensured by a reliability program designed to maintain and monitor the reliability level of each power source over time for assurance that the target reliability levels are being achieved. The reliability program is reviewed to verify its adequacy with respect to SBO considerations. The reviewer verifies that the reliability program includes provisions that conform with Position C.1.2 of RG 1.155 and Positions C.2.2 and C.2.3 of Article 2 of this ISG. The reviewer also verifies that the effectiveness of maintenance activities under the program are monitored in accordance with the Maintenance Rule (10 CFR 50.65) and RG 1.160, including the periodic monitoring of the condition and performance of emergency onsite AC power sources against licensee-established goals, periodic evaluation of performance and condition monitoring activities and associated goals and preventive maintenance activities, evaluation of operating experience, and incorporation of appropriate corrective actions when performance or condition of emergency onsite AC power sources do not meet established goals.

9. Fire Protection for Cable Systems

   In ensuring that the requirements of GDC 3 have been met, the organization responsible for plant systems will review the design of the fire stops and seals, including the materials, their characteristics with regard to flammability and fire retardancy, and their fire underwriters rating, in accordance with SRP Section 9.5.1. All cable and cable tray penetrations through walls and floors, as well as any other types of cable ways or conduits, should have fire stops installed. The reviewer will verify the design adequacy of cable derating and raceway fill to ensure compliance with accepted industry practices.

For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the final safety analysis report (FSAR) meets the acceptance criteria. DCs have referred to the FSAR as the DCD. The reviewer should also consider the appropriateness of identified COL action or information items. The reviewer may identify additional COL action or information items; however, to ensure these COL action or information items are addressed during a COL application, they should be added to the DC FSAR.

For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an ESP or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's safety evaluation report (SER). The reviewer also states the bases for those conclusions.

The onsite power system includes the standby power sources, distribution systems, auxiliary supporting systems, and I&Cs required supplying power to safety-related components and systems. The review of the AC power system for the ___________ plant covered the descriptive information, functional logic diagrams, electrical single-line diagrams, preliminary and final physical arrangement drawings, and electrical control and schematics.

The basis for acceptance of the AC power system in this review was conformance of the design criteria and bases to the Commission's regulations as set forth in the GDCs of Appendix A to 10 CFR Part 50. The staff concludes that the plant design is acceptable and meets the requirements of GDCs 2, 4, 5, 17, 18, and 50. This conclusion is based on the following:

1. The applicant has met the requirements of GDC 2, "Design Basis for Protection Against Natural Phenomena," with respect to SSCs of the AC power systems being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods by locating the AC power system and components in seismic Category I

structures which provide protection from the effects of tornadoes, tornado missiles, and floods. In addition, the AC power system and components have a quality assurance designation of Class 1E.

2. The applicant has met the requirements of GDC 4, "Environmental and Dynamic Effects Design Bases," with respect to SSCs of the AC power system being designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, and being appropriately protected against dynamic effects, including the effects of missiles, that may result from equipment failures, by having an adequate plant design and an adequate equipment qualification program.

3. The applicant has met the requirements of GDC 5, "Sharing of structures, systems, and components," with respect to SSCs of the onsite AC power system. The onsite AC power system and components associated with the multi-unit facility are housed in physically separate seismic Category I structures, are not shared between units, and the applicant has met the positions of RG 1.32, Position C.2.a, and RG 1.81, Positions C.2 and C.3.

4. The applicant has met the requirements of GDC 17, "Electric Power Systems," with respect to the onsite Class 1E AC power system's: (a) capacity and capability to permit functioning of SSCs important to safety; (b) independence and redundancy to perform its safety function assuming a single failure; and (c) provisions to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit or the loss of power from the transmission network. Acceptability was based on the applicant meeting the positions of RGs 1.6, 1.32, 1.75, 1.153, 1.155, 1.204, Article 2 of this ISG, and NUREG/CR-0660.

5. The applicant has met the requirements of GDC 18, "Inspection and Testing of Electric Power Systems," with respect to the onsite Class 1E AC power system. The AC power system is designed to be testable during operation of the nuclear power generating station as well as during those intervals when the station is shut down. This meets the positions of RG 1.118.

6. The applicant has met the requirements of GDC 50, "Containment Design Bases," with respect to penetrations containing circuits of the safety and nonsafety AC power system. Containment electric penetrations have been designed to withstand all ranges of over load and short circuit currents up to the maximum fault current versus time conditions that could occur given single random failures of protective devices. Also, for each electrical penetration, the applicant has provided redundant circuit breakers/fuses to assure containment integrity. This meets the positions of RG 1.63.

7. The applicant has met the requirements of 10 CFR 50.63, "Loss of All Alternating Current Power," with respect to appropriate use of the redundancy and reliability of emergency onsite AC power sources as factors in determining an appropriate SBO duration for which the plant should be capable of withstanding or coping with, and recovering from. The applicant has committed to suitable target reliability levels for emergency onsite AC power sources and a program that provides reasonable assurance that reliability targets will be achieved and maintained. The acceptable program is based on meeting the relevant positions of RG 1.155, and Article 2 of this ISG. The applicant’s overall compliance with the

requirements of 10 CFR 50.63 is discussed in further detail in Sections 8.2 and 8.4 of the SER.

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action or information items relevant to this ISG section.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

The staff will use this ISG section in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

The provisions of this ISG section apply to reviews of applications docketed 6 months or more after the date of issuance of this ISG section, unless superseded by a later revision.

VI. REFERENCES

1. SRP Section 8.1, Table 8-1, "Acceptance Criteria and Guidelines for Electric Power Systems." (See Table 8-1 for a detailed list of acceptance criteria and guidance references for all SRP Chapter 8 sections, including listing of relevant NRC-endorsed versions of standards).

2. SRP BTPs 8-2, 8-5, and 8-6.

3. SRP Section 8.4, "Station Blackout."

4. GL 96-01, "Testing of Safety-Related Logic Circuits," January 10, 1996.

5. IN 98-38, "Metal-Clad Circuit Breaker Maintenance Issues Identified by NRC Inspections," October 15, 1998.

6. IN 99-13, "Insights from NRC Inspections of Low- and Medium-Voltage Circuit Breaker Maintenance Programs," April 29, 1999.

7. IN 2000-06, "Offsite Power Voltage Inadequacies," March 27, 2000.

8. IN 2000-14, "Non-Vital Bus Fault Leads to Fire and Loss of Offsite Power," September 27, 2000.

9. IN 2002-01, “Metal-Clad Switchgear Failures and Consequent Losses of Offsite Power,” January 8, 2002.

10. IN 2002-04, “Wire Degradation at Breaker Cubicle Door Hinges,” January 10, 2002.

11. IN 2002-12, “Submerged Safety-Related Electrical Cables,” March 21, 2002.

12. IN 2005-04, “Single-Failure and Fire Vulnerability of Redundant Electrical Safety Buses,” February 14, 2005.

13. Regulatory Issue Summary 2000-24, “Concerns About Offsite Power Voltage Inadequacies and Grid Reliability Challenges Due to Industry Deregulation,” December 21, 2000.

14. SECY-90-016, “Evolutionary Light Water Reactor Certification Issues and Their Relationships to Current Regulatory Requirements,” January 12, 1990.

15. SECY-91-078, “EPRI’s Requirements Document and Additional Evolutionary LWR Certification Issues.” Approved in the SRM of August 15, 1991.

16. SECY-94-084, “Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs,” dated March 28, 1994.

17. SECY-95-132, “Policy and Technical Issues Associated with the Regulatory Treatment of Non-safety Systems (RTNSS) in Passive Plant Designs.” Approved in the SRM of June 28, 1995.

18. NRC Memorandum; From: D. Crutchfield; To: File; Subject: Consolidation of SECY-94-084 and SECY-95-132, July 24, 1995.

19. SECY-05-0227, “Final Rule – AP1000 Design Certification,” dated December 14, 2005. Approved in the SRM of December 30, 2005.

20. RG 1.6, “Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems (Safety Guide 6).”

21. RG 1.9, “Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants.”

22. RG 1.32, “Criteria for Power Systems for Nuclear Power Plants.”

23. RG 1.47, “Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems.”

24. RG 1.53, “Application of the Single Failure Criterion to Safety Systems.”

25. RG 1.63, “Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants.”

26. RG 1.75, “Criteria for Independence of Electrical Safety Systems.”

27. RG 1.81, “Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants.”

28. RG 1.118, “Periodic Testing of Electric Power and Protection Systems.”

29. RG 1.153, “Criteria for Safety Systems.”

30. RG 1.155, “Station Blackout.”

31. RG 1.160, “Monitoring the Effectiveness of Maintenance at Nuclear Power Plants.”

32. RG 1.182, “Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants.”

33. RG 1.204, “Guidelines for Lightning Protection of Nuclear Power Plants.”

34. RG 1.206, “Combined License Applications for Nuclear Power Plants (LWR Edition).

35. NUREG-0718, “Licensing Requirements for Pending Applications for Construction Permits and Manufacturing License,” Revision 1, June 1981.

36. NUREG-0737, “Clarification of TMI Action Plan Requirements,” November 1980.

37. NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” Draft Report for Comment, Section 8.3.1, Appendix I, and Appendix II, April 1996.

38. NUREG-0933, “A Prioritization of Generic Safety Issues,” November 2005.

39. NUREG-1462, “Final Safety Evaluation Report C80+,” August 1994.

40. NUREG-1503, “Final Safety Evaluation Report ABWR,” July 1994.

41. NUREG-1784, “Operating Experience Assessment - Effects of Grid Events on Nuclear Power Plant Performance,” December 2003.

42. NUREG-1793, “Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design,” September 2004.

43. NUREG/CR-0660, “Enhancement of Onsite Emergency Diesel Generator Reliability,” February 1979.

44. NUREG/CR-6866, “Technical Basis for Regulatory Guidance on Lightning Protection in Nuclear Power Plants,” January 2006.

45. NUREG-1801, “Generic Aging Lessons Learned (GALL) Report,” Revision 1, Volumes 1 and 2, September 2005.

46. GL 2007-01 “Inaccessible or Underground Power Cable Failures that Disable Accident Mitigation Systems or Cause Plant Transients,” February 7, 2007.

47. IEEE 141-1993, “Recommended Practice for Electric Power Distribution for Industrial Plants,” (Red Book).

48. IEEE 242-2001, “Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems,” (Buff Book).

49. IEEE 279-1971, “Criteria for Protection Systems for Nuclear Power Generating Stations.”

50. IEEE 308-2001, “Criteria for Class 1E Power Systems for Nuclear Power Generating Stations.”

51. IEEE 317-1983, “Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations.”

52. IEEE 338-1987, "Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems.”

53. IEEE 379-2000, “Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems.”

54. IEEE 384-1992, “Criteria for Independence of Class 1E Equipment and Circuits.”

55. IEEE 387-1995, “Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations.”

56. IEEE 399-1997, “Recommended Practice for Power Systems Analysis,” (Brown Book).

57. IEEE 603-1991, “Criteria for Safety Systems for Nuclear Power Generating Stations.”

58. IEEE 665-1995 (Reaffirmed 2001), “Standard for Generating Station Grounding.”

59. IEEE 666-1991 (Reaffirmed 1996), “Design Guide for Electric Power Service Systems for Generating Stations.”

60. IEEE 741-1997, “IEEE Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations.”

61. IEEE 765-2002, “Standard for Preferred Power Supply (PPS) for Nuclear Power Generating Stations.”

62. IEEE 835 -1994, “Standard Power Cable Ampacity Tables.”

63. IEEE 1050-1996, “Guide for Instrumentation and Control Equipment Grounding in Generating Stations.”

64. IEEE C62.23-1995 (Reaffirmed 2001), “Application Guide for Surge Protection of Electric Generating Plants.”

65. NUMARC 93-01, “Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," Section 11, Nuclear Energy Institute, February 11, 2000.

66. IN 2006-18, “Significant Loss of Safety-Related Electrical Power at Forsmark, Unit 1, in Sweden,” August 17, 2006.

67. ISO 3977-3, “Gas Turbine Procurement Part 3 Design Requirements,” August 18, 2004.

Article 4: MODIFIED SRP SECTION 9.5.4(I) EMERGENCY GAS TURBINE GENERATOR FUEL OIL STORAGE AND TRANSFER SYSTEM

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of EGTG support systems

Secondary - Organization responsible for the review of fuel oil quality and testing

I. AREAS OF REVIEW

NPPs are required to have redundant onsite emergency power sources of sufficient capacity to power safety-related equipment. EDGs have been widely used as the standby power source for onsite AC power systems. It is anticipated that some new reactor designs will incorporate EGTGs for the emergency AC power system. This interim document provides guidance on the review of fuel oil storage and transfer systems supporting an EGTG. This document is intended as a companion document to SRP Section 9.5.4, which explicitly applied only to a fuel oil system for an EDG.

