EU-APR Design in compliance with EUR Grid Requirement

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1. Introduction

European Utility Requirements (EUR) provides technical requirements for the generation III nuclear power plant in the European countries.

EUR grid requirements present the plant requirements to satisfy the needs of the grid network. The grid requirements are the precondition for the operation of a generating plant on the network.

This paper describes EU-APR design which has taken account of EUR grid requirements.

2. Voltage and frequency operation field

2.1 Rated frequency

The rated frequency of EUR grid requirement is 50 Hz. EU-APR on-site electrical power system was designed based on 50 Hz according to the European grid requirement. The 50 Hz frequency was applied to the main power system, auxiliary power system, DC distribution power system, and instrumentation and control power system of EU-APR.

2.2 Voltage-frequency field

The Voltage-frequency diagram which is suggested in the EUR grid requirement is shown as below.

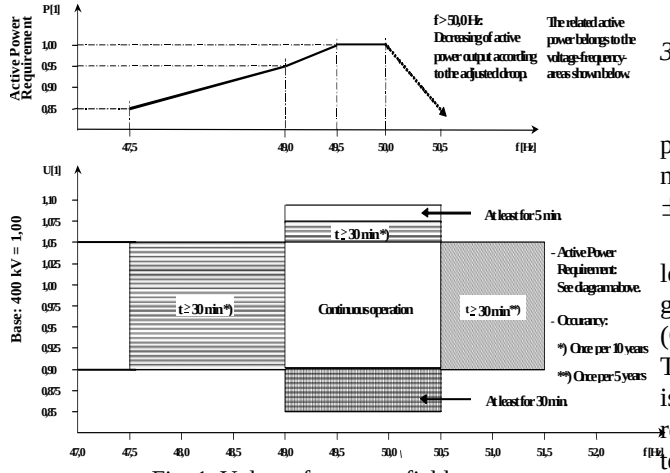

Fig. 1. Voltage frequency field

The EU-APR supply voltage variation at the motor terminals during normal operation does not exceed ±5% and the combined variation of the supply voltage and the supply frequency complies with IEC60034-1. The frequency ranges of IEC and EUR are in compliance.

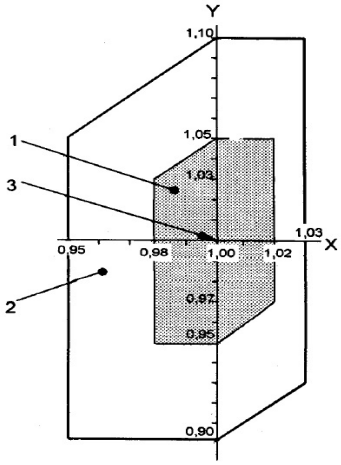

Fig. 2. IEC 60034-1 Voltage and frequency limits

The UAT, which is auxiliary normal transformer is equipped with automatic on-load tap changer. And the SAT, which is auxiliary standby transformer is also equipped with automatic on-load tap changer. So the voltage range can be achieved by on-load tap changers.

Considering the zone of operability defined by IEC60034-1, EU-APR voltage and frequency field is in compliance with the EUR requirement.

3. Load following capability

3.1 Primary control

Primary control means the automatic control of plant power according to the frequency variations of grid network. EUR requires the primary control range as ±3% of the rated power.

Primary frequency control has very fast and frequent load variations. If the control rods are moved during the governor free operation, mechanical wear in CEDM (Control Element Drive Mechanism) increase too much. Therefore, the control band of governor free operation is limited not to move the control rods. If the control rods are not moved with the load change, RCS temperature is changed to compensate the required reactivity change for power variation. Because the change in RCS temperature is limited by the LCO (Limited Condition for Operation) in Technical Specification, the control band of governor free operation is limited.

EU-APR was evaluated to have the primary frequency control capability of about ±2.5%, which is 2% at beginning of cycle (BOC) and 3% at end of cycle (EOC). The primary control is possible in a range between 50% and 100% Pr. So the EU-APR is capable of taking part in the primary control of grid supply.

3.2 Secondary control

Secondary control means the central control of selected regulating plants within an area according to the power variations of grid network. Participation in the secondary control is based on an agreement between the grid operator and the plant owner. EUR basically requires to allow the implementation of a secondary control.

The capability of secondary frequency control is limited by the PDIL (Power Dependent Insertion Limit) and by a concern on power distribution control. Because the operator action is not considered during the frequency control, control rod motion by the RRS (Reactor Regulating System) should compensate required reactivity change for load change. Deep insertion of control rods for larger load variation can cause the violation of the PDIL and xenon oscillation. It was evaluated that EU-APR has about ±5% secondary frequency control capability. So The EU-APR is designed to allow secondary control.

3.3 Daily load following

According to the EUR, the unit should be capable of daily load following operation in the range of output from 100% Pr down to the minimum load of the unit.

EU-APR daily load following capability is such as 10 to 16 hours (100%) - 2 hours (100%-50%) - 4 to 10 hours (50%) - 2 hours (50%-100%).

The NSSS (Nuclear Steam Supply System) design of the EU-APR has been designed to accommodate a 100-50-100% power daily load cycle operation without initiating a reactor trip, without opening primary and secondary safety valves, and without initiating an engineered safety features actuation system.

4. Conclusions

In this paper, EU-APR designs according to the EUR grid requirements were described.

EU-APR was designed in compliance with the voltage and frequency operation field and also designed to have the capability of load following such as primary control, secondary control, and daily load following.

Consequently, the EU-APR design according to the EUR grid requirements is expected to get competitiveness and enhance the license feasibility in the European nuclear market.

ACKNOWLEDGMENT

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