A Method of Parsing Based on Improving the Electricity Behavior and Regulating Excitation System of the Diesel Generating Set in the Nuclear Power Plant

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Abstract: This paper introduces an applicable test plan for emergency diesel generator in nuclear power plant. It advances improvement approaches with problems found during field commissioning test and its trouble-shooting processes. The method is based on the integration of complementary through, the extension theory of matter-element model and neural network theory combine to overcome a neural network to learn shelters, and other defects. The purpose of this paper is to provide the better running and commissioning experience for the similar emergency generator unit.

Keywords: Nuclear Power Plant; Emergency diesel generator unit; Commissioning; Operation

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1. Introduction

In Nuclear Power Plant (NPP), emergency diesel generator provides emergent AC power with automatic quick startup and power loading per pre-settings. Each unit of NPP is configured with 2 independent diesel generators. In the emergency of power loss of Main Transformers and Auxiliary Transformers, the diesel generators are designed to provide power for safety relevant equipment and equipment fed by 1E class in order to maintain the integrity of primary pressure boundary and to prevent radioactive leakage. Therefore, the emergency diesel generators play a vital role in the protection of fuel elements and nuclear safety.

The improvement approaches explained in this paper are expected to enhance the power quality of power loadings in emergency and to provide technical references as to import similar emergency diesel generators from abroad.

2. Emergency diesel generator commissioning

2.1 Generator short-circuit characteristic test

1) First, choose the short-circuit point inside the breaker cabinet of the output of the generator;

2) During this characteristic test, all low voltage protection shall be disenabled, gradually increase the exciting current and check the TA change at the generator and the

neutral point to ensure the primary current of the generator is between 5% and 10% of rated current;

3) Current relay verification. Gradually increase exciting current till relay actions and generator is stopped. Meanwhile, ensure the TA current relay is short-circuited, and verify the recorded action values versus setting values;

4) Modify the protection settings in a periodic manner to ensure the values are equal to rated current of the generator;

5) Extract the short-circuit characteristic curve and compare it with the curve generated at factory test. The curves should have the similar trends;

6) In the process of exciting current increase, verify the return values with over-current protection;

7) Verify the parameters of current measurement cards and ensure they are consistent with generator running parameters.

2.2 AVR test in rated speed and no-load conditions

It is not difficult to test Automatic Voltage Regulator (AVR) in rated speed and in no-load condition, and the only verification is the voltage pre-settings. For voltage regulation range, both manual and automatic modes should be checked. Restore the AVR into normal conditions and conduct the swap test from manual to auto and from auto to manual.

2.3 Generator open-circuit test

1) In open-circuit test, gradually increase the voltage up to 10% of the rated voltage and disenable all low voltage and over voltage protections in the cabinet. Check the TV trends at the generator side;

2) Extract the open-circuit curve and compare it with the factory test curve on the basis of the value changes of the curves. The test curve should match the factory test; 3) Modify the exciting current and verify over current/ low voltage protections to ensure the relay actions are qualified;

3) Modify the exciting current and verify over current/ low voltage protections to ensure the relay actions are qualified;

4) Modify the speed rate, verify over frequency/ low frequency protections and observe the relay action signals;

5) Verify the parameters of AVR stator voltage measurement cards and ensure all parameters are acceptable.

2.4 Synchronization test

Synchronization test, as one of significant parts for emergency diesel generator test, it includes the following steps:

1) Phase check: The phase check has two categories: same power supply and different power supply. In the term of same power supply, it means 1E and non-1E class equipment are fed by the diesel generator or normal power supply. In the phase check with the same power supply, instrument indications related to synchronizer and relevant input parameters should be checked. On the other hand, the different power supply refers to that 1E class equipment is fed by emergency diesel generator and non-1E class equipment by offsite power.

2) In general on the consideration of auxiliary transformer power supply, the output cable will be removed for the phase check with same power supply. It is easier to implement. However, without the auxiliary transformer power supply, procedure startup and synchronization will be more or less affected. The emergency diesel generator should be connected to non-1E equipment bus following system stable running and bus voltage phase check in order to meet the cooling requirements of diesel generator, and the power later should be fed to auxiliary transformer. This method provides more reliability for system running or later overhaul.

3) Synchronization dry-run: It includes the manual and automatic synchronization dry run for normal offsite power incoming breaker and diesel generator output breaker. The purpose of this dry-run is to test breaker close circuit and its frequency difference, angular difference and pressure difference and such electrical parameters.

