Radiation and Nuclear Safety Authority 127/0002/2016
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Guide YVL E.10, Emergency power supplies of a nuclear facility

1 Scope of application

Guide YVL E.10 is applied to safety class 2 and 3 emergency power supplies of nuclear facilities throughout their service lifetime. An emergency power supply comprises an emergency power machine, which is either a diesel engine or gas turbine generator, and the other related systems, structures and components that are needed in the emergency power generation of a nuclear facility in transient and accident situations.

2 Justifications of the requirements

The justifications of the requirements presented in the Guide are presented for each chapter and in so far as licensees have requested justifications when commenting the Guide or the requirements are otherwise presumed to need a more detailed examination.

2.1 Chapter 1 Introduction

The chapter presents the grounds for Guide YVL E.10 Emergency power supplies of a nuclear facility. The introduction makes references to the Nuclear Energy Act and STUK regulations on the safety of nuclear facilities and final disposal of nuclear waste and justifies the significance of emergency power supplies in the safe operation of nuclear facilities.

2.2 Chapter 2 Scope of application

The chapter presents the scope of the Guide and its interfaces with other guides. The Guide applies to safety-classified emergency power supplies throughout their service lifetime. This shall refer to the design, manufacture, installation, commissioning and operation. The Guide presents primarily requirements regarding emergency power machines set for licensees and operators belonging to the delivery chain of an emergency power machine, while the requirements pertaining to the other systems, structures and components of an emergency power supply at the system or component level are presented in their dedicated YVL guides.

2.3 Chapter 3 Safety analysis report and plan for principles

This chapter makes references to Guide YVL B.1 “Safety design of a nuclear power plant” with regard to preparing the preliminary safety analysis report (new construction of a nuclear power plant) and plan for principles (modification or replacement work of an emergency power supply) of the emergency power supply. Forward-looking design is emphasised in order for the system design to be, already in the preliminary safety analysis report and plan for principles, so far along that the design solutions of the emergency power supply’s structures and components would be recognisable for commencing basic design.

2.4 Chapter 4 Manufacturer

This chapter presents requirements for the emergency power machine manufacturer. The requirements generally aim to make the manufacturer understand the safety significance of the delivery. Another justification is to reduce the risk of the emergency power machine containing manufacturing defects that weaken operability and are not necessarily detected in inspections.

The management system of the emergency power machine manufacturer shall be appropriately certified and in Safety Classes 2 successfully certified for the nuclear industry. Appropriate certification shall refer to a situation where the certification body has been accredited against the requirements of standard EN ISO/IEC 17021 and the accreditation is covered by the Multilateral Agreements (MLA) entered into by FINAS. It is possible to deviate from the particular requirement regarding nuclear industry certification in a case where the management system is supplemented with a delivery-specific quality plan describing the procedures ensuring quality control.

If the emergency power machine manufacturer is not appropriately certified in Safety Class 3, the licensee may apply for approval for other management system assessment performed by an independent third party. The third party shall be an organisation independent of the emergency power machine delivery, design, manufacture and inspections. The preconditions and qualifications of the third party to assess the manufacturer's management system against the applied standard shall be assessed separately in connection with the processing of the construction plan.

2.5 Chapter 5 Design

The chapter presents the design requirements of emergency power supplies. The shared justification for all requirements presented in this chapter is the objective of ensuring that emergency power supplies operate in the required manner in situations where they are expected to operate. The design bases shall be specified to match the emergency power supply's performance requirements with the loads, stresses and conditions of the service place during normal operation and transient and accident conditions. Emergency power supplies still need to be designed and dimensioned so that the requirements set forth as design bases are met. In terms of design bases, references are made to Guide YVL B.1.

In the design of diesel engine generators, the reference standard is KTA 3702 (2014–11), "Emergency Power Generating Facilities with Diesel-Generator Units in Nuclear Power Plants". It is generally applied and also the only standard prepared for the emergency diesel generators of nuclear power plants. No nuclear-sector design standard is known for gas turbines. The design reference standard being applied is API 616 "Gas Turbines for the Petroleum, Chemical, and Gas Industry Services" which has been deemed as the most applicable. Even though this standard has been prepared for the needs of the petrochemical industry, the design requirements it contains to ensure performance are considered similar to those of a gas turbine to be installed as an emergency power machine of a nuclear power plant. Because API 616 does not cover a generator, the requirement level of KTA 3702 shall be applied for the design requirements of the gas turbine generator.