ISG Sections 9.5.4(I) through 9.5.8(I)[4] cover the review of various essential elements of the EGTG. This interim guidance covers the fuel oil storage and transfer system for these EGTGs up to the unit's housing. The specific areas of review are as follows:

The review of the EGTG fuel oil storage and transfer system (EGTGFSS) including all piping up to the connection to the turbine interface (piping that is not integral to the EGTG skid),[5] the fuel oil storage tanks, the fuel oil transfer pumps, day tanks, and the tank storage vaults assures compliance with the requirements of GDCs 1, 2, 4, 5, and 17. In addition, the review covers the quality and the quantity of fuel oil stored onsite and the availability and procurement of additional fuel from offsite sources. An implicit assumption is that the EGTG employs fuel oil as its combustion fluid. If however, another type of fuel is used (e.g., natural gas) then other sources of review guidance should be employed.

The specific areas of review are as follows:

1. The EGTGFSS is reviewed to verify whether:

    A. Each EGTG has an independent and reliable fuel oil storage and transfer system.

    B. The system has been designed, fabricated, erected, and tested to acceptable quality standards.

[4] The "(I)" following the SRP section number is intended to indicate Interim Guidance.

[5] As defined by the EGTG manufacturer.

C. The system has boundary divisions between safety-related and non-safety-related sections.

D. Sections of the system important to safety are housed within seismic Category I structures.

E. Failures of any non-seismic Category I SSC will not adversely affect any EGTGFSS safety function.

F. The consequences of a single active failure in a fuel oil system will not lead to a loss of more than one EGTG.

G. The design includes the capability to detect and control system leakage, including isolating system portions in the event of excessive leakage or component malfunction.

H. A minimum of seven days supply of fuel oil for each EGTG is onsite to meet the ESF load requirements following a LOOP and a DBA.

I. Adequate and acceptable sources of fuel oil are available, including the means of transporting and recharging the fuel oil storage tank, following a DBA to enable each redundant EGTG to supply uninterrupted emergency power for as long as required

J. I&C features permit operational testing of the system and assure that normal protective interlocks do not preclude EGTG operation during emergency conditions.

K. Suitable precautions will prevent deleterious material from degrading the stored fuel and periodic tests will verify whether fuel degradation affects EGTG performance.

L. Sufficient space permits inspection, cleaning, maintenance, and repair of the system.

2. ITAAC. For DC and COL reviews, the staff reviews the applicant's proposed ITAAC associated with the SSCs related to this interim guidance section in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." Since the proposed ITAAC are based on the design of the SSCs, the review of ITAAC should be performed subsequent to the review of the associated system design against the acceptance criteria contained in the appropriate interim guidance section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

3. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action or information items and requirements and restrictions (e.g., interface requirements and site parameters).

   For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other SRP sections interface with this interim guidance as follows (Note that interim guidance for review of the EGTGFSS has not been provided for the referenced sections. The review guidance, including acceptance criteria, in these sections should be used to the extent that it applies to the EGTGFSS.):

1. Upon request, EGTGFSS review is performed for compatibility of materials of construction with service conditions.

2. Chapter 2: review of functional capability during abnormally high site water levels (probable maximum flood).

3. Sections 3.2.1 and 3.2.2: review of the seismic and quality group classifications for EGTGFSS components.

4. Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4, and 3.8.5: review of the design analyses, procedures, and criteria establishing the ability of structures housing the EGTGFSS to withstand the effects of natural phenomena like the safe-shutdown earthquake (SSE), the probable maximum flood, and tornado missiles.

5. Sections 3.4.1: EGTGFSS review for whether protection against flooding is required.

6. Section 3.5.1.1: EGTGFSS review for whether protection against internally-generated missiles is required. Each system need not be protected from the missiles generated from its associated EGTG. However, it must be protected from missiles generated from other nearby EGTGs.

7. Section 3.5.2: EGTGFSS review for whether protection from tornado missiles is required.

8. Section 3.6.1: review of the plant design for protection against postulated piping failures in fluid systems, including high-energy and moderate energy piping systems outside containment, and effects upon the EGTGFSS.

9. Sections 3.9.1 through 3.9.3: review of EGTGFSS components, piping, and structures for whether they are designed per the applicable codes and standards.

10. Section 7.1: review of I&Cs to determine the design, installation, inspection, and testing of all essential EGTGFSS control and instrumentation.

11. Section 8.3.1: review of the adequacy of the design, installation, inspection, and testing of all electrical components (sensing, control, and power) required for proper EGTGFSS operation including interlocks.

12. Section 9.5.1: EGTGFSS review for fire protection requirements.

13. Section 14.0: review of the acceptability of the pre-operational and startup tests.

14. Section 16.0: review of EGTGFSS technical specifications.

15. Chapter 17: review of quality assurance requirements.

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

Requirements

Acceptability of the EGTGFSS, as described in the applicant's SAR, COL submission, or DCD is based on specific regulations, GDCs, and RGs. The reviewer also utilizes information from other federal agencies and published reports, industry standards, military specifications, available technical literature on commercially available products, and operational performance data from similarly designed systems at other plants having satisfactory operational experience.

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. GDC 2 as it relates to SSCs that must be protected from, or be capable of withstanding, the effects of such natural phenomena as earthquakes, tornadoes, hurricanes, and floods, as established in Chapters 2 and 3 of the SAR.

2. GDC 4 as it relates to SSCs that must be protected from, or be capable of withstanding, the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks.

3. GDC 5 as it relates to the capability of shared systems and components important to safety between units to perform required safety functions.

4. GDC 17 as it relates to the capability of the EGTG fuel oil system to meet independence and redundancy criteria.

5. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a facility that incorporates the DC is built and will operate in accordance with the DC, the provisions of the AEA, and the Commission's rules and regulations.

6. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will be operated in conformity with the COL, the provisions of the AEA, and the Commission's rules and regulations.

Interim Acceptance Criteria

Specific acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in this interim guidance. This guidance is not a substitute for the NRC's regulations, and compliance with it is not required. However, in accordance with 10 CFR 52.47 an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the acceptance criteria and evaluate how the proposed alternatives to these acceptance criteria provide acceptable methods of compliance with the NRC regulations.

1. GDC 2 requirements for which SSCs must be protected from, or be capable of withstanding, the effects of such natural phenomena as earthquakes, tornadoes, hurricanes, and floods apply to safety-related EGTGFSS SSCs. The identification of SSCs required to withstand earthquakes without the loss of capability to perform safety functions is listed in RG 1.29. Comprehensive compliance with GDC 2 is reviewed under other SRP sections as specified in Subsection I of this ISG.

2. GDC 4 requirements for which SSCs must be protected from, or be capable of withstanding the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks apply to safety-related EGTGFSS SSCs. Comprehensive compliance with GDC 4 is reviewed under other SRP sections as specified in Subsection I of this ISG.

3. GDC 5 requirements for sharing of SSCs important to safety among nuclear power units are met if each unit has its own EGTG(s) and each EGTG has an independent fuel oil system.

4. GDC 17 as to the capability of the fuel oil system to meet independence and redundancy criteria and the guidance and positions of the following:

   A. RG 1.137 as to the fuel oil system design, fuel oil quality, and tests which are specified in regulatory positions C1 and C2. The regulatory position C1 addresses the design criteria for the fuel oil system such as materials, physical arrangement, and applicable codes and regulations. The physical arrangements of the fuel oil system should provide for inservice inspection and testing in accordance with ASME Boiler and Pressure Vessel Code Section XI, "Rules for Inservice Inspections." Criteria for fuel oil quality are addressed in the position C2. The fuel oil stored in the fuel oil storage tank or used for filling or refilling the fuel oil storage tank should meet the Federal Fuel Oil, ASTM, or EGTG manufacturer requirements. The quality of fuel oil is determined by performing suitable tests and when it does not meet the prescribed standards it is replaced. Also, prior to adding new fuel oil to the fuel oil storage tank the tests for specific gravity, water sediment and viscosity testing should be performed and the fuel oil not meeting the test requirements should not be added to the tank.

      Although RG 1.137 is specific to EDG fuel oil systems, regulatory positions C1 and C2 are considered applicable for any standby emergency generator set employing fuel oil to provide motive power, including EGTGs.

   B. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability" offers suggestions on how design and testability features of the fuel oil supply system can improve the reliability of the overall system. Most of these are applicable to an EGTG system.

C. Each EGTG with its own EGTGFSS.

D. ANSI/ANS-59.51 regarding the onsite fuel oil storage for each EGTG being sufficient to operate the EGTG following any DBE and a continuous loss of off-site power either for seven days, or for the time required to replenish the fuel from sources outside the plant site following any design event without interruption of the operation of the EGTG, whichever is longer.

   Although ANSI/ANS-59.51 is specific to EDG fuel oil systems, it is considered applicable for any standby emergency generator set employing fuel oil to provide motive power, including EGTGs.

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this interim guidance is discussed in the following paragraphs:

1. GDC 2 requires that SSCs important to safety be designed to withstand the effects of natural phenomena like earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform safety functions. The EGTGFSS safety function is to store quality fuel and transfer it to the EGTG following a turbine start signal. Compliance with GDC 2 requirements ensures that natural phenomena will not affect EGTGFSS capability to supply fuel oil to the EGTGs.

2. GDC 4 requires that SSCs important to safety be designed to withstand the dynamic effects of pipe ruptures like pipe whip and jet impingement and externally- or internally-generated missiles. The EGTGFSS safety function is to store quality fuel and transfer it to the EGTG following an EGTG start signal. Compliance with GDC 4 provides assurance that the dynamic effects of equipment failures and events external to the plant will not affect EGTGFSS capability to supply fuel to the EGTGs.

3. GDC 5 prohibits the sharing of SSCs important to safety among nuclear power units unless such sharing can be demonstrated not to impair their ability to perform safety functions, including in the event of an accident in one unit an orderly shutdown and cooldown of the remaining unit. The EGTGFSS safety function is to store quality fuel and transfer the fuel to the EGTG following an EGTG start signal. Compliance with GDC 5 provides assurance that EGTGFSS failures in one unit will not affect other units of the site.

4. GDC 17 requires an onsite electric power system for the functioning of SSCs important to safety. GDC 17 requirements include sufficient independence and redundancy for the onsite electric power system to perform safety functions, assuming a single failure. RG 1.137 provides regulatory positions on an EDG fuel oil system design criteria and features subject to GDC 17 requirements, which provide assurance that electric power will be available for systems necessary (i) to prevent fuel damage in anticipated operational occurrences and (ii) to maintain core cooling and containment integrity in postulated

accidents. The guidance in RG 1.137 can be applied to an EGTG fuel oil system to provide similar assurance.

III. <u>REVIEW PROCEDURES</u>

The reviewer will select material from the procedures described below, as may be appropriate for a particular case.

These review procedures are based on the identified acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

Plant-to-plant variations in the design of fuel oil storage and transfer systems occur due to the number of architect-engineering companies having design responsibility in this area. Differences may occur in the number of redundant systems, in piping interconnections between EGTGs, and in sharing requirements between units. The reviewer selects and emphasizes material from the following paragraphs to fit the particular design under review.

1. The SAR is reviewed to verify whether the EGTGFSS description and related diagrams clearly indicate all modes of system operation, including the means for indicating, controlling, and monitoring fuel oil level, temperature, and pressure as required for uninterrupted operation.

2. The reviewer verifies whether the system is designed to withstand the effects of seismic events, other design bases, natural phenomena, and internally- and externally-generated missiles. Review of internally-generated missiles considers the relative locations and orientations of components in the facility.

3. Piping and interconnections between systems are reviewed to verify whether single active failures will cause unacceptable results. Drawings are examined to ascertain whether sufficient space around the components permits inspection, cleaning, maintenance, and repair.

4. The seismic design bases and the seismic and quality group classifications are reviewed by interfacing reviewers as indicated in Subsection I of this ISG. The primary reviewer verifies whether essential EGTGFSS portions including the isolation valves separating essential and nonessential portions are classified Quality Group C and seismic Category I. SAR component and system descriptions of mechanical and performance characteristics are reviewed to verify whether the seismic and quality group classifications are included and whether the piping and instrumentation drawings indicate any points of change at the system or system component interfaces.

5. The reviewer verifies whether the design minimizes turbulence of the sediment at the bottom of the fuel oil storage tank or any chance of deleterious material entering the system during recharging, by operator error, or due to natural phenomena.

6. The SAR descriptive information and drawings are reviewed to verify whether:

A. Each storage tank is equipped with an outside fill and vent line located and protected to minimize any chance of damage from vehicles, tornado, tornado missiles, and floods. The fill and vent point should be located higher than the probable maximum flood level. Each tank also has a stick gauge connection for determining its fuel level.

B. The minimum onsite inventory of fuel oil for each EGTG is sufficient to enable the EGTGs to power required ESFs for a period of seven days or longer as specified by ANSI/ANS-59.51 (as applicable to EGTGs) following any DBA and LOOP.