4) Synchronization test:

(1) Manual synchronization: i. Check the voltage loop of increase/decrease speed and increase/decrease stator; ii. Adjust speed and stator voltage to make both higher than system voltage, and observe the whole step meter pointer to start the synchronization in an earlier angular; iii. Record the time from diesel generator startup till it reaches the rated voltage. Startup time shall no more than 10 seconds and the interval between startups shall be no less than 20 seconds. It shall be stopped if the diesel generator fails to be started three times in successive and the trouble-shooting shall be conducted; iv. Check the instruments readings such as oil pressure, water temperature and power charging and be careful of abnormal noises. Stop the generator immediately if abnormal conditions are found; v. Verify the MCR graphics.

(2) Automatic synchronization: i. Check the synchronization loop; ii. System is placed into automatic syn-

chronization, and observe its progress and loading after synchronized; iii. Decrease the diesel generator frequency to check the reserve-power protection; iv. Check loss excitation protection through the decrease of excitation.

2.5 Load test

Increase the loading of step-load after synchronization, and record coil temperature, power factor and stator voltage after loading.

2.6 Sudden load change test

The purpose of this test is to verify the performances of the generator and speed regulating system. It is a significant test for the reliability of the diesel generator. The elements of this test are to understand the required abundant loadings to make generator steady running. The followings shall be checked during sudden load change test.

1) Check the running conditions of diesel generator via instrument indications such as oil pressure, water temperature or charging and be careful of abnormal noises. Stop the generator immediately if abnormal conditions are found;

2) Measure the loading current of diesel generator and check its heating conditions;

3) Check the operation of mechanical components such as leakage of cooling water, fuel oil, air ventilation or fan ducts.

4) The generator shall be running no less than 10 minutes in loading. Stop the generator as it reaches full loading. First unload the generator step by step and make the generator running for 3-5 minutes in idle speed to ensure components are fully cooled. Stop the generator as the temperature of all components are almost same.

2.7 Low-excitation test

After synchronization, gradually decrease the exciting voltage till low-excitation signal is triggered and exciting voltage or reactive power cannot be lowered. Record AVR power in active power and reactive power (low-excitation) and compare them with settings. The recorded values shall be close to the settings.

3. Trouble-shooting and improvement

3.1 Generator cannot be started

Trouble-shooting: Disassemble the generator and small amounts of diesel was found in oil pan after removed the air cylinder cap. Analysis: The oil level in fuel oil tank is 1400 mm, and spray is at 1260 mm. This generator uses V shaped twin-six engines. If the spindle rotates 720°, all twin-six engines finish one stroke and every 60° there is one air cylinder is making one stroke. In this case, as the generator is stopped, there will be one spray is at open position. In addition, if the solenoid valve is not tightly sealed, diesel will be brought into combustion chamber through PT pump or spray. Due to the big gap in piston rings the diesel goes into the oil pan. Suggestion: Decrease the fuel oil level in accordance with the height of main oil tank. Check the oil level, water level in cooling tank. Check the water temperature readings, and oil pressure readings after generator started and record all readings.

3.2 Improve exciting system

Through TA ratios, installed phase, input current polarity, voltage input signal phase, voltage pre-settings and control logic of excitation switch, interface and excitation are improved for different operation status. Original plan: In order to provide a steady voltage after loading of diesel generator, the difference coefficient is zero in normal startup or in emergency. The deficiency is reactive power is not steady after synchronization. In the fluctuation of system voltage, reactive power increase or decrease will be determined by emergency diesel generator. In this scenario, over-loading trip event cannot be avoided after synchronization and loading. Suggestion: Improvement is required for automatic voltage regulation system. Improved plan: the working conditions for AVR are separated into synchronization running and emergency running with loads.

4. Conclusion

The electrical features and excitation regulation system of emergency diesel generators are both enhanced and the capacity of system running in loading is also strengthened after improvement as stated above. It is hoped that the improvement plan will bring benefits for emergency diesel generator commissioning activities.

References

[1] GB 50150-2006. Standard for hand-over test of electric equipment electric equipment installation engineering[S]. (in Chinese)

[2] Northwest Engineering Institute, Electrical Power Engineering Manuals prepared by Hydraulic and Electrical Power[M] (Beijing: China Electric Power Press, 1989), pp.24-29. (in Chinese)

[3] Component procedure of molded case circuit breaker and motor over-loading relay (Company owned procedure). (in Chinese)