Justification for requirement 517, *starting an emergency power supply and connecting loads shall be possible during any loss of external electric power after the machine unit has been repaired or replaced*, has been separately requested in communication with licensees. An external electrical grid can be unavailable for a long period of time, e.g., due to an earthquake or storm. Power supply of rectifiers used for charging the batteries of battery-backed auxiliary systems of the emergency power supply is normally taken from a switchboard supplied by the electrical grid and emergency power supply. The batteries lose their charge, if power supply is lost for an extended period of time and starting the emergency power supply is unsuccessful. According to Guide YVL B.1, batteries supplying loads important to safety shall be dimensioned for a discharging period of two hours. This means that starting an emergency power supply and electricity supply to consumers would no longer be possible after two hours in a situation where the external electrical grid has been lost, even if the failure having caused the inoperability of the emergency power supply had been fixed. Therefore, in order for the emergency power supply to be available after a repair work when the external electricity grid is lost for an extended period of time, it shall be possible to prevent the discharging of batteries essential for the performance of the emergency power supply or the starting and connecting loads shall be independent of battery-backed electricity.

2.6 Chapter 6 Construction plan

The emergency power machine shall be designed and manufactured so that the design basis requirements are met, the demonstration of which is the ultimate purpose of the construction plan. By virtue of the Nuclear Energy Act (990/1987), the licensee is obliged to assure the safe use of nuclear energy and this obligation cannot be delegated or transferred to another party. In order to fulfil this obligation, a statement by the licensee on the acceptability of the emergency power machine (summary of justifications) shall always be appended to the construction plan. Based on the data of the construction plan, the licensee shall justify the abilities of the delivery chain and correspondence of the design input data to the service place as well as the conformity of the design and sufficiency of quality control.

The emergency power machine is considered as a diesel engine/gas turbine and a generator with its auxiliary equipment, but synchronising the processing of the mechanical components and electrical and I&C equipment or some other form of linking has proven impossible in practice. Therefore, contrary to the previous practice, the preliminary suitability assessments of electrical and I&C equipment, such as the generator, are not included in the construction plan of the emergency power machine and they shall be processed according to the submittal method and schedule specified in Guide YVL E.7 Electrical and I&C equipment of a nuclear facility. However, the mutual compatibility of the diesel engine/gas turbine and generator shall be demonstrated with an operability analysis (requirement 618a), which is appended to the construction plan and which includes the emergency power machine’s vibration and play analysis and possible strength analysis in an exceptional connection situation of the generator’s supply voltage.

According to requirement 611a the emergency power machine’s design bases shall be determined in the scope of the requirements that have been set for the emergency power machine’s operability in normal operation, during anticipated operational

occurrences, postulated accidents, design extension conditions and severe reactor accidents. Regarding emergency power machine's aforementioned service beyond normal operation (and conditions), the possible integrity and functionality requirements are determined both during and after such events.

Correspondingly, requirements 617 and 618 require a strength analysis of the force-transferring parts of both the diesel engine and gas turbine. The requirement is justified with reference standard KTA 3702, which requires the design and calculation of the diesel engine crankshaft according to the requirements of the classification society (IACS). The gas turbine shaft and blades are force-transferring critical parts analogically with the diesel engine crankshaft. Classification societies are not authorised inspection organisations, which STUK approves for the assessment of conformity, in which case the assurance of the classification society is not as such sufficient. In both cases, the strength analysis may be a dimensioning calculation based on an engineering standard, FEM analysis or some other report that allows the confirmation of the part's acceptable dimensioning.

