A study on the overhaul method for a Tandem type EDG

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1. Introduction

An Emergency Diesel Generator (EDG) manufactured by a French company Wärtsilä SACM, is a tandem type engine, consisted of two 10 cylindered diesel engines on each side. Manual provided by the manufacturer states that engine bearing requires inspection every 15 years. However, it is difficult for an inspector to access through a manhole located in the lower compartment of engine. Furthermore, during a routine or scheduled maintenance, it is not possible to disassemble main engine bearing and crank shaft, and perform inspection. Two methodologies are suggested here to resolve the problem. One method is to lift the engine and partially perform the maintenance service, and the other method is to disassemble the engine completely and to perform maintenance service by the manufacturer. Pros and cons of two methodologies were thoroughly compared.

2. EDG related regulation requisite(Tech. Criteria)

Electrical system of a Nuclear Power Plant (NPP) has to satisfy 10 CFR 50, General Design Criteria 2, 4, 5, 17, 18 and 50 of Appendix A. EDG and spare AC power supply have to satisfy 10 CFR 50.63 (Loss of all AC power supply), NUMARC 87-00 (rev.1), Reg. Guide 1.155 (on-site blackout), Reg. Guide 1.9 (Inspection and test of electrical system). Other tests

3. Failure type of NPP EDG main system components and issues on long-term operation

3.1 Failure type of EDG main system components

- Diesel engine system: Crank shaft damage due to crack in cylinder etc.
- Generator system: Generator output delay due to delay in electrical speed regulator etc.
- Fuel system: Ventilation pipe overheating due to injection pump plunger abrasion etc.
- Lubrication system: Low level of lubrication storage tank and temperature rise of lubrication oil etc.
- Coolant system: Coolant temperature rise due to damage of cooler fan belt etc.
- Starting air system; Damage of starting air vale due to inflow of impurities etc.
- Suction/Ventilation system: Damage of charger due to inflow of impurities etc.
- Exciter and Voltage control instrumentation system: deterioration of opening coil etc.

3.2 Issues on long-term operation of EDG

The manual provided by the manufacturer states that engine bearing should be inspected every 15 years. The main engine bearing requires inspection for a tanden type EDG and maintenance, since the engine may experience overwork due to quick initial load escalation during EDG quick start-up monthly test. In addition, any one of 24 engine bearings of each EDG should fail the operation of engine itself is impossible. Thus, thorough maintenance service is essential. The configuration of the engine prohibits from the exterior inspection and bearing disassembled inspection during routine or scheduled maintenance. This is because there is no manhole in the lower compartment of engine. According to the manufacturer's manual, in order to replace the bearing, all parts except for the engine body, in other words turbocharger, cylinder head, fuel pump etc., should be first removed, lift the engine, and turn the engine 180 degrees forward, backward and sideways(cf. figure 1). Therefore, the maintenance can easily necessitate a long period of time, and it may become a birden to the plant outage maintenance.

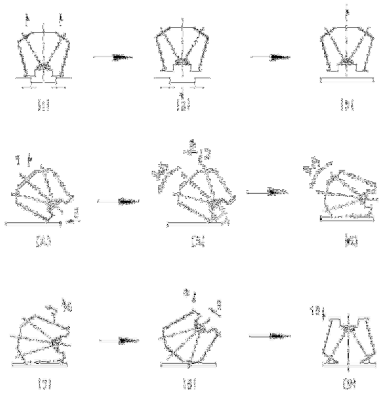

Figure-1 Engine Turn-over Procedure

4. Recommendation on engine maintenance from the manufacturer

The possibility of engine bearing abrasion is high for NPP EDG, since it experiences quick startup and quick load escalation test. At the same time the reliability of equipment respect to loss of off-site power should be high. It is recommended that in case of SACM engine, the engine requires overhaul in factory by over-turning method every 15 years. Especially, components with high influence on engine reliability, such as engine main bearing and crankshaft damper, require thorough overhaul. For the engine maintenance methodology, off-site complete disassembled maintenance was suggested, which is to remove the engine from site to

perform the maintenance service in a factory. Estimated service time is about 75days.