C. The physical location of the day tank for each EGTG is located at an elevation for a slight positive pressure at the fuel oil pump(s). Where this requirement is contrary to manufacturer recommendations, the SAR must provide justification and a detailed system description. Additionally, justification for locating the day tank otherwise must confirm that the EGTG can start automatically and attain the required voltage and frequency within an acceptable time. Any required booster pump must be powered from a reliable power supply, operate when the EGTG receives a start signal, and operate during the EGTG starting cycle or until system fuel oil pressure is established by the fuel oil pump.

D. A day or integral tank overflow line returns excess fuel oil delivered by the transfer pump back to the fuel oil storage tank.

E. A low-level alarm enables the operator to accomplish minor repairs or maintenance before all fuel in the day or integral tank is consumed (assuming full-power operation).

F. The day or integral tank and storage tanks for each EGTG include provisions for removal of accumulated water.

G. The fuel stability should be considered for fuel storage. This is especially of concern when ultra-low-sulfur diesel fuels and biodiesel blends are used (References 10 and 11).

7. The reviewer verifies whether suitable precautions will be taken, after the fuel oil storage tank has been filled, to exclude sources of ignition like open flames or hot surfaces and whether protective measures like compartmentation of redundant elements minimize the potential for and consequences of fires and explosions.

8. The reviewer verifies whether the system function will be maintained as required in any failure of non-seismic Category I systems or structures near the system. Reference to SAR sections describing site features and general arrangement and layout drawings is necessary in this verification. Plant arrangement features and the protections obtained by location and the design of the system and structures are considered in determining the ability of the system to maintain functions in such failures.

9. The EGTGFSS is reviewed for protection from the effects of breaks in high and moderate energy lines. Layout drawings are reviewed for whether high or moderate energy piping systems are located close to the fuel oil system and for protection from the effects of failure. Provisions for such protection are in SAR Section 3.6 and procedures for reviewing this information are in the corresponding SRP sections.

10. The SAR descriptive information, related system drawings, and results of failure modes and effects analyses are reviewed to verify whether minimum system requirements will be met following DBAs, assuming a concurrent single active component failure. For each case the design is acceptable if minimum system requirements are met.

11. For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the FSAR meets the acceptance criteria. The reviewer should also consider the appropriateness of identified COL action or information items. The reviewer may identify additional COL action or information items; however, to ensure these COL action or information items are addressed during a COL application, they should be added to the DC FSAR.

    For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an ESP, or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

    For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of the review of the EGTGFSS design.

12. For review under 10 CFR Part 50, the procedures determine during the CP review whether design criteria and bases and the preliminary design meet the acceptance criteria of Subsection II of this interim guidance. For review of OL applications, the procedures verify whether the initial design criteria and bases are implemented appropriately in the final design. The OL review verifies whether the content and intent of the applicant's TSs agree with requirements for system testing, minimum performance, and surveillance developed in the staff review as indicated in Subsection I of this interim guidance.

IV. <u>EVALUATION FINDINGS</u>

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's SER. The reviewer also states the bases for those conclusions.

1. The EGTGFSS includes storage tanks, fill, vent, stick gauge, drain, and overflow return lines, fuel oil transfer pumps, strainers, filters, valves, day tanks, and all components and piping up to the connections to the EGTG interfaces. The scope of review of the EGTGFSS for the plant includes layout drawings, P&IDs, and descriptive information for the system and auxiliary supporting systems essential to its operation. Essential EGTGFSS portions necessary for safe shutdown of the reactor or for mitigation of the consequences of an accident are designated to seismic Category I and Quality Group C.

   The basis for acceptance of the EGTGFSS in the staff's review was compliance of the design criteria and bases with NRC regulations as stated in the GDCs of Appendix A to 10 CFR Part 50. The staff concludes that the design is acceptable and meets the requirements of GDCs 2, 4, 5, and 17. This conclusion is based on the following findings:

A. The applicant has met the requirements of GDC 2, "Design Bases for Protection Against Natural Phenomena," for the ability of structures housing the EGTGFSS and the system itself to withstand the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods, and GDC 4, "Environmental and Dynamic Effects Design Bases," for the ability of structures housing the system and the system itself to withstand the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks. The EGTGFSS, except for the buried fuel oil storage tanks and related components and piping, is housed in a seismic Category I structure which protects against the effects of tornadoes, tornado missiles, turbine missiles, and floods. The buried portions also are protected from tornadoes, tornado and turbine missiles, and floods. This protection meets the positions of RG 1.115, "Protection Against Low-Trajectory Turbine Missiles," Position C.1, and RG 1.117, "Tornado Design Classification," Appendix Position 13.

B. The applicant has met the requirements of GDC 5, "Sharing of Structures, Systems, and Components," for the ability of shared systems and components important to safety to perform required safety functions. Each unit of the plant has its own EGTGs with EGTGFSS not shared between them.

C. The applicant has met the requirements of GDC 17, "Electric Power Systems," for the ability of the EGTGFSS to meet independence and redundancy criteria. Each EGTGFSS is independent and physically separated from the other system serving the redundant emergency generator. A single failure in any one EGTGFSS will affect only its EGTG. This arrangement meets the position of RG 1.137 "Fuel-Oil Systems for Standby Diesel Generators." The applicant has also met the positions of NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability."

The staff concludes that the EGTGFSS design complies with all applicable GDCs, RG positions cited, NUREG/CR-0660, staff positions, and industry standards and is therefore acceptable.

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action or information items relevant to this ISG.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this ISG in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, GDC 2, "Design Bases for Protection against Natural Phenomena."

2. 10 CFR Part 50, Appendix A, GDC 4, "Environmental and Dynamic Effects Design Bases."

3. 10 CFR Part 50, Appendix A, GDC 5, "Sharing of Structures, Systems, and Components."

4. 10 CFR Part 50, Appendix A, GDC 17, "Electric Power Systems."

5. 10 CFR Part 52, “Early Site Permits; Standard Design Certifications; and COLs for Nuclear Power Plants.”

6. RG 1.137, "Fuel-Oil Systems for Standby Diesel Generators."

7. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability," University of Dayton Research Institute; UDR-TR-79-07; February 1979.

8. ANSI/ANS-59.51-1997, “Fuel Oil Systems for Safety-Related Emergency Diesel Generators.”

9. ISO 3977-3, “Gas Turbine Procurement: Part 3 Design Requirements,” August 18, 2004.

10. IN 2006-22, “New Ultra-Low-Sulfur Diesel Fuel Oil Could Adversely Impact Diesel Engine Performance,” October 12, 2006.

11. IN 2009-02, “Biodiesel in Fuel Oil Could Adversely Impact Diesel Engine Performance,” February 23, 2009.

Article 5: MODIFIED SRP SECTION 9.5.5(I) EMERGENCY GAS TURBINE GENERATOR COOLING SYSTEM

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of EGTG support systems

Secondary - None

I. AREAS OF REVIEW

NPPs are required to have redundant onsite emergency power sources of sufficient capacity to power safety-related equipment. EDGs have been widely used as the standby power source for onsite AC power systems. It is anticipated that some new reactor designs will incorporate EGTGs for the emergency AC power system. This interim document provides guidance on the review of cooling systems supporting an EGTG. This document is intended as a companion document to SRP Section 9.5.5 which explicitly applied only to a cooling system for an EDG. SRP Sections 9.5.4(I) through 9.5.8(I)[6] cover the review of various essential elements of the EGTGs.

The EGTG cooling system (EGTGCS) provides cooling to the station EGTSs and is reviewed for compliance with GDCs 2, 4, 5, 17, 44, 45, and 46. The review covers EGTGCS portions housed within their respective EGTG compartments receiving heat from components essential for proper operation of the EGTGs and additional parts of the system transferring the heat to a heat sink. A typical packaged EGTG will include a ventilation system forcing ambient air through the EGTG enclosure and an air cooled lube oil radiator. These both provide system cooling. Other cooling systems are possible; however, this ISG section applies only to those EGTG units that employ air-cooled cooling systems. The system includes all valves, dampers, ductwork, radiators, pumps, and piping up to the EGTG interface.[7]

The specific areas of review are as follows:

1. The EGTGCS is reviewed to verify whether each EGTG requires the use of a cooling system to transfer heat from the EGTG for proper operation. The reviewer verifies that:

   A. Each EGTG has an independent cooling system.

   B. The system is properly designed, fabricated, erected, and tested to acceptable quality standards.

   C. The system has boundary divisions between safety-related and non-safety-related sections.

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[6] The "(I)" following the SRP section number is intended to indicate Interim Guidance.

[7] As defined by the EGTG manufacturer.

D. Failure of any non-seismic Category I SSC will not affect EGTCS safety-related functions.

E. Sections of the system important to safety are housed within seismic Category I structures.

F. The consequences of a single active failure in an EGTGCS or the loss of a cooling source will not lead to a loss of more than one EGTG.

G. I&C features permit operational testing of the system and assure that normal protective interlocks do not preclude EGTG operation during emergency conditions.

H. Sufficient space permits inspection, cleaning, maintenance, and repair of the system.

I. The design includes measures to preclude long-term corrosion and fouling that would degrade system cooling performance and the compatibility of any corrosion inhibitors or compounds with system materials.

J. The design addresses EGTGCS capacity as to manufacturer-recommended EGTG temperature differentials under adverse operating conditions.

K. EGTGCS functional performance characteristics and effects on those characteristics of adverse environmental occurrences, abnormal operational requirements, accident conditions, and LOOP.

2. If the EGTG does not require a cooling system to remove system heat for proper operation, then the reviewer verifies that this is appropriate for reliable operation under all design conditions.

3. ITAAC. For DC and COL reviews, the staff reviews the applicant's proposed ITAAC associated with the SSCs related to this interim guidance in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this interim guidance. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

4. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action or information items and requirements and restrictions (e.g., interface requirements and site parameters).

   For a COL application referencing a DC, a COL applicant must address COL action or information items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other SRP sections interface with this section as follows:

1. Upon request, EGTGCS review is performed for the compatibility of construction materials with service conditions.

2. Chapter 2: review of functional capability during abnormally high site water levels (probable maximum flood).

3. Sections 3.2.1 and 3.2.2: review of the seismic and quality group classifications for EGTGCS components.

4. Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4, and 3.8.5: review of the design analyses, procedures, and criteria that establish the ability of structures housing the EGTGCS to withstand the effects of natural phenomena like the SSE, the probable maximum flood, and tornado missiles.

5. Section 3.4.1: EGTGCS review for whether protection against flooding is required.

6. Section 3.5.1.1: EGTGCS review for whether protection against an internally-generated missiles are required. Each EGTGCS need not be protected from the missiles generated from its associated EGTG. However, it must be protected from missiles generated from other nearby EGTGs.

7. Section 3.5.2: EGTGCS review for whether protection from tornado missiles is required.

8. Section 3.6.1: review of the plant design for protection against postulated piping failures in fluid systems, including high-energy and moderate-energy piping systems outside containment, and the effect upon the EGTGCS.

9. Sections 3.9.1 through 3.9.3: review of EGTGCS components, piping, and structures to verify their design per the applicable codes and standards.

10. Section 7.1: review of all essential EGTGCS instrumentation and controls to determine their design, installation, inspection and testing.

11. Section 8.3.1: review of the adequacy of the design, installation, inspection, and testing of all electrical components (sensing, control, and power) required for proper operation of the system, including interlocks.

12. Section 9.2.1: reviews of the test program for monitoring the heat transfer capability of safety-related radiators. If such tests indicate heat transfer capability degradation that cannot be remedied by maintenance of the cooling system, then cooling systems like the EGTGCS reviewed under this interim guidance should be included in the scope of the inspection and maintenance program for cooling systems. Any test program should

consider all nearby temperature maintenance mechanisms for systems such as HVAC, lube and fuel oil coolers, etc.

13. Section 9.5.1: EGTGCS review for fire protection requirements.

14. Section 14.0: review of the acceptability of the pre-operational and startup tests.

15. Section 16.0: review of EGTGCS technical specifications.

16. Chapter 17: review of the quality assurance requirements.

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

Requirements

Acceptability of the EGTGCS design, as described in the applicant's SAR, COL submission, or DCDs is based on specific regulations, GDCs, and RGs. The reviewer also utilizes information from other federal agencies and published reports, industry standards, military specifications, technical literature on commercially available products, and operational performance data from similarly designed systems at other plants having satisfactory operational experience.

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. GDC 2 as it relates to SSCs that must be protected from, or be capable of withstanding, the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods as established in SAR Chapters 2 and 3.

2. GDC 4 as it relates to SSCs that must be protected from, or be capable of withstanding, the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks.

3. GDC 5 as it relates to the capability of systems and components important to safety shared between units to perform required safety functions.

4. GDC 17 as it relates to EGTGCS capability to meet independence and redundancy criteria.

5. GDC 44 for a cooling system with suitable redundancy to transfer heat to an ultimate heat sink under normal operating and accident conditions.

6. GDC 45 for design provisions to permit periodic inspection of safety-related system components and equipment.

7. GDC 46 for design provisions to permit appropriate functional testing of safety-related systems or components for structural integrity, leak-tightness, operability, and performance of active components and system capability function as intended under accident conditions.

8. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a facility that incorporates the DC is built and will operate in accordance with the DC, the provisions of the AEA, and the Commission's rules and regulations.

9. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will be operated in conformity with the COL, the provisions of the AEA, and the Commission's rules and regulations.

Interim Acceptance Criteria

Specific acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in this interim guidance. This guidance is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the acceptance criteria and evaluate how the proposed alternatives to these acceptance criteria provide acceptable methods of compliance with the NRC regulations.

1. GDC 2 requirements for which SSCs must be protected from, or be capable of withstanding, the effects of such natural phenomena as earthquakes, tornadoes, hurricanes, and floods apply to safety-related EGTGCS SSCs. The identification of SSCs required to withstand earthquakes without the loss of capability to perform safety functions is listed in RG 1.29. Comprehensive compliance with GDC 2 is reviewed under other SRP sections as specified in Subsection I of this interim guidance.

2. GDC 4 requirements for SSCs to be protected against the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks apply to safety-related EGTGCS SSCs. Comprehensive compliance with GDC 4 is reviewed under other SRP sections as specified in Subsection I of this interim guidance.

3. GDC 5 requirements for sharing of SSCs important to safety among nuclear power units are met if each unit has its own EGTG(s) and each EGTG has an independent and reliable cooling system.

4. GDC 17 requirements for the capability of the cooling system to meet independence and redundancy criteria are met when:

   A. Each EGTG has a separate and independent EGTGCS.

B. NRC recommendations specified in NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability," are implemented when they are applicable to an EGTG.

C. Intake systems should be protected from ice buildup if the ambient temperature is expected to reach below 5 C (40 F). This includes both the cooling air intake and the combustion air intake systems discussed in Section 9.5.8.

D. Intake and exhaust systems should be designed to allow ready accessibility for inspection and maintenance and should be periodically inspected for blockage due to birds and debris. This includes both the cooling and the combustion air systems discussed in Section 9.5.8.

5. Although GDC 44 is identified specifically for cooling water systems, the requirement for having a cooling capability is equally applicable for air-cooled safety-related systems. GDC 44 requirements for a system to transfer heat from SSCs important to safety are met when the EGTGCS has:

   A. The capability to transfer heat from systems and components to a heat sink under transient or accident conditions.

   B. Redundancy of components for performance of safety functions under accident conditions, assuming a single active component failure, or each EGTG has a separate and independent EGTGCS.

   C. The capability to isolate system or piping components if required to maintain the system safety function.

6. Although GDC 45 is identified specifically for cooling water systems, the requirement for having a system inspection capability is equally applicable for air-cooled safety-related systems. GDC 45 as to design provisions for periodic inspection of safety-related system components and equipment are met when the EGTGCS has:

   A. Accessible means for inspection of all valves, dampers, ducts, filters, radiators, pumps, and piping required for proper operation and functionality.

   B. Procedures for performing periodic inspections are developed and employed as part of the maintenance program.

7. Although GDC 46 is identified specifically for cooling water systems, the requirement for performing periodic tests is equally applicable for air-cooled safety-related systems. GDC 46 as to design provisions for appropriate functional testing of safety-related systems or components for structural integrity and leak-tightness, operability, performance of active components, and the capability of the system to function as intended under accident conditions.

<u>Technical Rationale</u>

The technical rationale for application of these acceptance criteria to the areas of review addressed by this interim guidance is discussed in the following paragraphs:

1. GDC 2 requires that SSCs important to safety be designed to withstand the effects of natural phenomena like earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform safety functions. The EGTGCS safety function is to provide cooling for the EGTG following an EGTG start signal. Compliance with GDC 2 requirements ensures that natural phenomena events will not affect EGTGCS capability to supply cooling to the EGTGs.

2. GDC 4 requires that SSCs important to safety be designed to withstand such dynamic effects of pipe ruptures as pipe whip and jet impingement, and externally- or internally-generated missiles. The EGTGCS safety function is to provide cooling to the EGTG following an EGTG start signal. Compliance with GDC 4 provides assurance that the dynamic effects of equipment failures and events external to the plant will not affect EGTGCS capability to provide cooling to the EGTGs.

3. GDC 5 prohibits the sharing of SSCs important to safety among nuclear power units unless such sharing can be demonstrated not to impair their ability to perform safety functions, including in the event of an accident in one unit an orderly shutdown and cooldown of the remaining unit. The EGTGCS safety function is to provide cooling to the EGTG following an EGTG start signal. Compliance with GDC 5 provides assurance that EGTGCS failure in one unit of the site will not affect other units of the site.

4. GDC 17 requires, for the functioning of SSCs important to safety, an onsite electric power system with sufficient independence and redundancy for the performance of safety functions assuming a single failure. Compliance with GDC 17 requirements provides assurance that electric power will be available for systems necessary (i) to prevent fuel damage in anticipated operational occurrences and (ii) to maintain core cooling and containment integrity in postulated accidents.

5. GDC 44 requires a cooling water system to transfer heat from SSCs important to safety to an ultimate heat sink. Requirements include suitable redundancy, interconnections, leak detection, and isolation capabilities for onsite power system operation if offsite power is not available. Typically, the EGTG is the onsite electric power system relied upon when offsite power is unavailable. The EGTGCS is integral to the EGTG and transfers heat away from EGTG components to the environment. GDC 44 provides assurance that important safety functions can be accomplished under normal operating and accident conditions.

6. GDC 45 requires design of cooling water systems for appropriate periodic inspection of important components like heat exchangers and piping to assure system integrity and capability. The EGTGCS provides cooling for the EGTGs which in turn provide emergency power to plant SSCs important to safety. Periodic EGTGCS inspections/tests provide assurance that the system will function as designed to support operation of the onsite emergency power supply.

7. GDC 46 requires design of cooling water systems for appropriate periodic pressure and functional testing under conditions as close to design as practical. The EGTGCS provides cooling for the EGTGs which in turn provide emergency power to plant SSCs important to

safety. Periodic EGTGCS inspections/tests provide assurance that the system will function as designed to support operation of the onsite emergency power supply.

III. REVIEW PROCEDURES

The reviewer will select material from the procedures described below, as may be appropriate for a particular case.

These review procedures are based on the identified acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

EGTGCS design may vary considerably from plant to plant due to the requirements of various EGTG manufacturers, the number and type of secondary cooling loops for heat removal, and the number of intermediate cooling loops required to transfer the rejected heat to the environment. Variations in design also may occur due to performances of various architect-engineer firms. Therefore, for purposes of this interim guidance, a typical system is assumed. Any variance in the review procedure to suit a particular design must cover the system review areas in Subsection I of this interim guidance and the system must meet the criteria in Subsection II of this guidance.

1. The SAR is reviewed to establish that the EGTGCS description and related diagrams clearly delineate system operation, individual and total heat removal rates required by components, and the margin in the design heat removal rate capability. The reviewer verifies the following:

   A. The interfacing branches review the seismic design bases and the seismic and quality group classifications as indicated in Subsection I of this interim guidance. The primary reviewer assures that essential EGTGCS portions including the isolation valves separating essential and non-essential portions are classified quality Group C and seismic Category I. SAR component and system descriptions of mechanical and performance characteristics are reviewed for whether the seismic and quality group classifications are included and whether the P&IDs indicate any points of change at system or system component interfaces.

   B. Failure of a piping interconnection, as shown on system P&IDs, between subsystems does not cause total EGTGCS degradation. Results of failure modes and effects analyses are bases of acceptance.

   C. Provisions are made for inspection of components as shown on system layout drawings.

   D. If applicable, EGTGCS performance complies with EGTG manufacturer recommendations.

   E. Temperature sensors alert the operator when unit temperatures exceed the limits recommended by the manufacturer. The interfacing review branch reviews protective interlocks as indicated in Subsection I of this interim guidance.

F. An alarm (typically to identify overheating conditions) alerts the operator and enables a timely action to accomplish minor repairs or maintenance to correct a fault condition.

2. The reviewer verifies whether system function will be maintained in the event of adverse environmental phenomena and LOOP. The reviewer evaluates the system for whether:

   A. Failure of nonessential EGTGCS portions or of other systems not designed to seismic Category I requirements and located close to essential EGTGCS portions or failure of non-seismic Category I structures housing, supporting, or located close to essential EGTGCS portions will not preclude essential functions. Reference to SAR sections describing site features and the general arrangement and layout drawings as well as the SAR tabulation of seismic design classifications for structures and systems is necessary. SAR statements to the effect that these conditions are met are acceptable.

   B. Essential EGTGCS portions are protected from the effects of floods, hurricanes, tornadoes, and internally- and externally-generated missiles. Flood protection and missile protection criteria are evaluated in detail under the SRP sections for Chapter 3 of the SAR. A statement to the effect that the system is located in a tornado-, missile-, and flood-protected seismic Category I structure or that system components are located in individual cubicles or rooms that will withstand the effects of both flooding and missiles is acceptable.

3. The reviewer verifies whether there are high- or moderate-energy piping systems located close to the EGTGCS or whether the EGTGCS is protected from the effects of postulated breaks in these systems. The means of such protection are in SAR Chapter 3 and procedures for review of such information are in the SRP sections for that chapter.

4. The descriptive information, P&IDs, onsite emergency power supply drawings, and system analyses are reviewed for whether essential portions of the system will function following DBAs, assuming a concurrent, single, active component failure. The reviewer evaluates the results of failure modes and effects analyses in the SAR for the functioning of required system portions.

5. The performance requirements of the EGTG are reviewed to determine the time available to provide cooling to the EGTGs and the other systems that must operate to assure onsite power capability.

6. The reviewer verifies whether the EGTGCS and the EGTG can perform for extended periods with less than full electrical power generation without degradation of performance or reliability. A statement to the effect that operating procedures will require loading of the EGTG up to a minimum of 25 percent of full load or as specified by the manufacturer recommendation for 1 hour after 8 hours of continuous no-load operation or as recommended by the manufacturer is acceptable.

7. For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the FSAR meets the acceptance criteria. DCs have referred to the FSAR as the DCD. The reviewer should also consider the appropriateness of identified COL action or information items. The reviewer may identify additional COL action or

information items; however, to ensure these COL action or information items are addressed during a COL application, they should be added to the DC FSAR.

For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an ESP, or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

8. For reviews under 10 CFR Part 50, the procedures are used during the CP review to determine whether the design criteria and bases and the preliminary design as set forth in the preliminary SAR meet the acceptance criteria of Subsection II of this interim guidance. For the review of OL applications, the procedures are used to determine whether the initial design criteria and bases are implemented appropriately in the final design as set forth in the final SAR. OL review procedures include a determination whether the content and intent of the applicant’s TSs agree with the requirements for system testing, minimum performance, and surveillance developed in the staff review as indicated in Subsection I of this guidance document.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's SER. The reviewer also states the bases for those conclusions.

1. The EGTGCS includes all piping, ductwork, valves, radiators, fans, and pumps up to the points where the cooling system piping connects to the EGTG interfaces. The EGTGCS scope of review for the plant included layout drawings, process flow diagrams, P&IDs, and descriptive information for the system and auxiliary supporting systems essential to its operation. EGTGCS essential portions necessary to mitigate the consequences of an accident are designed to seismic Category I and quality Group C.

   The basis for EGTGCS acceptance in our review was compliance of the designs, design criteria, and bases with NRC regulations as set forth in the GDCs of Appendix A to 10 CFR Part 50. The staff concludes that the plant design is acceptable and meets the requirements of GDCs 2, 4, 5, 17, 44, 45, and 46. This conclusion is based on the following findings:

   A. The applicant has met the requirements of GDC 2, "Design Bases for Protection Against Natural Phenomena," for the ability of structures housing the EGTGCS and the EGTGCS itself to withstand effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods, and GDC 4, "Environmental and Dynamic Effects Design Bases." The EGTGCS is housed in a seismic Category I structure which protects against the effects of tornados, tornado missiles, turbine missiles, and floods. This protection meets the positions of RG 1.115, "Protection Against Low-Trajectory Turbine Missiles," Position C.1, and RG 1.117, "Tornado Design Classification," Appendix Position 13.

B. The applicant has met the requirements of GDC 5, "Sharing of Structures, Systems, and Components," for the capability of shared systems and components important to safety to perform required safety functions. Each unit of the plant has its own EGTGs, each with an EGTGCS not shared between other EGTGs.

C. The applicant has met the requirements of GDC 17, "Electric Power Systems," for the capability of the cooling system to meet independence and redundancy criteria and GDC 44 as to the following:

   i. The capability to transfer heat from systems and components to a heat sink under transient or accident conditions,

   ii. Redundancy of components for performance of safety functions under accident conditions, assuming a single active component failure, and

   iii. The capability to isolate components of the system or piping if required for system safety function.

   The cooling air intake should be protected from icing if ambient conditions are likely to reach 5°C (40°F). Each EGTGCS is independent and physically separated from the other system serving the redundant EGTG. A single failure in the EGTGCS will affect only the associated EGTG. The EGTGCS transfers the heat generated by the EGTG to the ultimate heat sink or atmosphere via the heat exchangers, if applicable. The applicant has also met the applicable positions of NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability."