The inspection plan determines the inspections and tests that are intended to be performed to the construction materials, parts and the finished component before its installation, and the inspection plan is an integral part of the construction plan. The requirements regarding the scope of the inspections and tests are based on standard KTA 3702, where the parts of diesel engine generators to be inspected are itemised in detail. The same principle is applied similarly in the quality control of the parts of gas turbine generators. Guide YVL E.10 no longer set additional requirements regarding inspection certificates in view of the above-mentioned reference standard. The reference standard does not require a delivery batch-specific reception certificate of "type 3.1" for all parts significant for the performance of the emergency power machine (SFS-EN 10204: A document issued by the manufacturer in which they declare that the products supplied are in compliance with the requirements of the order and in which they supply test results.). For some of such parts (e.g. suction and exhaust valves) a quality assurance of "type 2.1" based on a manufacturing method-specific inspection is sufficient (SFS-EN 10204: *A document in which the manufacturer declares that the products supplied are in compliance with the requirements of the order without inclusion of test results).* In that case, the risk of quality non-conformances increases, when the parts are not inspected delivery batch-specifically or there is at least no evidence of it, and the licensee's responsibility in procurement of parts complying with the requirements is emphasised. In the previous version of the Guide, delivery batch-specific certificate was required for all parts, the aim of which was to reduce the possibility of counterfeit products. Besides nuclear power plants abroad, suspected/detected counterfeit products or similar attempted deceits have started to emerge also in Finland. Licensees have, however, criticised a requirement level stricter than the KTA by invoking the poor availability of the parts in question with delivery batch-specific certificates and/or the price impact of the delivery batch-specific certificate.

2.7 Chapter 7 Type test

The conformity of the emergency power machine's design solutions shall be ensured by a once-only type test. The requirement is based on the fact that a type test is considered to be the most reliable method of demonstrating performance of a

functional component (such as an emergency power machine) according to its design requirements. The type test is needed because a routine factory test, which tests an individual emergency power machine to demonstrate high-quality manufacturing and assembly, cannot fully confirm the functional properties required of an emergency power machine. The type test of a diesel engine generator observes standard KTA 3702 and, correspondingly, the type test of a gas turbine generator observes standard “ASME Performance Test Codes 22”.

2.8 Chapter 8 Manufacturing

Requirements regarding manufacturing of an emergency power machine are presented in this chapter. In practice, it is not possible for STUK or an AIO to monitor the manufacturing of the emergency power machine’s structural materials or parts excluding exceptions. The requirements of the chapter are justified generally with the aim of ensuring manufacturing quality, which meets the requirements set for the emergency power machine and which simultaneously excludes at least such quality non-conformances that cannot be detected in the final inspections carried out by STUK or an AIO.

2.9 Chapter 9 Construction inspection

The construction inspection serves as the emergency power machine’s final inspection and this chapter presents the requirements pertaining to it. The construction inspection is an established practice for mechanical components with the aim of getting proof that the materials, manufacture, structures and operation conform to the approved construction plan (manufactured according to its design). In the inspection, the acceptability of the manufacturing result documentation is determined, inspections are carried out and tests are monitored in the scope of the inspection plan submitted together with the construction plan.

If the emergency power machine is repaired or parts (other than single-use wearing parts) are replaced due to faults or some other non-conformances detected during the factory tests, the factory tests shall be repeated. The requirement is justified with the fact that only final and fully successful factory tests provide the most reliable confirmation of the emergency power machine’s conformity. In the same connection, it becomes clear whether the repaired or replaced part is responsible for the detected issue or is the repair or replacement need a result of some other issue.

2.10 Chapter 10 Installation

The emergency power machine installation is comparable to emergency power machine manufacturing from the monitoring perspective. A plan (installation construction plan) and final inspection on the finished installation (installation construction inspection) are needed. Necessary instructions, drawings and inspection plan for quality control are appended to the installation construction plan in order to enable the acceptability assessment of the installation work in advance. The installation construction inspection makes sure that the installation work and its quality control have been conducted according to the construction plan.

2.11 Chapter 11 Commissioning

Requirements regarding the two-phase commissioning inspection of the emergency power machine are presented in this chapter. In the first phase of the commissioning inspection, the test run preconditions are confirmed by verifying that all the previous emergency power machine inspection phases have been successfully completed, the suitability assessments of the actuator have been processed as specified in Guide YVL E.7, the licensee has carried out its own inspections, etc. In this phase, the aim is no longer in performing inspections but only on becoming convinced that the emergency power machine is ready, short of a test run.

