Summary Review of Responses to Questionnaire on The Effect of Network Considerations on the Design of Large Turbine Generators

Working Group A1.01.4
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Introduction

The questionnaire was developed in response to suggestions made at the 1999 meeting of the then Equipment Group 11.01 in Orlando and combined ideas from two contributors. The first was for a questionnaire on the subject of the effect of special operating regimes on generators connected to the network, and the second was to investigate the economic and technical relevance of turbine generator design parameter specification based on grid considerations. The members of the equipment group felt that as the two subjects have much in common; a single questionnaire would cover both proposals.

Following presentation at the meeting of the equipment group in Paris 2000, some small modifications were made and the questionnaire issued for comment shortly afterwards.

Part I of the questionnaire looked at the effect of any mandatory design requirements imposed by system operators, such as reactance limitations, off-frequency operation, etc. Part II was intended to ascertain the effect of any special operating regimes such as two-shifting or load following on the generator design. Although considered, questions regarding the effect of specific loads on generator design were not included in the questionnaire because the members of the equipment group felt that previous questionnaires had adequately covered these aspects.

Responses received

A total of 10 separate responses were received and, despite clarification at the meeting in Sweden in 2001 and subsequent reissue of the questionnaire, some responses contained inconsistencies and contradictions. Responses were received from seven countries with multiple responses from Canada. One response (CA h) was received that is biased to hydro-generators rather than to turbine generators. This has, however, been included in view of the general interest of the topic.

At the meeting of EG A1-01 in Paris 2002, the group decided that in view of the small number of responses and the limited amount of information gathered, the results of the questionnaire did not meet the requirements for publication in Electra. In order to maximise the value of the questionnaire it was decided to make a review of the responses for circulation so that non-responding member countries could still provide input.

Responses to Part I – Mandatory Design Requirements of the System Operator

Section 1.1 - Limitations on reactance/SCR
The responses indicate that, as expected, reactance limits affect the normal design of generators and impact both technically and financially. A majority of responses indicated that the normal solution to reactance limits was to use a larger frame than otherwise necessary. Other design changes mentioned were changes to stator and rotor windings or to the stator core. It was interesting that half those responding did not use standard reactance values if limitations were not imposed. There was an unfortunate typing error in this section of the questionnaire where ISO was used instead of IEC and this may have caused some confusion.

Section 1.2 – Long-term off-frequency operation
Approximately 70% of the responses indicated that there was no requirement for such operation. Where it was encountered it was dealt with by the use of a larger frame, operation at class F temperature rises, or unspecified custom design changes.

Section 1.3 – Short-term off-frequency operation
In contrast to long-term off-frequency operation, 60% of the responses indicated that short-term off-frequency was needed. Again this was dealt with by using a larger frame or operation at class F temperature rises. In addition, one country used limits on load and voltage during short-term off-frequency operation.

Section 1.4 – Operation away from nominal voltage
Only 30% of responses indicated using on-load tap-changers on GSUs. The usual method (75%) of dealing with changes of system voltage in the absence of on-load tap-changers is to allow the generator terminal voltage to be outside the IEC +/-5% limits.

Sections 1.5 & 1.6 – Reactive power capability
All responses indicated the dependence of generator design on specific power factor requirements. (The one apparently dissenting response is in fact in agreement.) All responses also indicated the effects to be both technical and financial, and the use of a larger frame than otherwise necessary was the preferred solution in 87% of the responses. Only one of the two responses indicating that other design changes may be necessary specified that modifications to the end-region would be used to improve operation at leading power factor, and that improved rotor cooling would be used to improve operation at lagging power factors.

Only 30% of the responses indicated that specific reactive power requirements were encountered at reduced loads, and of these 67% also encountered such requirements at reduced stator voltage. No information was provided about any design modifications necessary to meet these requirements.

Section 1.7 – Requirements for excitation systems
In view of the extensive performance requirements often specified for excitation systems, this section was included in the questionnaire to ascertain the impact of such requirements on the design of the generator as opposed to the design of the exciter and excitation system. Ten responses were received of which five indicated that the generator design was affected. One response was invalid (possibly as a result of misunderstanding the question) and the other four indicated that the requirements might impact on the design of the generator rotor in terms of turns/pole, insulation level and overall length.

Responses to Part II – Special Operating Regimes

Section 2.1 – General
Special operating regimes are encountered by 78% of the respondents with 57% stating that generators are not normally designed for two-shifting.

Section 2.2 – Two-shifting
Two-shifting is encountered by 86% of the respondents with 83% stating that this requires special design features such as improved support for the windings (bracing and connections) and improved provision for expansion. Note that of the two responses to section 2.1 indicating that generators are not normally designed for two-shifting; one states that two-shifting is encountered but does require special design features!

Section 2.3 – Load following
Load following is encountered by 78% of the respondents but all agreed that no special design features are required.

Conclusions

In general, the responses to the questionnaire indicate that although network considerations do affect the design of turbine generators, the necessary changes are basically those expected.

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