D. The applicant has met the requirements of GDC 45 for design provisions for periodic inspections of EGTGCS safety-related components and equipment and GDC 46 for design provisions for appropriate functional testing of safety-related systems or components for structural integrity, leak-tightness, operability, and performance of active components and the EGTGCS capability to function as intended under accident conditions. To assure structural integrity, leak-tightness, operability, and performance of active components and the capability of the system to function as intended, the EGTGCS permits periodic inspection and functional testing during standby and normal modes of power plant operation.

   The staff concludes that the EGTGCS design complies with all applicable GDCs, RG positions cited, NUREG/CR-0660, staff positions, and industry standards and is therefore, acceptable.

   For DC and COL reviews, the findings will also summarize the staff’s evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action or information items relevant to this interim guidance.

   In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this interim guidance in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

The provisions of this interim guidance apply to reviews of applications submitted 6 months or more after the date of issuance of this guidance document, unless superseded by a later revision.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, GDC 2, "Design Bases for Protection against Natural Phenomena."

2. 10 CFR Part 50, Appendix A, GDC 4, "Environmental and Missile Dynamic Effects Design Bases."

3. 10 CFR Part 50, Appendix A, GDC 5, "Sharing of Structures, Systems, and Components."

4. 10 CFR Part 50, Appendix A, GDC 17, "Electric Power Systems."

5. 10 CFR Part 50, Appendix A, GDC 44, "Cooling Water System."

6. 10 CFR Part 50, Appendix A, GDC 45, "Inspection of Cooling Water System."

7. 10 CFR Part 50, Appendix A, GDC 46, "Testing of Cooling Water System."

8. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and COLs for Nuclear Power Plants."

9. RG 1.115, "Protection Against Low-Trajectory Turbine Missiles."

10. RG 1.117, "Tornado Design Classification."

11. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability," University of Dayton Research Institute; UDR-TR-79-07; February 1979.

Article 6: MODIFIED SRP SECTION 9.5.6(I) EMERGENCY GAS TURBINE GENERATOR STARTING SYSTEM

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of EGTG support systems

Secondary - None

I. AREAS OF REVIEW

NPPs are required to have redundant onsite emergency power sources of sufficient capacity to power safety-related equipment. EDGs have been widely used as the standby power source for onsite AC power systems. It is anticipated that some new reactor designs will incorporate EGTGs for the emergency AC power system. This interim document provides guidance on the review of the starting system supporting an EGTG. This document is intended as a companion document to SRP Section 9.5.6 which explicitly applied only to a starting system for an EDG. SRP Sections 9.5.4(I) through 9.5.8(I)[8] cover the review of various essential elements of the EGTGs.

The review of the EGTG starting system (EGTGSS) covers system features necessary for reliable EGTG starting following a LOOP to assure compliance with the requirements of GDCs 2, 4, 5, and 17. The review includes the system air compressors, air dryers, air receivers, and devices to start the EGTG, valves, piping up to the connection to the EGTG interface[9], filters, and ancillary I&C systems. An implicit assumption is that the EGTG employs compressed air as its starting energy source. If however, another starting method is used (e.g., battery powered motors), then other sources of review guidance should be employed.

The specific areas of review are as follows:

1. The EGTGSS is reviewed to verify whether:

    A. Each EGTG has an independent starting system with adequate starting capacity.

    B. The system is designed, fabricated, erected, and tested to acceptable quality standards.

    C. The system has boundary divisions between safety-related and non-safety-related sections.

    D. Failures of any non-seismic Category I SSC will not affect system safety functions adversely.

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[8] The “(I)” following the SRP section number is intended to indicate Interim Guidance.

[9] As defined by the EGTG manufacturer.

E. System sections important to safety are housed within seismic Category I structures.

F. The consequences of a single, active failure in a starting system will not lead to a loss of more than one EGTG.

G. I&C features permit operational testing of the system and assure that normal protective interlocks do not preclude EGTG operation during emergency conditions.

H. The design includes the capability to detect and control system leakage, including isolation of portions of the system for excessive leakage or component malfunction.

I. Sufficient space permits inspection, cleaning, maintenance, and repair of the system.

2. ITAAC. For DC and COL reviews, the staff reviews the applicant's proposed ITAAC associated with the SSCs related to this interim guidance in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this interim guidance. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

3. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action or information items and requirements and restrictions (e.g., interface requirements and site parameters).

   For a COL application referencing a DC, a COL applicant must address COL action or information items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other SRP sections interface with this section as follows:

1. Upon request, review of the EGTGSS is performed for the compatibility of construction materials with service conditions.

2. Chapter 2: review of functional capability during abnormally high site water levels (probable maximum flood).

3. Sections 3.2.1 and 3.2.2: review of the seismic and quality group classifications for EGTGSS components.

4. Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4, and 3.8.5: review of the design analyses, procedures, and criteria establishing the ability of structures housing the EGTGSS to withstand the effects of natural phenomena like the SSE, the probable maximum flood, and tornado missiles.

5. Sections 3.4.1: EGTGSS review for whether protection against flooding is required.

6. Section 3.5.1.1: EGTGSS review for whether protection against internally-generated missiles are required. Each EGTGSS need not be protected from the missiles generated from its associated EGTG. However, it must be protected from missiles generated from other nearby EGTGs.

7. Section 3.5.2: EGTGSS review for whether protection from tornado missiles is required.

8. Section 3.6.1: review of the plant design for protection against postulated piping failures in fluid systems, including high-energy and moderate-energy piping systems outside containment, and effects upon the EGTGSS.

9. Sections 3.9.1 through 3.9.3: review of EGTGSS components, piping, and structures for design per applicable codes and standards.

10. Section 7.1: review of all essential EGTGSS instrumentation and controls to determine design, installation, inspection, and testing.

11. Section 8.3.1: review of the adequacy of the design, installation, inspection and testing of all electrical components (sensing, control, and power) required for proper EGTGSS operation, including interlocks.

12. Section 9.5.1: EGTGSS review for fire protection requirements.

13. Section 14.0: review of the acceptability of the pre-operational and startup tests.

14. Section 16.0: review of EGTGSS technical specifications.

15. Chapter 17: reviewing quality assurance requirements.

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

Requirements

Acceptability of the EGTGSS, as described in the applicant's SAR, COL submissions, or DCDs is based on specific regulations, GDCs, and RGs. The reviewer also utilizes information from other federal agencies and published reports, industry standards, military specifications, technical literature on commercially available products, and operational performance data from similarly designed systems at other plants having satisfactory operational experience.

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. GDC 2 as it relates to SSCs that must be protected from, or be capable of withstanding, the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods as established in SAR Chapters 2 and 3.

2. GDC 4 as it relates to SSCs that must be protected from, or be capable of withstanding, the effects of externally and internally generated missiles, pipe whip, and jet impingement forces of pipe breaks.

3. GDC 5 as it relates to the capability of systems and components important to safety shared between units to perform required safety functions.

4. GDC 17 as it relates to the capability of the EGTGSS to meet independence and redundancy criteria.

5. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a facility that incorporates the DC is built and will operate in accordance with the DC, the provisions of the AEA, and the Commission's rules and regulations.

6. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will be operated in conformity with the COL, the provisions of the AEA, and the Commission's rules and regulations.

<u>Interim Acceptance Criteria</u>

Specific acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in this interim guidance. This guidance is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the acceptance criteria and evaluate how the proposed alternatives to these acceptance criteria provide acceptable methods of compliance with the NRC regulations.

1. GDC 2 requirements for SSCs to be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods apply to safety-related EGTGSS SSCs. The identification of SSCs required to withstand earthquakes without loss of capability to perform safety functions is listed in RG 1.29. Comprehensive compliance with GDC 2 is reviewed under other SRP sections as specified in Subsection I of this interim guidance.

2. GDC 4 requirements for SSCs to be protected against the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks apply to safety-related EGTGSS SSCs. Comprehensive compliance with GDC 4 is reviewed under other SRP sections as specified in Subsection I of this interim guidance.

3. GDC 5 requirements for sharing of SSCs important to safety among nuclear power units are met if each unit has its own EGTG(s) and each EGTG an independent starting system.

4. GDC 17 as to the capability of the EGTGSS to meet independence and redundancy criteria. Specific criteria and guidance necessary to meet GDC 17 requirements are as follow:

   A. NUREG/CR-0660 "Enhancement of Onsite Emergency Diesel Generator Reliability" as applicable to EGTGs.

   B. Each EGTG should have a dedicated starting system consisting of an air compressor, an air dryer, one or more air receivers, piping, injection lines and valves, and devices to rotate the EGTG as recommended by the EGTG manufacturer.

   C. As a minimum, the starting system should be capable of starting the EGTG system 5 times without recharging the receiver(s). The starting system capacity should be determined as follows: (i) air required to rotate the turbine past all harmonic frequencies below its operational speed (ii) start requirements by the EGTG manufacturer, whichever start requirement is larger.

   D. Alarms should alert operating personnel if the air receiver pressure falls below the minimum allowable value.

   E. Provisions for the periodic or automatic blowdown of accumulated moisture and foreign material in the air receiver(s) and other system critical points.

   F. Starting air should be dried to a dew point of not more than 10º C (50º F) when installed in a normally-controlled 21º C (70º F) environment; otherwise, the starting air dew point should be controlled to at least 5.5ºC (10º F) less than the lowest expected ambient temperature.

<u>Technical Rationale</u>

The technical rationale for application of these acceptance criteria to the areas of review addressed by this interim guidance is discussed in the following paragraphs:

1. GDC 2 requires that SSCs important to safety be designed to withstand the effects of natural phenomena like earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform safety functions. The EGTGSS safety function is to assure reliable starting of the EGTG following a LOOP. Compliance with GDC 2 requirements ensures that natural phenomena events will not affect EGTGSS capability to start the EGTGs.

2. GDC 4 requires that SSCs important to safety be designed to withstand such dynamic effects of pipe ruptures as pipe whip and jet impingement and externally- or internally-generated missiles. The EGTGSS safety function is to assure reliable starting of the EGTGs following a LOOP. Compliance with GDC 4 provides assurance that the dynamic effects of equipment failures and events outside the plant will not affect EGTGSS capability to start the EGTGs.

3. GDC 5 prohibits the sharing of SSCs important to safety among nuclear power units unless such sharing can be demonstrated not to impair their ability to perform safety functions, including in the event of an accident in one unit an orderly shutdown and cooldown of the remaining unit. The EGTGSS safety function is to assure reliable starting of the EGTGs in a LOOP. Compliance with GDC 5 provides assurance that EGTGSS failures occurring in one unit will not affect other units of the site.

4. GDC 17 requires an onsite electric power system for the functioning of SSCs important to safety. GDC 17 requires the onsite electric power system to have sufficient independence and redundancy to perform their safety functions, assuming a single failure. GDC 17 requirements provide assurance that electric power will be available for systems necessary (i) to prevent fuel damage in anticipated operational occurrences and (ii) to maintain core cooling and containment integrity in postulated accidents.

III. <u>REVIEW PROCEDURES</u>

The reviewer will select material from the procedures described below, as may be appropriate for a particular case.

These review procedures are based on the identified SRP acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

1. The interfacing reviewers review the seismic design bases and the quality and seismic classifications as indicated in Subsection I of this interim guidance. The primary reviewer assures that essential EGTGSS portions, including the isolation valves separating essential and nonessential portions, are classified Quality Group C and seismic Category I. SAR component and system descriptions of mechanical and performance characteristics are reviewed for whether the seismic and quality classifications are included and whether the P&IDs indicate any points of change at the system or system component interfaces.

2. The reviewer establishes whether the EGTGSS description and P&IDs clearly delineate all modes of operation and include the means for monitoring, indicating, and controlling receiver air pressure as required by the EGTG starting service. The P&IDs are reviewed to determine whether a pressure gauge, relief valve, drain valve, automatic means of maintaining the receiver pressure within an allowable range, and suitable low pressure alarms are provided for the receiver(s). Piping interconnections between the dedicated start systems are reviewed for whether a failure in the interconnecting piping could lead to the loss of starting for more than one EGTG. The building layout drawings are examined for sufficient space around the components for inspection. The reviewer verifies whether the starting system meets the specific criteria of Subsection II, SRP Acceptance Criteria.

3. The SAR is reviewed for whether each EGTGSS has its own compressor and whether the compressor capacity is adequate for the air receiver capacities of the dedicated starting system.

4. The reviewer verifies whether the system is designed for operation and maintenance in adverse environmental like hurricanes, tornadoes, or floods, and is protected against the effects of internally- or externally-generated missiles.

5. The reviewer determines whether the failure of non-seismic Category I SSCs close to the EGTGSS will preclude system operation.

6. The reviewer determines whether the EGTGSS design precludes fouling of the start valve or filter with moisture and contaminants like oil and rust carryover. Air dryers should be installed upstream of air receivers to remove entrained moisture.