In the second phase of the commissioning inspection, the operability of the diesel engine generator is verified with a test run according to KTA 3702 (a commissioning test taking place at the nuclear facility). The test run of a gas turbine generator applies the principles of the same standard. Test runs are carried out according to a plan, the sufficiency of which has been confirmed in the first phase of the commissioning inspection. At the end of a successful test run, the emergency power machine is granted either a permanent or fixed-period operating licence. It is granted for a fixed period if, e.g., a test run phase cannot be completed until later and the emergency power machine is safe to operate despite this phase preventing the granting of a permanent operating licence.

2.12 Chapter 12 Operation, condition monitoring and maintenance

This chapter presents the general requirements that apply to the operation, condition monitoring and maintenance of the emergency power machine. The aim is that the emergency power machine is not subjected to unnecessary loading or unfavourable operating conditions. Moreover, the emergency power machine is serviced and its condition is monitored to a scope that the loss of the emergency power machine or weakening of its operability cannot cause a safety risk at the nuclear facility.

Emergency power machines in standby mode shall undergo regular inspections and tests especially in view of the targets and parameters that allow the confirmation of design basis operability. For this reason, condition monitoring and maintenance programmes shall be prepared for the emergency power machine’s periodic maintenance, inspections and tests. These programmes shall be based on applicable standards, manufacturer recommendations or the licensee’s own operating experiences or experiences gained from other nuclear facilities. They shall be regularly assessed and any observed needs for changes shall be analysed in the same connection.

The requirements regarding fuel of the emergency power machine are generally justified with the aim of ensuring that fuel/lubricant is suitable for the emergency power machine and that fuel remains serviceable when stored at the plant site.

A maintenance task not forming a part of the emergency power machine’s maintenance programme is considered repair work for which approval shall be sought with a repair plan and an inspection following its implementation. The repair plan shall include a procedure description, illustrative drawings and an inspection plan covering manufacturing, installation and commissioning. The repair plan and construction inspection are not required, if the repair work only involves the

replacement of parts to approved spare parts without any special processes or if the repair work is minor and targets emergency power machine parts insignificant for its operability.

2.13 Chapter 13 Modifications

Requirements regarding possible modifications of the emergency power machine are presented in this chapter. Typically, modifications impact the emergency power machine's performance or operability or the safety of the nuclear facility.

Modifying the structure or operation of the emergency power machine requires a systematic approach and comprehensive assessment of the impact of the modification. For this reason, approval for the modification design bases is applied with a plan for principles accordant with Guide YVL B.1 and for the modification implementation with a construction plan and construction inspection.

2.14 Chapter 15 Regulatory oversight by the Radiation and Nuclear Safety Authority

This chapter presents STUK and an AIO's regulatory activities concerning the emergency power machines of a nuclear facility (documents to be submitted and inspections to be carried out in the different phases of the emergency power supply's service lifetime).

3 International provisions concerning the scope of the Guide

- IAEA Safety Standards No. SSR-2/1, Safety of Nuclear Power Plants: Design (Vienna 2012).
- IAEA Safety Standards No. SSR-2/2, Safety of Nuclear Power Plants: Commissioning and Operation (Vienna 2011).
- KTA 3702 (2014-11), Emergency Power Generating Facilities with Diesel-Generator Units in Nuclear Power Plants.

4 Impacts of the Tepco Fukushima Dai-ichi accident

The Fukushima accident has no impact on the requirements of the Guide.

5 Needs for changes taken into account in the update

The needs for changes due to changes made to international and national laws/regulations and the change proposals made in connection with the preparation of the YVL Guide implementation decisions (SYLVI) together with others recorded in STUK's change proposal database have been considered when updating the requirements. In addition, the possibilities to reduce the so-called administrative burden have been considered.

The inspection responsibility of an AIO has been increased for emergency power machines. The division of inspection responsibilities regarding the emergency power machine, i.e. diesel engine and gas turbine generator, has not changed in the update of the Guide, but the increase in the responsibilities of an AIO can be seen in the new division of inspection responsibilities regarding the emergency power supplies' other

components, such as valves and pumps. Requirement changes regarding the emergency power machine itself are mostly specifications or moderations.