Development of Reliability Monitoring System for Emergency Diesel Generators

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ABSTRACT

This paper describes Reliability Monitoring System (RMS) which has been developed to evaluate and monitor the reliability of emergency diesel generators (EDGs) in Yonggwang Units 3&4. The program of RMS is designed with three modules: Reliability Monitor, Reliability Evaluator, and Availability Evaluator. RMS will be utilized as a part of reliability program that implements effective root cause analysis of all EDG failures and that is designed to monitor, improve, and maintain reliability at selected levels according to Regulatory Guide 1.9 Rev. 3.

1. Introduction

Emergency Diesel Generators (EDGs) are used to provide on-site power to emergency safety systems during losses of off-site power. There is a need for a high level of reliability in these systems, and because of this, there is interest in developing reliability program designed to maintain and monitor the reliability level of each power source over time for assurance that the selected reliability level. To meet the current necessity of improving the reliability of EDGs, a project, "Development of reliability program for emergency diesel generators of Yonggwang units

1,2 & 3,4″, has been started in Oct. 1997. The objective of the project is to mitigate the EDGs surveillance test interval and method by developing reliability program. As a product of the project, Reliability Monitoring System (RMS) has been developed to evaluate and monitor the reliability of emergency diesel generator according to NUMARC 87-00 Rev. 1[1] approved by U.S. NRC.

2. Description of RMS

RMS is a web-based intranet program for the evaluation and monitoring of the reliability of emergency diesel generators in Yonggwang Units 1,2 & 3,4. It can be accessed by site engineer in Yonggwang Nuclear Power Plants (NPPs) using web-browser such as Internet Explorer and Netscape Navigator. There are three modules in the program: Reliability Monitor, Reliability Evaluator, and Availability Evaluator. 1) Reliability Monitor module has two menus, one is Target Reliability Monitor in which target reliability of EDGs is monitored by trigger values and the other is Test Interval Guidance in which test intervals of each EDG are guided by the failure numbers out of the past 25 valid demands. Through 2) Reliability Evaluator and 3) Availability Evaluator module, the reliability and availability of EDGs is calculated, and these results are displayed into a chart showing the trend of reliability and availability.

2.1. Development environment and tool

The development environment of RMS is Windows NT Server 4.0 for the operating system and MS SQL Server 6.5 for the database server. And MS Visual InterDev 1.0 has been used for the development tool aiding in coding of web-based RMS program. Finally the developed program has been serviced through IIS (Internet Information Server) working in the operating system. This systematic configuration of the development environment is shown in Fig. 1.

If a user intend to know the information on EDGs or intend to analyze EDGs' reliability: first step, send a request to Web Server (IIS) using Web browser, second step, the request is processed by the Active Server Page Scripting technique in the Web Server and then the processed request is delivered into database, third step, MS SQL Server process the request again and the result records are returned to Web Server, forth step, the results are transformed into

HTML (Hypertext Markup Language) which is readable language in Web Browser and then the transformed results are delivered into Web Browser, finally, a user can obtain the results in the Web browser screen.

2.2. Reliability Monitor

If a new failure of EDG break out, it is a good thing to evaluate whether EDG's reliability are maintained within the target reliability level or not. This work can be performed by RMS, especially in the Reliability Monitor module in which two menus are laid for its own function. The first menu is Target Reliability Monitor and the second is Test Interval Guidance. Before we analyze the target reliability of EDGs using RMS, target reliability level of EDG must be determined, because the target reliability is monitored by trigger values which are different according to target reliability levels. So, we have evaluated the target reliability of Yonggwang Units 3&4 by Regulatory Guide 1.155[3]. As a results of evaluation, it was found out that we were able to select freely 0.95 or 0.975 for Yonggwang Units 3&4. If we select the 0.95 as a target reliability, the trigger exceedence values are 3, 5, and 8 which means the failure numbers out of the past 20, 50, and 100 demands, and if we select the 0.975, the trigger exceedence values are 3, 4, and 5, these values are shown in Table 1.