7. The reviewer determines whether essential EGTGSS portions are protected from the effects of high-and moderate-energy line breaks. Layout drawings are reviewed for whether high- or moderate-energy piping systems are close to the system or for protection from the effects of failure. Provisions for such protection are addressed in SAR Section 3.6 and the procedures for reviewing this information are in the corresponding SRP sections.

8. The SAR information, P&IDs, related system drawings, and failure mode and effect analyses are reviewed for whether minimum requirements of the system will be met following DBAs, assuming a concurrent, single, active failure and LOOP. The analyses presented in the SAR are reviewed for function of required components following postulated accidents. Utilizing the descriptions, related drawings, and analyses, the reviewer verifies whether minimum system requirements are met for each degraded situation over required time spans. For each case the design is acceptable if it meets minimum system requirements.

9. For reviews under 10 CFR Part 50, the procedures are used during the CP or review to determine whether the design criteria and bases and the preliminary design as set forth in the preliminary SAR meet the acceptance criteria of Subsection II of this interim guidance. For the review of OL applications, the procedures are used to verify whether the initial design criteria and bases are implemented appropriately in the final design as set forth in the final SAR. The review procedures for OL applications determine whether the content and intent of the applicant’s TSs agree with the requirements for system testing, minimum performance, and surveillance developed in the staff review as indicated in Subsection I of this interim guidance.

10. For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the FSAR meets the acceptance criteria. DCs have referred to the FSAR as the DCD. The reviewer should also consider the appropriateness of identified COL action or information items. The reviewer may identify additional COL action or information items; however, to ensure these COL action or information items are addressed during a COL application, they should be added to the DC FSAR.

    For review of a COL application under 10 CFR 52, the scope of the review is dependent on whether the COL applicant references a DC, an ESP, or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's SER. The reviewer also states the bases for those conclusions.

The EGTGSS has an air compressor, air dryer(s), filters, valves, air receiver(s), and all components and piping connecting to the EGTG interfaces necessary for the system to be available and capable of starting the EGTG following a LOOP. The scope of review of the system for the plant included layout drawings, flow diagrams, P&IDs, and descriptive information for the EGTGSS and supporting systems essential to its operation. The essential EGTGSS portions necessary to shut down the reactor safely or to mitigate the consequences of an accident are designed to seismic Category I and Quality Group C.

The staff concludes that the EGTGSS design is acceptable and meets the requirements of GDCs 2, 4, 5, and 17. This conclusion is based on the following findings:

1. The applicant has met the requirements of GDC 2, "Design Bases for Protection Against Natural Phenomena," for the ability of structures housing the EGTSS and the system itself to withstand the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods and GDC 4, "Environmental and Dynamic Effects Design Bases," for the ability of structures housing the system and the system to withstand the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks. The EGTGSS is housed in a seismic Category I structure which protects it from the effects of tornados, tornado missiles, turbine missiles, and floods. This protection meets the positions of RGs 1.115, "Protection Against Low-Trajectory Turbine Missiles," Position C.1, and 1.117, "Tornado Design Classification," Appendix Position 13.

2. The applicant has met the requirements of GDC 5, "Sharing of Structures, Systems and Components," for the ability of shared systems and components important to safety to perform required safety functions. Each unit of the plant has its own EGTGs with an EGTGSS not shared between other EGTGs.

3. The applicant has met the requirements of GDC 17, "Electric Power Systems," for the ability of the starting system to meet independence and redundancy criteria. Each EGTGSS is independent and physically separated from the other system serving the redundant EGTG. A single failure in any one of the systems will affect only its own EGTG. Each of the starting systems can rotate a cold EGTG 5 times without air receiver recharging. The applicant has also met the positions of NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability."

For DC and COL reviews, the findings will also summarize the staff’s evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action or information items relevant to this interim guidance.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this interim guidance in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

The provisions of this interim guidance apply to reviews of applications submitted 6 months or more after the date of issuance of this guidance, unless superseded by a later revision.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, GDC 2, "Design Bases for Protection Against Natural Phenomena."

2. 10 CFR Part 50, Appendix A, GDC 4, "Environmental and Dynamic Effects Design Bases."

3. 10 CFR Part 50, Appendix A, GDC 5, "Sharing of Structures, Systems, and Components."

4. 10 CFR Part 50, Appendix A, GDC 17, "Electric Power Systems."

5. 10 CFR Part 52, "Early site permits; standard design certifications; and combined licenses for nuclear power plants."

6. RG 1.115, "Protection Against Low-Trajectory Turbine Missiles."

7. RG 1.117, "Tornado Design Classification."

8. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability.," University of Dayton Research Institute; UDR-TR-79-07; February 1979.

Article 7: MODIFIED SRP SECTION 9.5.7(I) EMERGENCY GAS TURBINE GENERATOR LUBRICATION SYSTEM

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of EGTG support systems

Secondary - None

I. AREAS OF REVIEW

NPPs are required to have redundant onsite emergency power sources of sufficient capacity to power safety-related equipment. EDGs have been widely used as the standby power source for onsite AC power systems. It is anticipated that some new reactor designs will incorporate EGTGs for the emergency AC power system. This interim document provides guidance on the review of the lubrication system supporting an EGTG. This document is intended as a companion document to SRP Section 9.5.7 which explicitly applied only to a lubrication system for an EDG. SRP Sections 9.5.4(I) through 9.5.8(I)[10] cover the review of various essential elements of the EGTGs.

The EGTG lubrication system (EGTGLS) provides essential lubrication to EGTG components. Review of the EGTGLS and its auxiliary systems assures compliance with the requirements of GDCs 2, 4, 5, and 17. The review includes system piping, pumps, components, and auxiliary equipment essential for system operation up to the engine interface.[11] The specific areas of review are as follow:

1. The EGTGLS is reviewed to verify whether:

    A. Each EGTG has an independent and reliable lubrication system.

    B. The system is designed, fabricated, erected, and tested to acceptable quality standards.

    C. The system has boundary divisions between safety-related and non-safety-related sections.

    D. Sections of the system important to safety are housed within seismic Category I structures.

    E. Failure of any non-seismic Category I SSC will not affect any EGTGLS safety-related function.

    F. The consequences of a single failure in an EGTGLS or the loss of a cooling source will not lead to a loss of more than one EGTG.

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[10] The "(I)" following the SRP section number is intended to indicate Interim Guidance.

[11] As defined by the EGTG manufacturer.

G. The design includes the capability for detection and control of system leakage, including the capability for isolating system portions in the event of excessive leakage or component malfunction.

H. The design includes measures to assure lubricating oil quality.

I. I&C features permit operational testing of the system and assure that normal protective interlocks do not preclude EGTG operation during emergency conditions.

J. The design includes measures for cooling the system and removing system heat load.

K. Sufficient space permits inspection, cleaning, maintenance, and repair of the system.

2. ITAAC. For DC and COL reviews, the staff reviews the applicant's proposed ITAAC associated with the SSCs related to this interim guidance in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this interim guidance. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

3. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action or information items and requirements and restrictions (e.g., interface requirements and site parameters).

   For a COL application referencing a DC, a COL applicant must address COL action or information items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other SRP sections interface with this section as follows:

1. Chapter 2: review of functional capability during abnormally high site water levels (probable maximum flood).

2. Sections 3.2.1 and 3.2.2: review of the seismic and quality group classifications for EGTGLS components.

3. Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4, and 3.8.5: review of the design analyses, procedures, and criteria that establish the ability of structures housing the EGTGLS to withstand the effects of natural phenomena like the SSE, the probable maximum flood, and tornado missiles.

4. Sections 3.4.1: review of EGTGLS to determine whether protection against flooding is required.

5. Section 3.5.1.1: review of EGTGLS to determine whether protection from internally-generated missiles is required. Each EGTGLS need not be protected from the missiles generated from its associated EGTG. However, it must be protected from missiles generated from other nearby EGTGs.

6. Section 3.5.2: review of EGTGLS to determine whether protection from tornado missiles is required.

7. Section 3.6.1: review of the plant design for protection against postulated piping failures in fluid systems, including high-energy and moderate-energy piping systems outside containment and effects upon the EGTGLS.

8. Sections 3.9.1 through 3.9.3: review of EGTGLS components, piping, and structures to verify they are designed per applicable codes and standards.

9. Section 7.1: review of all essential EGTGLS controls and instrumentation for design, installation, inspection, and testing.

10. Section 8.3.1: review of the adequacy of the design, installation, inspection, and testing of all electrical components (sensing, control, and power) required for proper EGTGLS operation, including interlocks.

11. Section 9.5.1: review of EGTGLS for fire protection requirements.

12. Section 14.0: review of the acceptability of the pre-operational and startup tests.

13. Section 16.0: review of EGTGLS technical specifications.

14. Chapter 17: review of quality assurance requirements.

15. Upon request, EGTGLS review is performed for the compatibility of materials of construction with service conditions

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

Requirements

Acceptability of the EGTGLS, as described in the applicant's SAR, COL, or DCD is based on specific regulations, GDCs, and RGs. The reviewer also utilizes information from other federal agencies and published reports, industry standards, military specifications, technical literature on commercially available products, and operational performance data from similarly designed systems at other plants with satisfactory operating experience.
Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. GDC 2 as it relates to SSCs that must be protected from, or be capable of withstanding, the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods, as established in SAR Chapters 2 and 3.

2. GDC 4 as it relates SSCs that must be protected from, or be capable of withstanding, the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks.

3. GDC 5 as it relates to the capability of systems and components important to safety shared between units to perform required safety functions.

4. GDC 17 as it relates to EGTGLS capability to meet independence and redundancy criteria.

5. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a facility that incorporates the DC is built and will operate in accordance with the DC, the provisions of the AEA, and the Commission's rules and regulations.

6. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will be operated in conformity with the COL, the provisions of the AEA, and the Commission's rules and regulations.

Interim Acceptance Criteria

Specific acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in this interim guidance. The interim guidance is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the interim guidance acceptance criteria and evaluate how the proposed alternatives to the interim guidance acceptance criteria provide acceptable methods of compliance with the NRC regulations.

1. GDC 2 requirements for SSCs to withstand or be protected from the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods apply to safety-related EGTGLS SSCs. The identification of SSCs required to withstand earthquakes without the loss of capabilities to perform safety functions is listed in RG 1.29. Comprehensive compliance with GDC 2 is reviewed under other SRP sections as specified in Subsection I of this interim guidance.

2. GDC 4 requirements for SSCs to be protected against the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks apply to safety-related EGTGLS SSCs. Comprehensive compliance with GDC 4 is reviewed under other SRP sections as specified in Subsection I of this interim guidance.

3. GDC 5 requirements for sharing of SSCs important to safety among nuclear power units are met if each unit has its own EGTG(s), each with an independent EGTGLS.

4. GDC 17 requirements of independence and redundancy criteria are applicable to the EGTGLS. Acceptance is based on the following specific criteria:

   A. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability." The enhancements proposed by the NUREG apply to the EGTLS.

   B. System operating pressure, temperature differentials, flow rate, and heat removal rate external to the EGTG in accordance with EGTG manufacturer recommendations.

   C. Sufficient system protective measures to maintain required oil quality during EGTG operation.

   D. Protective measures (e.g., relief ports) to prevent unacceptable explosions and to mitigate consequences of such events.

   E. A keep-warm oil lubricating system may be provided to maintain the sump (and possibly the bearings) in a warmed state when the EGTG is in the standby mode. If the applicant takes credit for these systems in their starting reliability determinations, these systems must be of appropriate safety grade.

   F. A continuous lube oil circulation system may be provided to maintain the EGTG lubrication passages filled in the standby mode. If the applicant takes credit for this system in their starting reliability determinations, this system must be of appropriate safety grade.

   G. Each EGTGLS is completely independent of other EGTGs so a single failure will not cause a loss of more than one EGTG.

   H. Onsite lubricating oil storage capacity for each EGTG is sufficient for seven days operation after any DBE and a continuous loss of off-site power as specified in ANSI/ANS-59.52. The guidelines stated in ANSI/ANS-59.52 for EDGs in this matter apply to the EGTGs.

<u>Technical Rationale</u>

The technical rationale for application of these acceptance criteria to the areas of review addressed by this interim guidance is discussed in the following paragraphs:

1. GDC 2 requires that SSCs important to safety be designed to withstand the effects of natural phenomena like earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform safety functions. The EGTGLS safety function is to provide essential lubrication to the EGTG under standby, startup, and operating conditions. Compliance with GDC 2 requirements provides assurance that natural phenomena events will not affect EGTGLS capability to provide essential lubrication to the EGTG.

2. GDC 4 requires that SSCs important to safety be designed to withstand such dynamic effects of pipe ruptures as pipe whip and jet impingement and externally- or internally-generated missiles. The EGTGLS safety function is to provide essential lubrication to the EGTGs under standby, startup, and operating conditions. Compliance with GDC 4 provides assurance that the dynamic effects of equipment failures, and events external to the plant, will not affect EGTGLS capability to provide lubrication to the EGTGs.