5. Issues on maintenance method suggested by the manufacturer

The cost of complete disassembled maintenance of one set of engine, offered by the engine manufacturer, is very high. This is because it is necessary to buy a set of spare engine to replace the existing engine, since the existing engine needs to be removed from the site for the maintenance service. Following processes, engine removal, shipping, complete disassembled maintenance, performance test, placing back of the engine and so forth require over 6 months, which is substantially long period of time. In addition, the generated cost from sea or land transportation to transport the engine for the maintenance is significant, and any accident during the transportation process makes the methodology even less attractive. Suggested category of the complete disassembled maintenance by the engine manufacturer is re-qualification level, which the range of main component replacement will be increased extensively. This will in turn generate more cost, and the independence of domestic engine complete disassembled maintenance technology will not be achievable. Therefore, our dependence to the manufacturer will increase and monopoly will likely to be established. This results in less effective response to the EDG operation during an emergency situation or when need of emergency maintenance rises.

6. Study on optimized maintenance method through engine lifting

This study shows that it is possible to perform the maintenance service without any major difficulties, when the upper compartment of the engine is lifted from the floor for approximately 1m.

Major procedures for engine lifting maintenance are as follows.

○ Reinforce the engine lifting crane or chain block.
○ Remove accessory equipments located in upper part of the engine or interfering pipeline/support with the lift.
○ Remove removable interior parts, such as engine cylinder block.
○ Unbolt the engine bed base bolt to separate the engine body from the engine base.
○ Slowly and steadily lift the engine while placing support, such as square bars, under the engine.
○ After the completion of the lifting, rest the engine on the support, and install crank shaft support loosely under the crank shaft.
○ Unscrew the first inspection part, main bearing support nut, and disassemble radial support lock nut or locking key to take the lower main bearing to the off-site, and perform inspection and maintenance.
○ Wrap wires around the upper compartment, push downward, and rotate upper main bearing towards radial direction of the crank shaft and lower compartment to take it out and bring it to the off-site to perform inspection and maintenance.
○ After placing upper and lower bearings on proper position, fasten the radial support lock nut or locking key by applying appropriate torque.
○ Tighten the main bearing support nut with appropriate torque.
○ Sequentially perform offsite inspection and reassemble the main bearing.

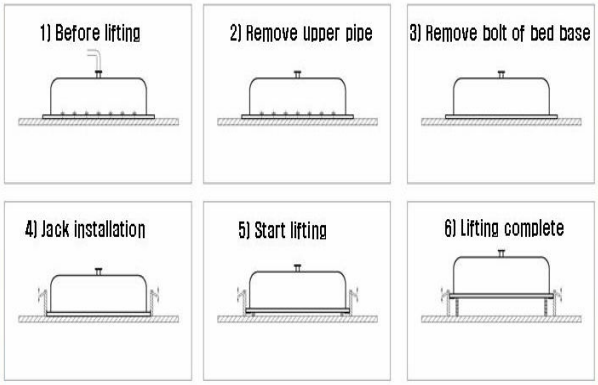

Figure-2 EDG Lifting Maintenance Procedure EDG

7. Conclusions

Currently the tandem type EDG receives maintenance during routine scheduled preventive maintenance, which even involves replacing some parts, except for maintenance requires for lifting or moving of the main engine body. Therefore, considering limited scheduled preventive maintenance period, we investigated partial inspection of the item difficult to inspect through lifting the engine. The item shown here as an example is the engine bearing. This method is attractive since it does not require a spare engine, additional inspection or performance test facilities and so forth, which reduces the cost and duration. However, we will investigate further if this methodology is viable during the plant routine scheduled preventive maintenance period, and if it is possible to obtain maintenance confidence in inspection and quality assurance though this method.

References

[1] Korea Hydro & Nuclear Power Co., Final Safety Analysis Report of Younggwang 3 and 4 units
[2] Investigation Report on Optimized Maintenance of Younggwang 3 and 4 units Emergency Diesel Generator 2007. 9