Now we can analyze a new failure using RMS; 1) Input the data such as target reliability and EDG to be analyzed through the pop-up sub-screen that is showed up when the Target Reliability Monitor menu is selected, 2) then final results are displayed in the web-browser screen like as shown in Fig. 2. In a case of Yonggwang Units 3&4, the EDG of AAC is shared with both units, so the failure numbers are counted as a summation of all EDGs' [1], these are from train A, B of an Unit, and AAC. Additional action items according to exceedence trigger values are also showed in the screen, it provide the plant personnel with a guide: what they should do to maintain or retrieve the target reliability level when a new failure break out.

Test interval of each EDG can be guided by the number of failures out of the past 25 valid tests through the Test Interval Guidance menu. If the failure numbers is equal to or larger than 4, the surveillance test interval is accelerated into seven day.

2.3. Reliability evaluator

Reliability of EDG can be evaluated in the Reliability Evaluator module, and it is defined as a product of start reliability and load-run reliability according to NSAC-108[4] approved by Regulatory Guide 1.155. The start reliability is defined as a ratio of number of successful starts to total number of valid demands to start, also the load-run reliability is defined as a ratio of number of successful load-run to total number of valid demands to load. The Reliability data of Yonggwang Units 3&4 have been collected from the surveillance test log sheet, and the data have been filed up into the MS SQL Server 6.5.

When the information for EDGs is selected through the pop-up sub-screen, the results of reliability are displayed in the web browser screen as shown in Fig. 3, also in the figure the results are plotted in a line that showing the trend of reliability.

2.4. Availability evaluator

Availability is calculated from unavailability, and unavailability is defined as a ratio of unavailable time to EDG required time that the EDG should be available. Unavailable time is calculated from the maintenance history data and surveillance test data. If the maintenance of a EDG is conducted under the maintenance mode, the EDG will not be operable. Then this working time is counted as a unavailable time. When a failure break out during surveillance test, potential failure of a EDG should be taken into account as a unavailable time, that is a half of surveillance test period. As all cases of unavailable time are counted, finally unavailability can be evaluated.

Availability and unavailability are easily calculated in the Availability Evaluator module like as shown in Fig. 4 according to the methods described above. Availability of EDG is very useful for the reliability management of EDG, because it show the actual condition of EDG in point of reliability.

3. Conclusions

Reliability Monitoring System (RMS) has been developed to evaluate and monitor the reliability of emergency diesel generator in Yonggwang Units 3&4. The program of RMS was designed with three modules, those are Reliability Monitor, Reliability Evaluator, and Availability Evaluator. In the Reliability Monitor module, target reliability of EDGs is monitored by trigger values and surveillance test interval is guided. In the Reliability and Availability Evaluator module, the results and trend of reliability and availability of EDGs are evaluated and displayed. RMS will be utilized as a part of reliability program that implements effective root cause analysis of all EDG failures and that is designed to monitor, improve, and maintain reliability at selected levels according to Regulatory Guide 1.9 Rev. 3.

References

[1] NUMARC-8700 Rev. 1, "Guidance and Technical Bases for NUMARC Initiatives Addressing Station Blackout as Light Water Reactors", , NUMARC, Aug. 1991.

[2] Reg. Guide 1.9 Rev. 3, "Selection, Design, Qualification and Testing of Emergency Diesel Generator Units Used as Class 1E Onsite Electric Power Systems at Nuclear Power Plants", U.S. NRC, 1993

[3] Reg. Guide 1.155, "Station Blackout", U.S. NRC, June 1998

[4] NSAC-108, "The Reliability of Emergency Diesel Generators as U.S. Nuclear Power Plants", EPRI, Sep. 1986.

