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Introduction of OFS System for CANDU Spent Fuel Verification

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1. Introduction

In CANDU, spent fuels are discharged 16~24 bundles everyday from a reactor core, which are to be verified during the PIV by the IAEA.

For the present, the agency uses the CANDU Bundle Verifier for Stacks (CBVS), or Spent Fuel CANDU Verifier (SCAV). It consists of a CZT gamma spectrometric probe that moves vertically along the space in between the columns of trays. This CBVS is unable to verify the spent fuels at the bottom layer of a stack due to limited accessibility of a large size detector through the funnel structure. In addition, the large size of piping sensor is heavy and difficult to handle.

The use of optical fiber scintillator for CANDU spent fuel verification has a benefit to detect gross gamma rays in storage ponds without the hindrance by the funnel structure. Since the optical fiber scintillator is excellent to radiation hardness and is able to withstand high temperature and humidity, more precise and safe measurement is possible in between bundles of tray. To have a better knowledge of OFS system performance, the field test was being performed at Wolsung NPP (Nuclear Power Plant) pond storage area. This system will be registered for IAEA's verification equipment (Category A) by following the IAEA QA procedure. Currently, KINAC/IAEA developed the user, functional requirement and design specification for System, hardware and software separately. It will be using for verification of spent fuel in lieu of CANDU Bundle Verifier for Stacks (CBVS) after the procedure accede to IAEA terms.

2. Methods and Results

2.1 Configuration of Optical Fiber Scintillator System

A schematic of the OFS system is shown in Figure 1. It consists of an optics detector with passive fiber cable in 1 mm diameter, a Photo Multiplier Tube (PMT) module, electronic equipment, a scanning system and data acquisition software.

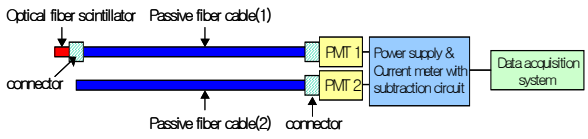

Figure 1. A spent fuel verification system using optical fiber scintillator.

The end of optical fiber places inside of a gap about 1.5 cm between bundles in tray. The OFS system measures the gross gamma intensity as a function of vertical position by scanning the storage stack without moving the tray.

Newly designed OFS system has been based on three principles of functional and user requirement; compact, user friendly and easy handle to decommission for system. First, they are compact less than 40 kg of total weight, furnished a knob for easy handling, and moved simply by a firm wheel. Secondly, they are manually handled a rolling position (X,Y), automatically loading the sensor to vertical direction of the target position, and sustained structure with bridge for no vibration.

2.2 Graphic User Interface (GUI) Software

The developed Graphic User Interface (GUI) Software focused on two main concepts, (1) Store the inspected information and results correct. (2) Help inspector to judge the verified results easy.

Figure 2 shows the several sample windows of the developed graphic user interface software. The initial communication status displayed a color of lamp when green is normal and red is abnormal at each case as shown in figure 2(a) and 2(b) respectively. Notice window pops up when abnormal communication status happens in figure 2(c). After checking the communication status, the window of inspection information shows items. It configures with 13 items that included inspection number, facility name and code, MBA code, item ID and number of declared bundle layer etc. as shown in figure 3.

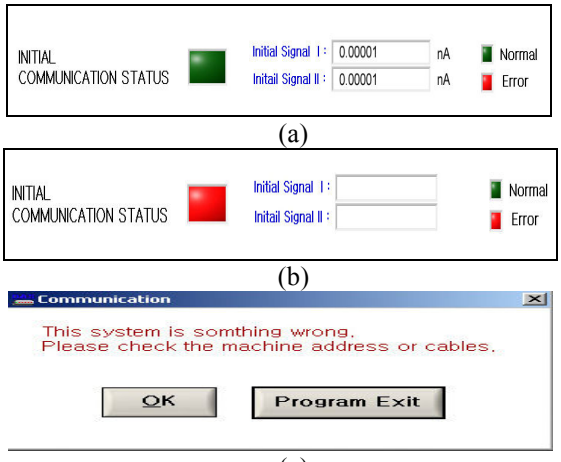

Figure 2. Initial communication status windows
; (a) normal status, (b) abnormal status, (c) notice window.