3. GDC 5 prohibits the sharing of SSCs important to safety among nuclear power units unless such sharing can be demonstrated not to impair their ability to perform safety functions, including in the event of an accident in one unit an orderly shutdown and cooldown of the remaining unit. The EGTGLS safety function is to provide essential lubrication to the EGTGs under standby, startup, and operating conditions. Compliance with GDC 5 provides assurance that an EGTGLS failure in one unit will not affect other units of the site.

4. GDC 17 requires an onsite electric power system for the functioning of SSCs important to safety. GDC 17 requires that the onsite electric power system have sufficient independence and redundancy for safety functions, assuming a single failure. GDC 17 requirements provide assurance that electric power will be available for systems necessary (i) to prevent fuel damage in the event of anticipated operational occurrences and (ii) to maintain core cooling and containment integrity in postulated accidents.

III. REVIEW PROCEDURES

The reviewer will select material from the procedures described below, as may be appropriate for a particular case.

These review procedures are based on the identified interim guidance acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

1. For reviews under 10 CFR Part 50, the procedures below are used during the CP review to determine whether the design criteria and bases and the preliminary design as set forth in the preliminary SAR meet the acceptance criteria of Subsection II of this interim guidance. For the review of OL applications, the procedures verify whether the initial design criteria and bases are implemented appropriately in the final design as set forth in the final SAR. The OL review determines whether the content and intent of the applicant's TSs agree with the requirements for system testing, minimum performance, and surveillance developed as a result of the staff's review as indicated in Subsection I of this interim guidance.

2. For review of a DC application, the reviewer should follow the procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the FSAR meets the acceptance criteria. DCs have referred to the FSAR as the DCD. The reviewer should also consider the appropriateness of identified COL action or information items. The reviewer may identify additional COL action or information items; however, to ensure these COL action or information items are addressed during a COL application, they should be added to the DC FSAR.

For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an ESP or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

3. The SAR is reviewed for whether the EGTGLS is a dedicated system and whether the description and related diagrams clearly delineate system operation, including the means for indicating and monitoring oil levels, temperatures, and pressures required for continuous operation of the system. The reviewer verifies the following:

   A. Interfacing reviewers review the seismic design bases and the quality and seismic classification as indicated in Subsection I of this interim guidance. The primary reviewer assures that essential EGTGLS portions including the isolation valves separating essential and nonessential portions are classified Quality Group C and seismic Category I. Component and system descriptions in the SAR that identify mechanical and performance characteristics are reviewed to verify that the above seismic and quality classifications have been included and that the P&IDs indicate any points of change at systems or systems components interfaces.

   B. Failure of a piping interconnection between subsystems as shown on the system P&IDs will not cause total degradation of the EGTGLS function. The results of failure modes and effects analyses are used in this verification.

   C. The system layout drawings are examined for sufficient space to permit inspection of components.

   D. The system P&IDs indicate the temperature, pressure, and level sensors which alert the operator when these parameters exceed the ranges recommended by the EGTG manufacturer.

   E. The design provides for the total heat removal rates required by the system and the margin in the design heat removal rate capability.

   F. The system inventory, including the EGTG sump and onsite storage capacity, is designed with sufficient volume to support continuous, full-load EGTG operation for seven days.

   G. The EGTGLS is alarmed both locally and in the MRC for high and low pressure and high temperature to enable a timely response to fault conditions.

4. The reviewer determines whether the system is designed to maintain its function under adverse environmental phenomena. The reviewer, using engineering judgment and the results of failure modes and effects analyses, determines whether:

   A. The failure of either systems not designed to seismic Category I requirements or nonseismic Category I structures that house, support, or are close to the EGTGLS, will not preclude functioning of the system. Chapters 2 and 3 of the SAR describe related site features and provide the general structural arrangement and layout drawings and a tabulation of seismic design classifications for the structures and systems. Statements in the SAR to the effect that the above design requirements are met are acceptable.

B. The essential portions of the system are protected from the effects of floods, hurricanes, tornadoes, and internally- and externally-generated missiles.

5. The reviewer verifies whether the EGTGLS is protected from the effects of high- and moderate-energy line breaks. System descriptions in the SAR are reviewed for high- or moderate-energy piping systems close to the EGTGLS or that protection from effects of failure will be provided. SAR Chapter 3 presents the means of such protection, and procedures for reviewing the information are presented in the corresponding SRP sections.

6. The descriptive information, P&IDs, related system drawings, and system analyses in the SAR are reviewed to assure that essential EGTGLS portions will function following DBAs, assuming a concurrent single active component failure. The reviewer evaluates the results of failure modes and effects analyses presented in the SAR to assure functioning of required components, traces the availability of these components on system drawings, and checks that minimum system requirements are met for each degraded situation over required time spans. For each case, the design is acceptable if it meets minimum system requirements.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's SER. The reviewer also states the bases for those conclusions.

The EGTGLS includes the pumps, radiators, valves, piping, makeup piping, and connection or interface points with other systems. The scope of EGTGLS review for the plant included layout drawings, flow diagrams, P&IDs, and descriptive information for the system and supporting systems essential to its operation. The essential EGTGLS portions that are necessary for the safe shut down of the reactor or necessary to mitigate the consequences of an accident are designed to seismic Category I and Quality Group C.

The staff concludes that the EGTGLS design is acceptable and meets the requirements of GDCs 2, 4, 5, and 17. This conclusion is based on the following findings:

1. The applicant has met the requirements of GDC 2, "Design Bases for Protection Against Natural Phenomena," for the ability of structures housing the EGTGLS and the system itself to withstand the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods and GDC 4, "Environmental and Dynamic Effects Design Bases," for the ability of structures housing the system and the system to withstand the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks. The EGTGLS is housed in a seismic Category I structure which protects it from the effects of tornados, tornado missiles, turbine missiles, and floods. This protection meets the positions of RG 1.115, "Protection Against Low-Trajectory Turbine Missiles," Position C.1, and RG 1.117, "Tornado Design Classification," Appendix Position 13.

2. The applicant has met the requirements of GDC 5, "Sharing of Structures, Systems and Components," for the capability of shared systems and components important to safety to perform required safety functions. Each unit of the plant has its own EGTGs, each with an EGTGLS not shared between the EGTGs.

3. The applicant has met the requirements of GDC 17, "Electric Power Systems," for EGTGLS capability to meet independence and redundancy criteria. Each EGTGLS is independent and physically separated from the other system serving the redundant EGTG. A single failure in any one of the systems will affect only its own EGTG. The EGTGLS for each EGTG provides the necessary lubrication during operation and maintains the lube oil at a temperature that improves first-start reliability. The applicant has also met the positions of NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability."

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action or information items relevant to this interim guidance.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this interim guidance in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

The provisions of this interim guidance apply to reviews of applications submitted 6 months or more after the date of issuance of this interim guidance, unless superseded by a later revision.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, GDC 2, "Design Bases for Protection Against Natural Phenomena."

2. 10 CFR Part 50, Appendix A, GDC 4, "Environmental and Dynamic Effects Design Bases."

3. 10 CFR Part 50, Appendix A, GDC 5, "Sharing of Structures, Systems, and Components."

4. 10 CFR Part 50, Appendix A, GDC 17, "Electric Power Systems."

5. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."

6. RG 1.115, "Protection Against Low-Trajectory Turbine Missiles."

7. RG 1.117, "Tornado Design Classification."

8. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Operating Reliability," University of Dayton Research Institute; UDR-TR-79-07; February 1979.

9. ANSI/ANS-59.52-1998, “Lubricating Oil Systems for Safety-Related Diesel Generators.”

Article 8: MODIFIED SRP SECTION 9.5.8(I) EMERGENCY GAS TURBINE GENERATOR COMBUSTION AIR INTAKE AND EXHAUST SYSTEM

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of EGTG support systems

Secondary - None

I. <u>AREAS OF REVIEW</u>

NPPs are required to have redundant onsite emergency power sources of sufficient capacity to power safety-related equipment. EDGs have been widely used as the standby power source for onsite AC power systems. It is anticipated that some new reactor designs will incorporate EGTGs for the emergency AC power system. This interim document provides guidance on the review of combustion air intake and exhaust systems supporting an EGTG. This document is intended as a companion document to SRP Section 9.5.8 which explicitly applied only to combustion air intake and exhaust systems for an EDG. SRP Sections 9.5.4(I) through 9.5.8(I)[12] cover the review of various essential elements of the EGTGs.

The EGTG combustion air intake and exhaust system (EGTGCAIES) supplies combustion air of reliable quality to the EGTGs and exhausts combustion products from the EGTGs to the atmosphere. The system is reviewed from the outside air intake to the combustion air supply lines connected to the EGTG interface and from the exhaust connections at the EGTG interface[13] to the discharge point outside the building for compliance with GDCs 2, 4, 5, and 17.

The specific areas of review are as follow:

1. EGTGCAIES review verifies that:

   A. Each EGTG has an independent combustion air intake and exhaust system.

   B. The components are designed, fabricated, erected, and tested to acceptable quality standards.

   C. The system has boundary divisions between safety-related and non-safety-related sections.

   D. Failures of any non-seismic Category I SSC (or failures of other non-seismic components or systems) will not affect the safety functions of the system adversely.

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[12] The "(I)" following the SRP section number is intended to indicate Interim Guidance.

[13] As defined by the EGTG manufacturer.

E. Sections of the system important to safety are housed in or on a seismic Category I structure.

F. The consequences of a single, active failure in an EGTGCAIES will not lead to the loss of function of more than one EGTG.

G. I&C features permit operational testing of the system and assure that normal protective interlocks do not preclude EGTG operation during emergency conditions.

H. Sufficient space permits inspection, cleaning, maintenance, and repair of the system.

2. ITAAC. For DC and COL reviews, the staff reviews the applicant's proposed ITAAC associated with the SSCs related to this interim guidance in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this interim guidance. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

3. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action or information items and requirements and restrictions (e.g., interface requirements and site parameters).

   For a COL application referencing a DC, a COL applicant must address COL action or information items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other SRP sections interface with this section as follows:

1. Chapter 2: review of functional capability during abnormally high site water levels (probable maximum flood) is performed under this chapter.

2. Sections 3.2.1 and 3.2.2: review of the seismic and quality group classifications for EGTGCAIES components is performed under this section.

3. Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4, and 3.8.5: review of the design analyses, procedures, and criteria that establish the ability of structures housing the EGTGCAIES to withstand the effects of natural phenomena like the SSE, the probable maximum flood, and tornado missiles is performed under these sections.

4. Sections 3.4.1: review of EGTGCAIES for whether protection against flooding is required is performed under this section.

5. Section 3.5.1.1: review of EGTGCAIES for whether protection against internally- generated missiles is required is performed under this section. Each EGTG need not be protected

from the missiles generated from its associated EGTG. However, it must be protected from missiles generated from other nearby EGTGs.

6. Section 3.5.2: review of EGTGCAIES for whether protection from tornado missiles is required is performed under this section.

7. Section 3.6.1: review of the plant design for protection against postulated piping failures in fluid systems, including high-energy and moderate-energy piping systems outside containment, and effects upon the EGTGCAIES is performed under this section.

8. Sections 3.9.1 through 3.9.3: review of EGTGCAIES components, piping, and structures for design per applicable codes and standards is performed under this section.

9. Section 7.1: review of all essential EGTGCAIES control and instrumentation for design, installation, inspection, and testing is performed under this section.

10. Section 8.3.1: review of the adequacy of the design, installation, inspection and testing of all electrical components (sensing, control, and power) required for proper operation of the EGTGCAIES, including interlocks is performed under this section.

11. Section 9.5.1: review of EGTGCAIES for fire protection requirements. In addition to fire protection adequacy, this review should analyze the potential impact on the effectiveness of gaseous fire suppression systems in the area(s) from which the EGTG intake air is drawn.

12. Section 9.5.5: review of EGTG cooling flow routes as a possible path for cycling EGTG exhaust to the EGTG inlet.

13. Section 14.0: review of the acceptability of the pre-operational and startup tests is performed under this section.

14. Chapter 16.0: review of EGTGCAIES technical specifications is performed under this section.

15. Chapter 17: review of quality assurance requirements is performed under this section.

16. Review of EGTGCAIES for compatibility of materials of construction with service conditions.

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

Requirements

Acceptability of the EGTGCAIES design as described in the applicant's SAR, COL submittal, or DCD, is based on specific regulations, GDCs, and RGs. The reviewer also utilizes information from other federal agencies and published reports, industry standards, military specifications, available technical literature on commercial products, and operational performance data from similarly designed systems at other plants having satisfactory operational experience.

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. GDC 2 as it relates to SSCs that must be protected from, or be capable of withstanding, the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods as established in SAR Chapters 2 and 3.

2. GDC 4 as it relates to SSCs that must be protected from, or be capable of withstanding the effects of, externally- and internally-generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

3. GDC 5 as it relates to safety-related systems and components shared between units able to perform required safety functions.