Table 1
Exceedence trigger values

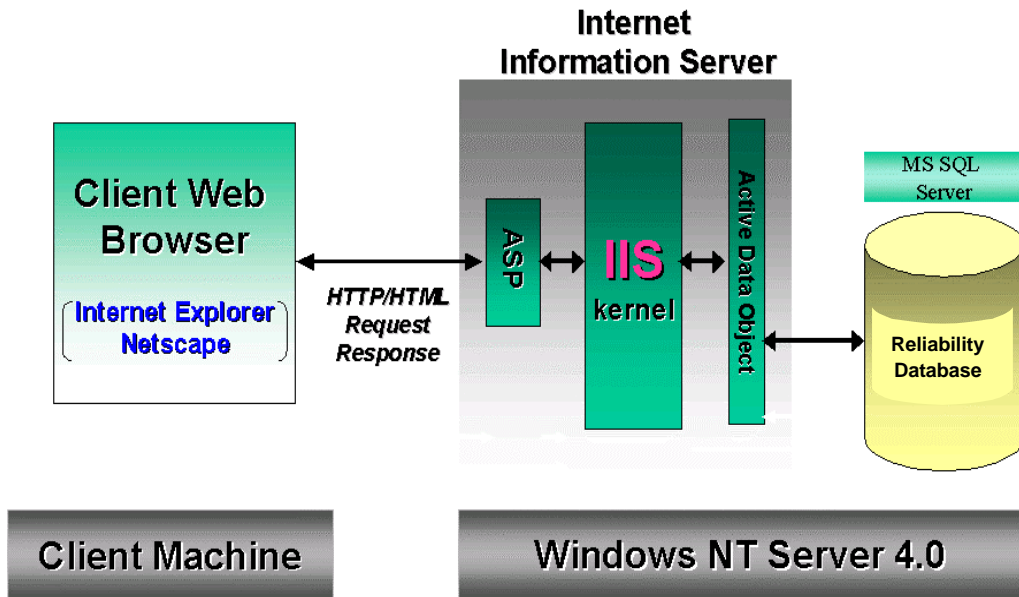| Selected Target Reliability	Failures in 20 Demands	Failures in 50 Demands	Failures in 100 Demands
0.95	3	5	8
0.975	3	4	5

Fig. 1 Systematic configuration of the development environment

Fig. 2 A screen of Target Reliability Monitor module
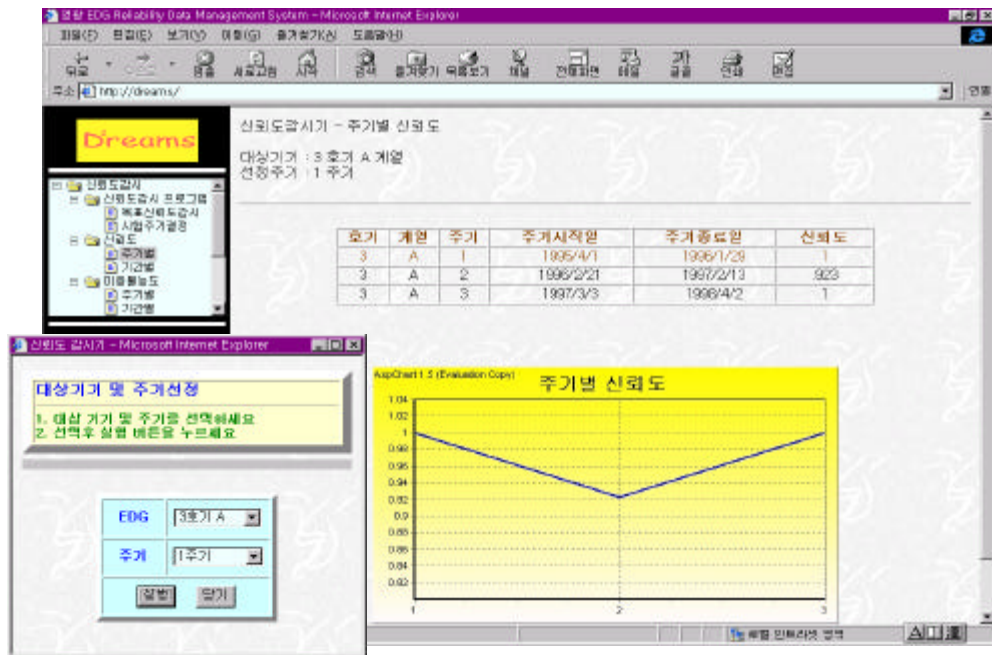
Fig. 3 A screen of Reliability Monitor module

Fig. 4 A screen of Availability Monitor module