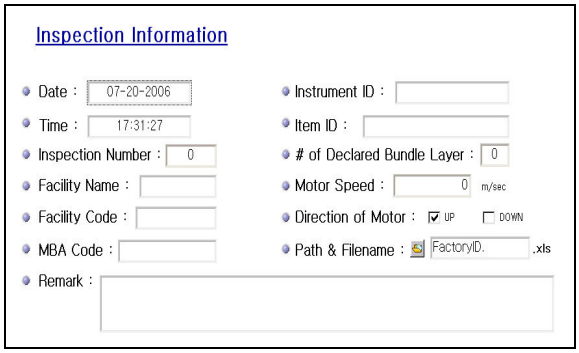

Figure 3. The window of inspection information.

The result of obtained data is shown in figure 4. The configurations for the window of data acquisition consist of three sub-windows. The upper window shows data acquisition from sensor displayed the subtracted values between signal I with scintillator and signal II without scintillator. The lower left window displays the text values of data. The lower right window shows the comparison between the measured number of bundle layer and declared number of bundle layer.

If the measured numbers of bundle layers are identity, then the lamp displayed green with success. If not, the lamp displayed red and fail. The inspector may retry by rescan button. For the comparison the number of declared bundle layer with the number of measured bundle layer, bundle-searching algorithm is developed. The frame of bundle searching algorithm determines bundles when two series of sample data appear on increase and decrease.

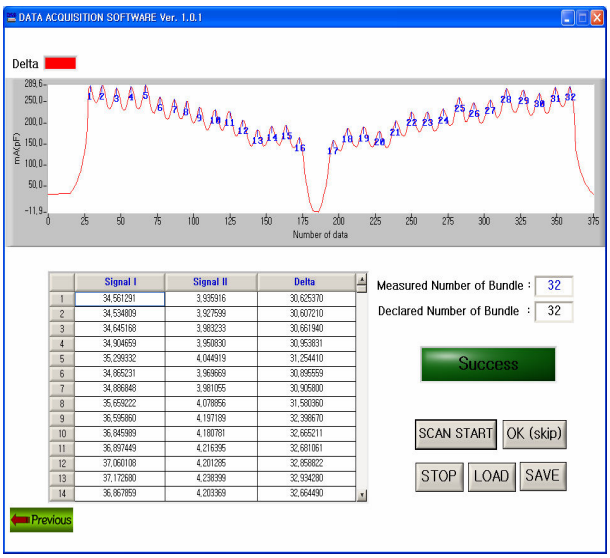

Figure 4. The window of data acquisition and save function. The test data scanned from top and bottom position from reference point.

3. Conclusion

NDA and underwater viewing devices have been used during physical inventory verification of the spent fuels by the IAEA. This current NDA device is CANDU Bundle Verifier for Stacks (CBVS), which is moving vertically along the space in between the columns of trays. However, spent fuels at the bottom layer of a stack are unable to verify due to limited accessibility of a large size detector through the funnel structure. The inspector requires moving the trays to verify the bundle hidden by the funnel structure. In addition, this movement has given the burden and a potential danger to the facility, as well as a time consuming.

KINAC developed a verification system based on optical fibers that measures gross gamma intensity by scanning vertical position in the storage stack without moving the tray. The result of measurement on the spot found out clear peaks easily as the spent fuel existed in each tray. The MSSP (Member State Support Program), “Optical Fiber Radiation Probe System for Spent Fuel Verification”, is being on progress to authorize inspection use of the OFS for item counting of bundle inventory in CANDU ponds. This will entail providing the Agency with a demonstration system, including appropriate documentation supporting its use as a “Category A” instrument for routine inspection use. In addition, field test will be organized and performed by MSSP and attended by and Agency representative for the next year.

REFERENCES

[1] Jong-Soo Kim et.al, “Development of Optical Fiber System for CANDU Spent Fuel Verification in Korea”, 2004 INMM.

[2] I.J.Park, etc, “Development and Test of Spent Fuel Verification System Using a Scintillating Glass Fiber”, Proc. 2005 IEEE NSS/MIC, Oct. 2005, Puerto Rico.