4. GDC 17 as it relates to the capabilities of the EGTGCAIES to meet independence and redundancy criteria.

5. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a facility that incorporates the DC is built and will operate in accordance with the DC, the provisions of the AEA, and the Commission's rules and regulations.

6. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will be operated in conformity with the COL, the provisions of the AEA, and the Commission's rules and regulations.

Interim Acceptance Criteria

Specific SRP acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in this interim guidance. This guidance is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the acceptance criteria and evaluate how the proposed alternatives to these acceptance criteria provide acceptable methods of compliance with the NRC regulations.

1. GDC 2 requirements for SSCs to withstand or be protected from the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods, apply to safety-related EGTGCAIES SSCs. The identification of SSCs required to withstand earthquakes without the loss of capabilities to perform safety function is listed in RG 1.29. Compliance with GDC 2 is reviewed under other SRP sections as specified in Subsection I of this interim guidance.

2. GDC 4 requirements of SSCs to be protected against the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks, apply to

safety-related EGTGCAIES SSCs. Compliance with GDC 4 is reviewed under other SRP sections as specified in Subsection I of this interim guidance.

3. GDC 5 requirements for sharing of SSCs important to safety are met when each EGTG has its own independent and reliable EGTGCAIES.

4. GDC 17 as related to the capabilities of the EGTGCAIES to meet independence and redundancy criteria. Acceptance is based on meeting the following specific criteria:

   A. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability."

      i. EGTG combustion air should be through piping and/or ductwork directly from outside the building with the air intake sufficiently (≥20 feet) above ground level and filtered to preclude any degradation of continuous EGTG function.

      ii. The ductwork for room ventilation air should be separate from that for EGTG combustion air.

      iii. EGTG exhaust gas should not circulate back into the EGTG room, fuel storage room, or any part of the power plant.

      iv. EGTG exhaust should not circulate back into the EGTG inlet of the same unit or neighboring units. The air ventilation system used for system cooling should be examined as a potential source for recycling exhaust to the inlet.

   B. Each EGTG should have an independent and reliable EGTGCAIES sized and physically arranged for no degradation of the EGTG function when the EGTG must operate continuously at the maximum rated power output.

   C. The combustion air intake system must have a means of reducing airborne particulate material over the entire time period requiring emergency power, assuming the maximum airborne particulate concentration at the combustion air intake.

   D. Suitable design precautions must preclude degradation of the EGTG power output due to exhaust gases and other diluents that could reduce oxygen content below acceptable levels.

   E. Combustion air intake systems should be protected from ice buildup if the ambient temperature is expected to reach below 5º C (40º F). This includes both the combustion air intake and the cooling air intake systems discussed in Section 9.5.5.

   F. EGTGCAIESs should be designed to allow ready accessibility for inspection and maintenance and should be periodically inspected for blockage due to birds and debris. This includes both the combustion and the cooling air systems discussed in Section 9.5.5.

   G. The EGTG and downstream components should be purged with three air volumes to remove any fuel vapors prior to ignition of the fuel.

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this interim guidance is discussed in the following paragraphs:

1. GDC 2 requires that SSCs important to safety be designed to withstand the effects of natural phenomena like earthquakes, tornadoes, hurricanes, floods, tsunamis, and seiches without loss of capability to perform safety functions. The EGTGCAIES safety function is to supply quality combustion air and an exhaust path for the EGTG following a LOOP. Compliance with GDC 2 requirements provides assurances that natural phenomena events will not affect EGTGCAIES capability to supply quality combustion air and an exhaust path for the EGTG.

2. GDC 4 requires that SSCs important to safety be designed to withstand the dynamic pipe rupture effects like pipe whip, jet impingement, and externally- or internally-generated missiles. The EGTGCAIES safety function is to provide combustion air and an exhaust path for the EGTGs following a LOOP. Compliance with GDC 4 provides assurance that the dynamic effects of equipment failures and events outside the plant will not affect the EGTGCAIES capability to provide combustion air and an exhaust path for the EGTG.

3. GDC 5 prohibits the sharing of SSCs important to safety among nuclear power units unless such sharing can be demonstrated not to impair their ability to perform safety functions, including in the event of an accident in one unit an orderly shutdown and cooldown of the remaining unit. The EGTGCAIES safety function is to provide combustion air and an exhaust path for the EGTGs in a LOOP. Compliance with GDC 5 provides assurance that EGTGCAIES failures and events in one unit will not affect other units of the site.

4. GDC 17 requires provision of an onsite electric power system for the functioning of SSCs important to safety. GDC 17 requires the onsite electric power system to have sufficient independence and redundancy to perform safety functions, assuming a single failure. GDC 17 requirements provide assurance that electric power will be available for systems necessary (i) to prevent fuel damage in anticipated operational occurrences and (ii) to maintain core cooling and containment integrity in postulated accidents.

III. REVIEW PROCEDURES

The reviewer will select material from the procedures described below, as may be appropriate for a particular case.

These review procedures are based on the identified SRP acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

For reviews under 10 CFR Part 50, the procedures below are used during the CP review to determine that the design criteria and bases and the preliminary design, as set forth in the preliminary SAR, meet the acceptance criteria of Subsection II of this interim guidance. For the review of OL applications, the procedures are utilized to verify that the initial design criteria and bases are implemented appropriately in the final design as set forth in the FSAR. The review procedures for OL applications include a determination that the content and intent of the applicant's TSs are in agreement with the requirements for system testing, minimum performance, and surveillance developed as a result of the staff review, as indicated in Subsection I of this interim guidance.

1. The SAR is reviewed for whether the EGTGCAIES is a dedicated system and whether the description and related diagrams clearly delineate system components and modes of system operation. The interfacing branches review the seismic design bases and the quality and seismic classifications as indicated in Subsection I of this interim guidance. The interfacing branches assure that essential EGTGCAIES portions are classified Quality Group C and seismic Category I. Components and system descriptions in the SAR that identify mechanical and performance characteristics are reviewed to verify whether the seismic and quality classifications have been included and whether P&IDs indicate any points of change at system or system component interfaces.

2. The SAR is reviewed to ascertain that sufficient space has been provided around the components to permit inspection of the system components.

3. The SAR is reviewed to assure that the combustion air intake and exhaust are arranged and located to prevent dilution or contamination of the intake air by exhaust products, fire extinguishing (gaseous) media, or other gases intentionally or accidentally released on site from precluding operation of the EGTGs at rated power output or causing EGTG shutdown as a consequence of any meteorological or accident condition. The review should consider the cooling air flow path as a potential route for cycling exhaust air to the inlet. Any nearby system, including other redundant EGTGs, should also be included.

4. The SAR is reviewed to verify that if the intake air flow or EGTG exhaust depends upon the actuation of flow control devices (louvers, dampers), the EGTGCAIES will function if there is a failure of an active component.

5. The SAR is reviewed to assure that the system components exposed to atmospheric conditions (dust storms, rain, ice, snow) are protected from possible clogging during standby or operation system.

6. The reviewer verifies whether the system will function as required in other adverse natural phenomena. The reviewer evaluates the system to determine that:

   A. The failure of nonessential portions of the system or of other systems not designed to seismic Category I requirements and located close to essential portions of the system, or of non-seismic Category I structures that house, support, or are close to essential portions of the EGTGCAIES, will not preclude operation of the system. Reference to SAR sections describing site features and the general arrangement and layout drawings and SAR tabulation of seismic design classifications for structures and systems will be necessary. Statements in the SAR that verify that the above conditions are met are acceptable.

   B. Essential EGTGCAIES portions are protected from the effects of floods, hurricanes, tornadoes, and internally- or externally-generated missiles. Flood protection and missile protection criteria are discussed and evaluated in detail under the SRP sections for

Chapter 3 of the SAR. The location and the design of the systems and structures are reviewed to determine that the degree of protection provided is adequate. A statement to the effect that the system is located in a seismic Category I structure that is tornado-missile and flood-protected, or that components of the system will be located in individual cubicles or rooms that will withstand the effects of both flooding and missiles is acceptable.

C. Essential portions of the system are protected from the effects of high-energy and moderate-energy line breaks. Layout drawings are reviewed to assure that no high- or moderate-energy piping systems are close to the essential portions of the system, or that protection from the effects of failure will be provided. The means of providing such protection will be given in Section 3.6 of the SAR and procedures for reviewing this information are in the corresponding SRP sections.

7. The descriptive information, P&IDs, EGTGCAIES layout drawings, and failure modes and effects analyses in the SAR are reviewed to assure that functional requirements of the system will be met following DBAs, assuming a concurrent single, active component failure. The reviewer evaluates the effects of failure of components, traces the availability of redundant components on system drawings, and checks that the SAR contains verification that the system functional requirements are met.

8. The SAR is reviewed for provisions in the EGTGCAIES design to minimize the ingestion of airborne particulate material by the intake system over the entire time requiring emergency power. The reviewer also verifies the following:

   A. The bottom of the intake opening is located a minimum of 6.1 meters (20 feet) above grade.

   B. Provisions are made to minimize the generation of dust, particularly in multi-unit plants when one unit is operating and the other is under construction (abnormal generation of dust).

   Dust control in the ventilation system for the EGTG rooms is reviewed by interfacing branches under SRP Section 9.4.5. In SRP Section 8.3.1, interfacing branches review the SAR for whether electrical equipment for starting the EGTGs (e.g., auxiliary relay contacts, control switches, individually or panel mounted) are protected from dust accumulation, other deleterious material entering EGTG rooms, and dust generated from concrete floors and walls.

9. For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the FSAR meets the acceptance criteria. DCs have referred to the FSAR as the DCD. The reviewer should also consider the appropriateness of identified COL action or information items. The reviewer may identify additional COL action or information items; however, to ensure these COL action or information items are addressed during a COL application, they should be added to the DC FSAR.

For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an ESP, or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's SER. The reviewer also states the bases for those conclusions.

The EGTGCAIES includes all components and piping of the air intake system from the atmospheric air intake to its connection to the EGTG interface and all components and piping of the exhaust system from its connection to the EGTG interface to where it exhausts to the atmosphere. The scope of the EGTGCAIES review included layout drawings, P&IDs, and descriptive information for the EGTGCAIES and auxiliary supporting systems essential to its safe operation. The essential portions of the EGTGCAIES necessary for safe shut down of the reactor or necessary to mitigate the consequences of an accident are designed to seismic Category I and Quality Group C.

The staff concludes that the EGTGCAIES design is acceptable and meets the requirements of GDC 2, 4, 5, and 17. This conclusion is based on the following findings:

1. The applicant has met the requirements of GDC 2, "Design Bases for Protection Against Natural Phenomena," for the ability of structures housing the EGTGCAIES and the system itself to withstand the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods, and GDC 4, "Environmental and Dynamic Effects Design Bases," for structures housing the system and the system itself able to withstand the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks. The EGTGCAIES is housed in a seismic Category I structure which protects it from the effects of tornados, tornado missiles, turbine missiles, and floods. The exposed portions of the system are also protected from tornadoes, tornado missiles, turbine missiles, and floods. This protection meets the positions of RGs 1.115, "Protection Against Low-Trajectory Turbine Missiles," Position C.1, and 1.117, "Tornado Design Classification," Appendix Position 13.

2. The applicant has met the requirements of GDC 5, "Sharing of Structures, Systems and Components," for the capability of shared systems and components important to safety to perform required safety functions. Each unit of the plant has its own EGTGs with an EGTGCAIES not shared between other EGTGs.

3. The applicant has met the requirements of GDC 17, "Electric Power Systems," for the ability of EGTGCAIES to meet independence and redundancy criteria. Each EGTGCAIES is independent and physically separated from the other system serving the redundant EGTGs. A single failure in any one of the systems will affect only its own EGTG. Each system is sized and physically arranged for no degradation of EGTG function when the EGTG must

operate continuously at maximum rated power output. The air intakes are located __ meters (__ feet) above plant grade and adequate filters are provided to minimize airborne particulate material (dust) from entering the system. Suitable design precautions preclude degradation of the EGTG power output due to recirculation of exhaust gases and ingestion of other adulterates that would reduce the oxygen content below acceptable levels. The applicant has also met the positions of NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability."

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action or information items relevant to this interim guidance.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this interim guidance in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

The provisions of this interim guidance apply to reviews of applications submitted six months or more after the date of issuance of this interim guidance, unless superseded by a later revision.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, GDC 2, "Design Bases for Protection Against Natural Phenomena."

2. 10 CFR Part 50, Appendix A, GDC 4, "Environmental and Dynamic Effects Design Bases."

3. 10 CFR Part 50, Appendix A, GDC 5, "Sharing of Structures, Systems, and Components."

4. 10 CFR Part 50, Appendix A, GDC 17, "Electric Power Systems."

5. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."

6. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability," University of Dayton Research Institute; UDR-TR-79-07; February 1979.

7. RG 1.115, "Protection Against Low-Trajectory Turbine Missiles."

8. RG 1.117, "Tornado Design Classification."